ASSESSMENT OF PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF DAIRY COWS IN THE AGRO-ECOLOGICAL ZONES OF LESOTHO

BY

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Thesis

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THESIS APPROVAL

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ABSTRACT

Dairy cows, in most part of the world, are primarily reared for milk production even though in Lesotho they can also be sufficiently used in socio-cultural activities. Moreover, reproductive performance remains an essential trait in dairy production because if a dairy cow is infertile, there would be no milk production. A cross sectional study was conducted for the purpose of assessing the productive and reproductive performance of dairy cows in four agro-ecological zones of Lesotho. The specific objectives were to evaluate farmer's experience in dairy production, determine age at puberty and conception rate of dairy cows per year, determine the age at first calving and calving interval, determine types of concentrates utilized in feeding strategies, evaluate reproductive health and related problems in dairy cows and determine milk yield in 300 days per cow. Farmers (249) were interviewed by means of a phone call and Statistical Package for the Social Sciences (SPSS 20) was used for data analysis. Farmers (47.6%) had experience of 10 years in dairy production which increased significantly ($p<0.05$) in the Lowlands and Highlands. Again, natural mating (49.9%) had high conception rate than AI (34.6%). The current study revealed that calving interval ranges between 10 and 15 month hence most dairy cow bore a calf every year which also indicated that milk production cycle fell within 12 months. In terms of milk yield, the majority of dairy cows in the Low lands (18.6%), Foothills (31.8%) and High lands (37.5%) were producing an average of 10 litres of milk per day except in the Senqu RV (63.6%) where production decreased significantly ($p>0.05$) to 5 litres of milk per day. It's also revealed that Friesian produced more milk than all breeds followed by Jersey and that was vivid in the Low lands and Foothills. However, milk production was still below optimum and that has been associated with factors such as poor feeding regimes, inadequate knowledge of milking, utilization of local bulls at the expense of using high quality semen for AI. In conclusion, based on the current study, dairy cow's reproductive performance was very efficient and it confirms that dairy cows in Lesotho are very fertile. This is made on the basis of high conception rate. The major limiting factor on reproductive efficiency was the quantity and/or quality of feeds availability and dairy farmers who attempted to formulate ration at their own backyards lacked knowledge and skills. Hence they produced mixtures that could not meet animal requirements as such mixtures did not contain specific nutrient quantities and/or qualities.

DECLARATION

I, Thabiso Lawrence Monaheng, confess that the assignment under which this thesis is established is completely fulfilled by me and that none of this work has formerly been presented for extra degree at this or any other University in the world. The facts from different sources were cited and recognized by means of references. Therefore, I fully entitle the National University of Lesotho to provide duplicate of this dissertation to the libraries as well as individuals upon inquiry.

Signature……………………………….. Date…………………………….

DEDICATION

This thesis is dedicated to my family members in particular my beautiful wife, a daughter and a son. They have been with me through thick and thin while I was pushing very hard to succeed in this tough work. They have indeed been the everlasting source of inspiration and motivation behind this adventurous journey.

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Initially, I sincerely wish to pay homage to my lovely wife for compromising the little funds in order to pay for my tuition fees. Her optimistic decision and patience cannot be ignored, rather, I acknowledge her in that regard and it's my desire to always respect her. I also acknowledge my supervisor Professor Dawuda Phillip Makama for the guidance and tolerance he persistently offered. In actual fact, he shall remain in my heart because of his leadership qualities and the manner in which he addressed the details of this thesis. Ever since I started this work, he was always available and passionately encouraged me to concentrate on the technicalities of this thesis. He additionally had immense contribution in all phases of this accomplishment and therefore, endlessly deserves my extreme appreciation together with all Animal Science Department lecturers.

The other people whom I would like to embrace are my relatives and friends. These are my life-time project partners spontaneously from heaven and some of them maintained my school specifics in their hearts knowing that I definitely needed their support. Given the green light to mention a few, especially within my relatives, I have two brothers and a younger sister who perfectly assisted me and their uncomplaining attitude has been a symbol of love and understanding of what I was involve in. I am again blessed with my adopted parents who are genuinely grown-ups now if they are both aged above 80 years and that is a great achievement ever to them. They undoubtedly deserve similar acknowledgements same as my dead biological parents.

There are many people who may be observed in this dissertation but Doctor Nchele Kuleile deserves better as the one who triggered eager and courage throughout this journey. His advices have been fruitful and I salute him. Moreover, I pass my special gratitude to the extension workers and DAPOs from the Ministry of Agriculture, Food Security and Nutrition for the provision of the lists of dairy farmers before data collection. Farmers are also recognized for their time and honesty during the administration of the questionnaire. It was not a child play to allocate time for me in what could not benefit them directly hence their significant assistance should be upraised. Lastly, I will assign my noteworthy thanks to my classmates, the people I worked hand in hand with from the start of this work to the end and it is because of their support together with drive they consistently exhibited during the time of the baffling peculiarities. They participated like fighting soldiers throughout the entire activity and they advised me accordingly leaving no stone unturned.

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LIST OF ABBREVIATIONS

GDP	-	Gross Domestic Product
NSC	-	Number of service per conception
CI	-	Calving interval
DO	-	Days open
LL	-	Lactation length
LY	-	Lactation yield
DMY	-	Daily milk yield
NEB	-	Daily milk yield
RFM	-	Retained fetal membranes
ES	-	Estrus synchronization
CL	-	Corpus luteum
FSH	-	Follicle stimulating hormone
LH	-	Luteinizing hormone
PID	-	Pelvic inflammatory diseases
IBR	-	Infectious Bovine Rhinotracheitis
VHHM	-	Veterinary Herd Health Management
EB	-	Energy balance
CP	-	Crude Protein
TMR	-	Total mixed ration
TDN	-	Total Digestible Nutrients
DMI	-	Dry matter intake
RDP	-	Rumen degradable protein
MEC	-	Mammary epithelial cells
LDP	-	Lesotho Dairy Products
RV	-	River valley
DLS	-	Department of Livestock Services
SPSS	-	Statistical Package for Social Sciences
AI	-	Artificial insemination
SSA	-	Sub-Saharan Africa

CHAPTER 1

1.0. INTRODUCTION

1.1. BACKGROUND

Lesotho dairy farming is dominated by smallholder (backyard) farmers rearing between one and five dairy cows. The dominant breeds of dairy cows used for milk production are Holstein Friesian, Jersey, Brown Swiss and Ayrshire, as well as cross breeds of exotic and indigenous breeds (LNDB, 2022). Regardless of the fact that many dairy farmers in the Mountain Kingdom commonly practice subsistence farming, an unspecified figure keep them for milk production. Most dairy cows seem to be exotic while others are bred in Lesotho. The present situation is that, on average, dairy producers have three cows and that makes 52.5% within the range of one to five cows. A very small (2.5%) care about 18 and 21 cows (Rantšo and Makhobotloane, 2020). 108 heifers have been delivered to the farmers after purchasing them from South African breeders (Lesotho Times, 2020).

Milk yield and reproductive performance are the primary factors of dairy enterprise but both traits can deleteriously be affected by the udder health status (Rearte *et al.*, 2022). Even though Rhoads (2023) regarded reproduction as the base of animal productivity, the suboptimal reproductive performance contributed immensely on economic loss in dairy industry generally. Furthermore, Martin *et al.* (2022) expressed that the critical issue was poor female fertility that resulted in longer lactation and uncontrollable involuntary cullings. Moreover, LNDB (2022) reported that less experienced farmers (less than five years in dairy farming) in Lesotho constitute thirty-seven percent (37%) while experienced farmers (more than five years in dairy farming) represent twenty-three point two percent (23.2%). Lack of experience in dairy production cost farmers a fortune due to reproduction failures and poor breeding practices that leads to longer calving interval.

The association of dairy cow's reproductive performance with significant factors such as genetics, production, nutrition, diseases and environment, together with individual characteristics cannot be denied. Therefore, recent hygiene and proper feeding of dairy herds and application of well-planned or developed reproductive programs could greatly enhance reproductive performance. In addition, Kim *et al.* (2023) expressed that it was vital to outline all detrimental causes of poor fertility in order to find correct and specific counter-measures for improvement of dairy cow's reproductive performance. Consentini *et al.* (2021) also demonstrated that dairy herd's reproductive performance contributes hugely on every farm profitability.

1.2. PROBLEM STATEMENT

Most of the dairy cows in Lesotho have poor reproductive performance and the indicators for inefficient reproduction in dairy cows are: repeat mating, low conception rate, long calving interval, silent estrus, anestrus and retarded growth rate. The reproductive system can also be infected by reproductive diseases such as brucellosis, trichomoniasis, campylobacteriosis, salmonellosis, leptospirosis, mastitis, etc. As a result, most calves have been aborted. Other common reproductive challenges dairy farmers are experiencing are as follows: Retained placenta, stillbirth, anestrus and dystocia. Another contributing factor is poor nutrition. Even though some of dairy farmers are basically drying to formulate rations using local feed sources, dairy cow's reproductive needs have not been satisfied nutritively. For instance, essential minerals for efficient reproduction such as selenium, zinc and manganese have been excluded in daily feeds. The aforementioned factors impact negatively on the productive performance of both local and imported dairy cows from South Africa which produce below expectations in comparison with their parent's pedigree records. Ineffective reproductive performance is a direct cause of dairy cow's low productivity and sluggish growth of milk production industry in Lesotho. Moreover, it is distinguished as the main cause of poor heifers' production and backyard minimum milk production by individual farmers. Consequently, dairy production industry in Lesotho will not reach its potential production capacity and it will progressively deteriorate leading to stunted dairy enterprise. Eventually, poor productive performance will impact severely on Gross Domestic Product (GDP) due to inadequate dairy production for the market and as such appears as a barrier for Lesotho economic growth.

1.3. JUSTIFICATION

This study will determine reproductive efficiency by giving deep thought to proper reproductive management with the involvement of good nutrition, management techniques and reproductive diseases prevalence and milk yield per lactation period. Thereafter, the combination of the above-mentioned factors will be recommended for the improvement of dairy cow's reproductive performance. Management techniques such as artificial insemination and estrus synchronization are very significant for reproductive performance improvement. Subsequently, dairy production industry in Lesotho shall flourish following enhanced reproductive efficiency and in the long run, backyard dairy farmers will be self-sufficient. Again, jobless people are going to be hired in order to work for those farmers who are engaged in dairy farming. High unemployment rate will definitely be reduced as dairy production industry prospers and the more dairy products are produced for the market, the more the gross domestic product (GDP) will increase.

1.4. HYPOTHESIS

1.4.1. Null hypothesis (Ho)

Dairy farmers within four agro-ecological zones of Lesotho lack technical knowledge and skills to determine the presence of low productive and reproductive indices in their farms that cause their huge financial losses.

1.4.2. Alternative hypothesis (H_1)

Dairy farmers within four agro-ecological zones of Lesotho are equipped with technical knowledge and skills to determine the presence of low productive and reproductive indices in their farms that cause their huge financial losses.

1.5. GENERAL OBJECTIVES

The aim of this survey is to assess the productive and reproductive performance indices of dairy cows in four agro-ecological zones of Lesotho.

1.5.1. Specific objectives

1. To evaluate farmer's experience in dairy production in four agro-ecological zones of Lesotho.
2. To determine age at puberty and conception rate of dairy cows per year in four agro-ecological zones of Lesotho.
3. To determine age at first calving and calving interval in four agro-ecological zones of Lesotho.
4. To determine types of concentrates utilized in feeding strategies in four agro-ecological zones of Lesotho.
5. To evaluate reproductive health and related problems in dairy cows in four agro-ecological zones of Lesotho.
6. To determine milk yield per 300 days per cow in four agro-ecological zones of Lesotho.

CHAPTER 2

2.0. LITERATURE REVIEW

2.1. INTRODUCTION

Reproductive performance emerged as an outstanding attribute of dairy cow enterprises and milk production depended heavily on reproductive efficiency. Reproductive traits have been outlined as follows: number of service per conception (NSC), calving interval (CI) and days open (DO). The other attributes such as lactation length (LL), lactation yield (LY) and daily milk yield (DMY) represented the measures of profit in dairy farming (Alem, 2021). Additionally, Yusuf (2020) stated that reproductive efficiency determined the profitability of commercial dairy enterprise. It clearly demonstrated that the better the reproductive performance the higher the profits in contrasts to the defective reproductive performance. Again, Mouncey (2023) reported that deficient reproductive activity bore automatic culling and it has been very detrimental to the output of calves born. Furthermore, early ovulation post-partum was a sign of superior reproductive performance than cows that remained anovular for longer than voluntary waiting period (Rial *et al.*, 2022).

The best reproductive efficacy could be achieved if the cow had the following reproductive traits: A heifer had puberty quickly and conceived earlier in the breeding season, calved smoothly without farmer's interference to a healthy calf that could live until it was marketed and then after conception, the heifer/cow could be impregnated at first service in order to parturate quickly in the following calving season. Any interference following heat cycle could initiate reproductive damage. A technical approach aimed at enhancing reproductive efficiency depended upon the basic knowledge of the physiological, cellular and molecular procedures controlling both sexes genitalia (Pohler *et al.*, 2020). The investigations revealed that recently, Dairy farmers preferred high producing cows at the detriment of reproductive efficiency and health factors. Improved choice of characteristics linked to reproduction together with the reliability gains that genomics provided for less heritable traits such as reproduction has led to tremendous progress among dairy herds pertaining to genetic potential for reproduction recently (Consentini *et al.*, 2021; Crowe *et al*., 2018).

2.2. FARMER'S EXPERIENCE IN DAIRY PRODUCTION

As Utami *et al*. (2022) provided, farmers experience was ranging from 6-10 years in dairy production and that was associated with the smallholder dairy profit. Yaemkong *et al*. (2010) reported that experienced farmers have knowledge and skill for proper management of their herd under unfavourable climatic and economic condition than inexperienced farmers. Also, farmers with many years in production fed and cared for their cow better and attained high yield and collected more money than those with less experience. Experienced farmers were better in management activities such as stables cleaning, fresh water access and more comfortable milking practices; have better feeding strategies with cheaper food alternatives of high nutritional value in difficult economic times such as corn silage, grass silage, brewer grain, dry leucaena leaf and cassava leaves; and developed good health techniques due to higher knowledge of how to treat common diseases such as tick fever, mastitis, acidosis, laminitis without calling veterinarians, thus kept the costs low.

However, Feyisa *et al*. (2024) demonstrated that individual farmers who were educated or experienced on milk safety information, access to credit and training on milk safety inspections significantly adopted more milk safety measures. Also, Mamusha and Temesgen. (2024) reported that one female participant shared her learning experience about the importance of good animal welfare saying she would give similar approach to her cows and children. In the same way, Feyissa *et al*. (2024) showed that older farmers having more knowledge and experience may have acquired more physical and social capital over time and easily assess technical facts than younger farmers. Additionally, Korir *et al*. (2023) reported that farmers with poor working experience adopted multiple technologies later than those with more than 5 years of experience. As Rantšo and Makhobotloane (2020) stated, more educated and experienced farmers had best opportunity of taking out fears related to risks and uncertainties in adopting new technologies.

2.3. PUBERTY

Puberty was determined by factors such as body mass and constituents, breed, nutrition, genetics and time of the year. Young cows that reached puberty quicker than normal had considerable lifetime productivity (Estill, 2021). Liveweight, breed and geographical background where heifers lived were the most influential factors contributing to the differences noticed in the amount of pubertal animals within a herd by 10–12 months of age. They again highlighted the significance of owning flourishing heifers for multiplying the opportunities of reaching puberty early and embraced the effect of breed and good managerial features underpinned in heifer's ability to achieve puberty quickly (Steele *et al.*, 2023). A heifer that exhibited initial signs of estrus or heat at puberty and went on showing normal estrous cycles every 21 days was prioritized (Figure 2.2). If it was fed a correct ration, it would simply establish estrus cycle between 9 and 15 months of age. Dairy heifers attained cycling quicker at 9 to 12 months whereas beef heifers reached it a little bit later, at 13 to 15 months (FDA, 2019).

2.4. ENDOCRINE REGULATION OF ESTRUS CYCLE

The range for estrous cycle in dairy cows was 18–24 days and comprised of a luteal phase (14–18 days) followed by follicular phase (4–6 days) (Figure 2.1) . Amidst the cycle there were basically 2 (dairy cows) or 3 (heifers and beef cows) waves of ovarian follicle growth. Normal estrous cycles in cattle commenced during the time of sexual maturity. Heifers became mature at 6 to 24 months of age distinctively at 50% of mature body mass. In the beginning of first estrous cycle, it took a minimum of 3 to12 days and that occurred after a quiet ovulation. As demonstrated in figure 2.1, estrous cycles halted after conception due to continuous secretion of progesterone from the Corpus Luteum and placenta (Crowe, 2022). Estrogen (E2) influenced follicle development and determined signs of estrus such as a willingness to be mounted. Progesterone (P4) was vital for standard reproductive cycling. Prostaglandin $F_{2\alpha}$ (PG) released from the uterus inhibited pregnancy beginning by encouraging luteolysis. Follicle stimulating hormone (FSH) simplified follicles development, mature and ovulation; influencing the production of multiple embryos after insemination. Luteinizing hormone (LH) activated ovulation and development of the corpus luteum (Pal and Dar, 2020; Praharee, 2021).

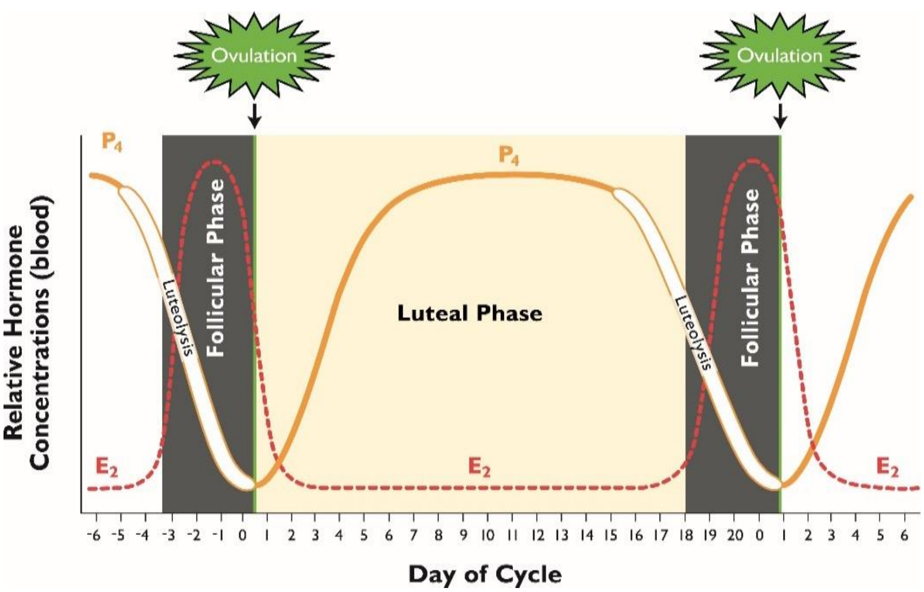

Figure 2. 1 Hormonal involvement in cow's estrus cycle

Source: FDA, (2019)

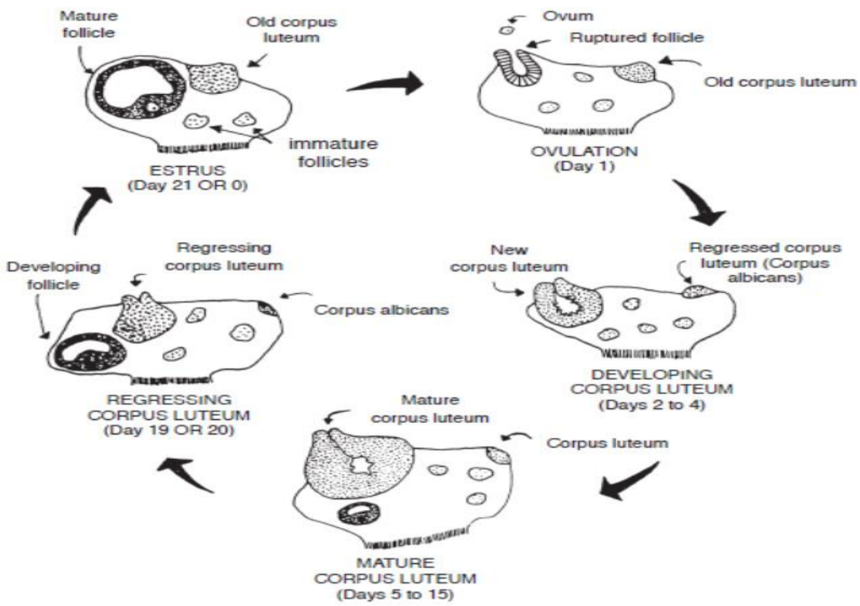

Figure 2. 2 Day-21 of normal estrus cycle

Source: Thomas and Ellis, (2021)

2.5. CONCEPTION RATE

According to Van Knegsel *et al*. (2024), an extended lactation period was associated with a high conception rate even though at that time milk yield was commonly decreased. However, Temesgen *et al*. (2022) indicated that cows with less time from giving birth to mating and AI exposed had a great chance to conceive than cows with greater opportunity for calving to insemination intervals and natural service exposed cows and the conception rate was found to be 44.7%. However, Praharee (2021) expressed that the frequencies of services per conception was often an indicator of poor fertility. Presently, the first service conception rate ranged from 40 to 44% which made SPC higher than optimal. The number of services per conception around 2 was still considerable, but values more than 3 were signs of considerable health problems with reproduction.

In accordance with Ali (2021), reduced conception rate or repeated breeding has been the indicators of fertilization failure. Therefore, the possible causes of unsuccessful fertilization primarily involved uterine inflammation, imbalanced nutrition, particularly very small minerals and vitamin A, age of the dam, heat observation failure and endocrinal impairment, oocyte quality or development and associated factors. As concluded in the report of Ali (2021), the major causes comprised of genetic, environmental, endocrine, infectious nutritional factors. So a balanced breeding strategies should put more emphasis on fertility, feed intake and energy development. However, Adeyeye *et al*. (2020) stated that the reproductive variables were affected by poor management practice, calving season, return to estrus, dystocia, abortion, retained fetal membrane and uterine prolapse. On top of that, Wrzecińska *et al*. (2021) provided that production systems such as housing systems together with stress could reduce the cow's fertility. Again, the environmental pollutants such as pesticides, toxic metals and feed contaminated with mould or fungi could also cause infertility hence poor conception rate.

2.6. ANESTRUS CONDITION

Usually, anestrus condition occurred post-partum as the cow was still recovering from parturition peculiarities and still undergoing recuperation and reorganization of the brain. It was common for cows to ovulate 3 weeks after calving but the cow could not show signs of estrus at this time. It also provided that corpus luteum lived for short time and the cow released the ovum 15 to 18 days from there and that was regarded as second estrus in which the cow exhibited the signs of estrus. It was forty to eighty percent of dairy cows that showed signs of estrus at second ovulation. The permutation was that by 60 to 70 days all cows should have shed the egg (Gorman, 2021). First ovulation after calving was the sign that follicular development has resumed even though the hormonal state was still not fully recovered at the end of gestation period. Despite the situation of energy deficit, post-partum follicular waves came out at around 5 to 7 days after calving in response to the high concentration of follicle-stimulating hormone (FSH) in the blood plasma. The shedding of these dominant follicles developed by the follicular waves in the early lactation period depends on the presence of luteinizing hormone (LH). In actual fact, it has been found that the lower frequency of LH release was the cause of poor ovulatory activity in cows post-partum when compared with those that liberated a dominant follicle (Kim *et al.*, 2021).

2.7. COMPARISON OF NATURAL (BULL) MATING AND ARTIFICIAL INSEMINATION

Many dairy cows conceived under AI (77.6%) utilization compared with natural mating (56.79%) and as such, AI equipment could be employed to replace natural service in local cows of Zimbabwe (Washaya *et al*., 2019). Moreover, cows that had shorter calving to insemination interval and bred with AI happened to have a higher chance to conceive than cows with longer calving to insemination interval and bred naturally using a bull (Temesgen *et al*., 2022). But in order to improve the conception rate and the economic loss, regular and close monitoring of dairy cows is necessary, farmers should be equipped with estrus detection techniques and the inseminators should perfect accuracy in AI timing through refresher courses (Tadesse *et al*., (2022). Generally common causes of conception failure in dairy cows according to the dairy owners were incorrect time of insemination (28.18%), heat detection problem (26.36%), lack of skilled technician (21.81%), management problem (14.54%), unhygienic condition (5.45%) and different diseases (3.63%) (Fesseha *et al*., 2020).

The report by Belay (2016) showed that majority of farmers in Ethiopia bred with a bull as the conception results from the AI services were not successful. In the rural lowland areas of Metema, a great number of farmers bred their cows with the present bull in the village and that was because farmers did not keep breeding bulls. As a result, breeding happened freely under communal grazing system. However, Chawala *et al*. (2021) indicated that enhancement of local breeds by importing semen of highly improved breeds can upgrade local breeds genetic material in dairy cows in Sub-Saharan Africa (SSA) compared to developing a new synthetic breed or improving the indigenous breeds with domestic selection. Furthermore, Lukuyu *et al*. (2019) expressed that farmers who faced a challenge of choosing suitable breeding method preferred AI even though the most of them utilized bull service because it was cheap and easy to use.

2.8. AGE AT FIRST CALVING AND CALVING INTERVAL

AFC that increased yield for Holstein and Brown Swiss was 21 to 22 months and it was 20 to 21 months for Jersey. Therefore, the effect of AFC on stillbirth decreased the results of heifers calving early such as lifetime production (Hutchison *et al*., 2017). Age at first calving appeared as a critical and great performance characteristic for consideration in dairy production. Establishing a range of 22–25 months at first calving could consistently assist in increasing milk yield, fertility and time a cow stayed in the herd (Steele, 2020; Van Eetveld *et al*., 2020). Despite the fact that a deduction in AFC could multiply the returns during the first lactation, it could increase calving problems and compromised the subsequent reproductive performance if it was accompanied by low body weight (BW) (Kusaka *et al*., 2023). Heifers that had first calf at the above-mentioned dates needed brief time after parturition to conceive and also played a significant role in replacement cost (Turiello *et al*., 2020).

In-depth, maintenance of herd in the last trimester was important to ensure neonatal and maternal survival, health and welfare. Knowledge of various calving part was the only workable way to give maximum-quality attention (Villamediana, 2023). Correct parturition anticipation was an essential tool to decrease a detrimental effect on cow and calf health and welfare (Vázquez-Diosdado *et al*., 2023). Perfectly, 60% of the cows would give birth within the first 21-day period. The first 21-day calving interval could easily begin when the third mature cow (3-years-old or older) has calved or began the first 21-day period 285 days after resumption of the breeding time. A reduced calving season permitted thorough monitoring during calving and provided a more-uniform and heavier calves to the market. A limited breeding season would not only enhance the fertility level of the cows, it could also banish extra labor during the calving season (Amundson, 2023).

Cows with high milk production were easily impregnated. However, husbandry activities and breeding decisions happened to be significant for the situation analyzed here for the cows with the least production and those with limited opportunity to be impregnated. Dairy farmers were equipped with technical acumen on animal husbandry and breeding decisions and those were important determinants of improved conception rate of the dairy cow (Temesgen *et al*., 2022). Again, when giving birth to a bull calf, reception period would not exceed 80 to 85 days if a farmer was to recognize a 12 months calving interval. Therefore, an assistance aimed at reducing the calving to first service interval (CSI) would help a farmer to establish the best calving interval (Bigirwa *et al*., 2019). A larger calving interval in dams resulted in heifers with bigger body mass and lower milk returns (Wang *at el*., 2024).

2.9. CONSIDERATIONS FOR IMPROVING REPRODUCTIVE EFFICIENCY.

2.9.1. Dairy breeding and genetics

Breeding programmes in the early 2000s began to take fertility traits such as longevity as well as calving intervals and health as part of the selection criterion (Crowe *et al*., 2018). However, genetic selection for enhanced cow fertility was a priority worldwide. It was also noted that production and fertility did not correlate hence selection programmes had unavoidably indicated a drop of reproductive performance (Peñagaricano 2020). Fruitfulness and reproductiveness were important attributes of dairy farm lucrativeness. Hence reproduction qualities have dominated dairy cattle selection indexes in almost all countries worldwide. Reproductive properties were moderately inherent but could be upgraded by direct choice for best qualities (Chen *et al.*, 2021). Nonetheless, Shao *et al*. (2021) categorized reproductive traits into ovulation, breeding and calving associated parameters.

2.9.2. Nutrition and metabolic disorders

Deficiency of dietary energy nutrients in early lactation and transition period were spontaneous for the high yielding dairy cows. Therefore, the consequences of negative energy balance (NEB) on dairy cows were reduced milk yield, ill-looking and infertility; therefore, the value of dairy farming was reduced (Mekuriaw, (2023). A balanced energy feed beginning from 21 days was beneficial prior to calving period (Sammad *et al.*, 2022). For alleviation of NEB and the risks for such health disturbances, the major factor affecting energy balance (EB) could be corrected by modifying energy intake to some extent by dietary measures such as serving an appetizing, energetic and sufficiently structured diets. Eventually allocating supplements that would boost rumen capacity, provided more energy and an improved intermediary metabolism could contribute to NEB mitigation (Meyer *et al*., 2024).

Furthermore, Mekuriaw (2023) concluded that prompt policing and engagement of nutritional tactics could reduce the harmful results of negative energy balance (NEB) on dairy cows. Daily and close review of the nutritional value for the cows and upgrading the nourishment regimes cordially could be beneficial for disease prevention. The nutritional management prior to dry period and after lactation stoppage were crucial for keeping the health and productivity of cows in transformation. Again, Zhang *et al.* (2020) stated that NEB at the start of lactation decreased cow productivity and reproductive performance and influenced immunosuppression and elevated elimination chances for dairy cows. Likewise, Yeshambel (2023) expressed that the presence of NEB prior to calving and early post-partum of dairy cows could contribute to both short and long-term negative effects on production and reproduction ability. Poor body condition, decreased milk production, a change in the milk fat to protein ratio, high incidences of health problems, a late time to exhibit estrus, delayed ovarian cycle and a lower conception rate were known problems.

Essentially, Bates *et al*. (2022) reported that minerals required in small quantities such as copper and selenium were critical for the activation of immune response prior to calving time and trace mineral supplementation (TMS) was necessary to decrease diseases incidences. Lately, injecting with TMS having zinc, manganese, selenium, copper and chromium was related to decreased calf movement and death over the first 140 days of life. Also, Jones (2022) maintained that in beef and dairy herds, deficient status of zinc and selenium were both connected with several occurrences of retained fetal membranes. Moreover, Cavallini *et al*. (2023) noted that if a feed contained inadequate protein or minerals, the cow's capacity to break down fibrous feed would be negatively affected and the animal would be deprived of nutrients that were crucial in rumen microbial fermentation. Consequently, the balanced nutrient composition could notably be assured together with animal requirement in order to enhance fibre breakability, general health and productiveness of the nursing dairy cow.

Low nutritive value and insufficient management of milking cows feeding regime could result in various health problems, called metabolic disorders. Prior to calving hypocalcemia, commonly known as milk fever, was a metabolic problem that impact on dairy cows before calving. Dairy cows' calcium needs were minimum throughout the dry period but increased as milk production starts during calving (Nurye and Animut, 2022). When solving metabolic disorders, especially subacute ruminal acidosis (SARA), ketosis and hypocalcemia in dairy cattle; nutritional management, balanced diets and proactive supplementation were critical when preventing the outbreak of these metabolic conditions (Tufarelli *et al*., 2024)·

2.9.3. Heat and pregnancy detection

Notice of estrus signs was an important factor when improving reproductive performance in dairy industry. It was commonly done by observation and normally the cow position herself to be mounted. Nevertheless, other methods applying sensors were utilized to observe estrus quickly and they comprise of pedometers and neck-mounted collars that record physical activity and pressure-sensing utensils that record standing estrus (Napolitano *et al.*, 2020). Naturally, a bull depended on various senses such as olfactory, visual and auditory for estrus detection in exclusive of human intervention (Mottram, 2022). However, detecting estrus early and correctly was important (Ali *et al.*, 2022).

In cattle production, the success of reproductive management was economically measured with accurate and convenient pregnancy diagnosis. There was a need to detect pregnancy at an early stage because it was a valued instrument for fertility management (Mphaphathi *et al.*, 2022). Dairy cows primarily needed early pregnancy diagnosis and embryonic mortality as management activities postpartum in order to enhance reproductive performance (Szenci, 2021). Pregnancy diagnosis procedures that were commonly present involved an observation of non-return to estrus, transrectal palpation, transrectal or transcutaneous ultrasonography and analysis of progesterone and pregnancy-associated glycoproteins in milk or blood (Delhez *et al.*, 2020). Rectal palpation was a general and highly popular method among all cattle producers in primarily performing pregnancy checks on cows and heifers and also for checking the genital parts of a male during a bull breeding soundness exam (Lindquist, 2024).

2.9.4. Synchronization programs and artificial insemination (AI)

Estrus synchronization (ES) could effectively multiply how many cows bred at specific breeding season and decreased hardships related to estrus inspection such as its errors and labor damage (Das *et al.*, 2022).

It permitted the efficient AI utilization and embryo transfer procedures (Mellado, 2022). ES and AI remained as dominant technologies for genetic enhancement, reproductive management and animal reproductive as well as productive performance (Haile *et al.*, 2023). Lately, AI was relatively considered as the great technique for improving reproductive capacity and conception rate at the first mating postnatal. It was also very important for better reproductive performance in dairy cows hence improve income (Tadesse *et al.*, 2022).

2.9.5. Managing minor uterine issues post-partum

Oxytetracycline was recommended for treatment of a wide range of microbes anaerobically on top of its effective action post-partum which has also made it appropriate for treatment of clinical endometritis by intrauterine infusion (Ghallab *et al.*, 2023; Barański *et al.*, 2022). There were factors of poor fertility underlying the decline of reproductive performance and those occurred in cows such as genital area infections, endocrine disorders and defective ova. Therefore, dairy farmers were advised to examine their cows/heifers on daily basis or within a short time, normally first 10–14 days postpartum (Yagisawa *et al.*, 2023). Fresh cow management activity would embrace both visual/clinical (general brightness and alertness, rumen fill and appetite, udder fill, manure consistency, hydration status, respiration pattern and effort, nasal, ocular and uterine discharge, lung and rumen auscultation, body temperature and lameness) and record-oriented (first test-day milk production, mature-equivalent 305-days projected milk (ME305), milk components and ratios, somatic cell counts) observations, coupled with the ubiquitous blood or milk/urine ketosis-test (Valergakis *et al*., 2024).

2.10. REPRODUCTIVE HEALTH AND RELATED PROBLEMS

Uterine infection was still without doubt the main issue on most high-producing dairy cattle farms, as it affected about half of all dairy cows and had serious consequences regarding reproductive performance and milk production. Problems with reproductive performance were the main reasons for culling on large-scale dairy cattle farms. These diseases could not be prevented by management tools only and commonly applied treatment procedures required manual labour, extensive drug usage and repeated follow-up examinations (Várhidi *et al*., 2024). However, implementing integrated veterinary herd health program led to an improvement in fertility or its maintenance (Barański *et al.*, 2021). Eventually, a healthy cow postpartum had an opportunity for enhanced embryo quality, high fertility at first service and deduction of early embryonic loss from conceived cows (Elsevier, 2023).

2.11. HERD HEALTH PLAN AND VACCINATION

The aim of a herd health program was to stop the arrival and spread of infections within the herd and to maintain all bulls in optimal health. The program could give clean surveillance and diagnostic testing to discover the invasion or incursion of disease. Management strategies focused on biosecurity could be employed in both facility design and everyday bull management (Tank and Monke, 2022). Dairy farmers who opted for Veterinary Herd Health Management (VHHM) were inclined to produce a bigger group of cows that also produced more than backyard producers (Ries *et al*., 2022). Moreover, for further improvement in animal health, welfare, productivity and sustainability, it was significant for animal doctors to strengthen their involvement in VHHM (Svensson *et al*., 2022). In contrast, even if the development has been made on that, the operation was sluggish and veterinarians had singled-out communication as the main barrier for quick responses in herd health plan (Svensson, 2022).

Nonetheless, McGrath (2022) demonstrated that farmers could communicate frequently with their veterinary practitioner to talk about the medication farmers could consider when developing herd health plan. Owing to the fact that individual herd was distinctive and could be exhibited to various infections risks; it was important to build a vaccination plan that was specific to each herd and employ vaccines strategically. It could be clear that vaccination was simply associated with good management or well-planned biosecurity measures as it was only one part of disease prevention. That being the case, Statham *et al*. (2022) concluded that vaccination programmes were critical tools in a clearly defined and well-planned herd health control. As indicated by McGrath, (2022), a calf had its full immune response at 3 to 4 weeks of age; before that, colostrum supplied antibodies for protection and it could be simply used as first feeds of a calf just before 3 weeks and within 2 hours of birth, give at least 3 litres (1-2-3) of colostrum.

Dairy cows were usually infected after birth and the occurrence resulted in poor fertility and speed up culling risk; as such control and care were very significant (Gilbert, 2016). Metritis was reasonably managed with acceptable antibiotics but the procedure for more critical treatment that maintain similar performance were introduced. Uterine inflammatory contamination had a detrimental effect on oocytes, embryo growth together with endometrium for at least three months even if the disease was obviously resolved. Advanced concepts of the remedy and control of the swelling were important for the improvement of prevention and therapy of endometritis (LeBlanc, 2023).

Utilization of antibiotics for uterine infections was not satisfactory, either they were ineffective or as a result of present regulations targeted to decrease employment of antimicrobials. Hence finding better resolutions other than antibiotics was necessary (Várhidi, (2024). Programmed vaccination before breeding could improve cow's fertility and ability to carry healthy calf for the entire gestation period (Ingelheim, 2020). The appropriate time to inject cows for reproductive infections was before calving. If farmers really targeted to secure the fetus, cows had to be well vaccinated and immunity maximized prior to conception (Wardynski, 2013). There was no perfect vaccine and good management practices could not be substituted and maintenance of healthy cows needed to be assured all the time, treating and performing diagnostics on infected cows, keeping correct vaccination records and be on guard for outbreaks within the herd (Maday, 2018).

2.12. ABORTION AND DYSTOCIA

It was explained as gestational loss that took place between day 45 to the end of pregnancy (calving) (Macías-Rioseco *et al.*, 2020). The findings of Keshavarzi *et al*. (2020) provided that successive performance of dairy cows depended on the type of abortion and the stage of pregnancy when abortion happened. Usually, farmers easily determined the direct losses materializing subsequent to abortion which was nothing other than pregnancy and there were also economic losses which spread all over the entire herd. Again, Keshavarzi *et al*. (2017) have shown that associated losses were related to well-being, milk yield and reproductive effectiveness. There was a general decrease in conception rate following abortion incidences. Again, the report by Sigdel *et al*. (2021) provided that pregnancy termination would cause placental retention and endometrium inflammation, which really reduced reproductive effectiveness and increased expenses for veterinarian and labour. As a result, pregnancy termination could be ignored, rather, it could be included in breeding programs produced for reproductive efficacy enhancement.

If a cow has come across calving problems, reproductive problems take advantage of it such as retained placenta accompanied by pyometra. As a result, ovarian diseases together with poor fertility will occur. Moreover, dystocia quietly happens and cows become anestrus after calving (Zoca, 2023). The rate of occurrences of dystocia was significantly ($P < 0.05$) greater with twinning than single calving (15.5% vs. 6.5%), whereas not significantly impacted by a calf being either male or female. That being the case, reproductive fruitfulness milk production can be negatively affected (Gaafar *et al.*, 2011). The research has revealed that trainings of calving and dystocia management can efficiently decrease the number of open days in cows. On top of that, the incidences of dystocia seem to be high in traditional farms than commercial ones. Obviously, cows which had dystocia had extended time in open day than those which calved successfully (Keshipour *et al*., 2024).

2.12.1. Causes of abortion

The first sign of brucella infection was abortion at the last trimester of gestation period; orchitis and bursitis in dairy cows. It caused abortion, stillbirths, retention of the placenta and weak calves (Tulu, 2022). The reproductive activities still continued as though nothing had happened hence disease control was difficult (Abnaroodheleh, 2023). In conceived cows, *Brucella* displayed a powerful tropism for placental trophoblasts and also for mammary glands, in which it replicated extensively causing placentitis and abortion in the last trimester of pregnancy in ruminants (González-Espinoza *et al.*, 2021).

Laptospira spp was generally causing leptospirosis in mammals and most common symptoms of leptospirosis, abortion and fertility disorders in Europe and popularly known with chronic infections. This type of bacterial typically caused abortion, fertility disorders and decline in milk yield. However, the disease constituted a significant economic impact due to both reproductive and non-reproductive losses to production (Sohm *et al.*, 2023).

Campylobacter fetus commonly caused abortion and resulted in bovine campylobacteriosis that heated hard on the countries practicing extensive production system (Juan *at el.*, 2023). It was among the major causes of infertility and abortion in ruminants (Sauceda-Becerra, 2023). These species can harbor silently in countless amount in throat of livestock such as poultry, ruminants and pigs (Taghizadeh, 2022).

Fungal infections could be seen as very tiny lesions on the placenta, not on the fetus (Jonker *et al.*, 2023). Moreover, Sato *et al*. (2022) provided an example of aspergillus terreus infection in association with abortion while De Carli *et al*., (2022) described Fungi as the cause of venereal diseases such as uterine inflammation and infertility in cows.

According to Bruinjé *et al.* (2023), health abnormalities after calving had dangerous effects on early pregnancy initiation and continuation. As diagnosed by Macmillan *et al*. (2021), common disorders were fetal membrane retention, dispositioned abomasum, low blood calcium, ketosis and inflammation of endometrium. Furthermore, Stevenson *et al*. (2020) concluded that infections delayed the first post-partum ovulation.

2.13. RETAINED PLACENTA AND ANESTRUS

The findings of Gaafar *et al*. (2010) provided that year and season of calving, cow's body weight, number of parity, sex, calves birth weight, type of birth and feeding system had noticeable effects on the problem of retained placenta and it showed harmful effects on reproductive performance and milk yield of Friesian cows. Furthermore, Mahnani *et al*. (2021) provided that harmful effects of RP on the milk yield was greater in cows immediately after calving than in the middle and last trimester. Nonetheless, Gautam (2023) reported that poor re-cyclicity postpartum was the cause of low conception rate or infertility in dairy cows. Even though a limited time of ovulation abruptly after calving was common, the oversized anestrus over 60 days postpartum in dairy cattle had bad effects on the calving to conception interval. Anestrus instantly afterbirth was associated with late start of estrus cycle.

Ovarian cysts were most popular ovarian infections that were detrimental to reproductive efficiency and was quickly recognized when the cow repeatedly refused to conceive or cow having anestrus condition. Dairy cows living in poor environmental conditions such as bad housing, poor nutrition as well as inappropriate feeding were at high risk of the problem with housing being the most critical factor (Silviu-Ionuț and Alina, 2020). It was indicated that endometrium swelling was often associated with oviduct inflammation in cows. Moreover, it appeared that many diseases causative agents such as Trueperella pyogenes, Fusobacterium necrophorum, Streptococcus and Porphyromonas levii could possibly capture cow's fallopian tube as mounting infection from the uterus. Metritis, prior to breeding, minimized oocyte fertilization rate and growth to the blastocyst stage which however caused destruction of the embryo viability and conceptus enhancement (Sadeghi, 2022). A robust and well-organized immune system shell had reduced the reproductive tract inflammatory diseases such as metritis, purulent vaginal discharge or endometritis. Systemic inflammation was related to the level of trauma and bacterial contamination of the uterus. In the same way, stinking pus from vagina at 4 to 6 weeks post-partum was firmly related to bacterial invasion in the uterus (LeBlanc, 2023).

2.14. FEEDING STRATEGIES

Feeding with total mixed ration (TMR) within 30 days of lactation could increase dry matter intake (DMI) and provided more nutrients, valuable fiber and required quantity of rumen degradable protein (RDP). The provision of all feed constituents assisted in the fast solutions physiologically, endocrine and tissue remodeling steps needed for good metabolic processes and reproductive efficiency (Brady *et al.*, 2021). This feeding strategy was profitable and beneficial, particularly production efficient enhancement of dairy cattle in terms of milk production, milk constituents, dry matter consumption and nutrients metabolism (Karunanayaka *et al*., 2021). This feeding method ensured that each cow received a balanced diet in every bite (Sundrum, 2019).

The findings of Kuleile *et al*. (2024) revealed that majority of farmers (84.5%) practiced supplementary feeding of concentrated feeds and minerals. However, they were not using recommended vitamin and mineral premixes for dairy cattle, rather, they used white salt as a source of mineral and vitamins. Furthermore, Ibtisham *et al*. (2018) stated that deficiency of minerals could also alter the reproductive performance of the animal. Therefore, according to Gross (2022), diet ingestion could be fully achieved by incorporation of tasteful ingredients, at the same time not decreasing rumen passage movement and overall digestibility. Prescriptive roughage types engaged as feedstuffs in dairy cow nutrition include pasture and rangelands; conserved forms such as silage and hay, besides crop residues and byproducts such as straw, hulls from soy and sunflowers. Roughages were known with comparably high fiber and inadequate energy and nutrient content.

Animals served with starchy diets produced more than those which were consuming higher-fibre concentrates (Sethy *et al*., 2019). Pasture feeding provided more fibre to the animals but other feed constituents such as protein and minerals were also critical in a well-managed pasture. The natural pasture was more beneficial when managers discontinued with fertilizers application but re-seeded properly in order to maintain the plant balance (Botha, 2022). Dairy cows needed a balanced diet rich in energy, protein and vitamins and mineral for maintenance of health and to produce high-quality milk. Nutritional needs of dairy cows changed depending on their stage of lactation, pregnancy status, age and health condition. Therefore, feeding regimes could be tailored to meet these dynamic requirements (Ludenyi, 2023). In pasture-based feeding, some dairy farmers allowed their cows to graze on pastures for significant portion of their diet and this method was commonly organic or grass-fed dairy operation (Sundrum, (2019).

However, substituting grass silage with lucerne silage in lactating cow feed indicated an increase dry matter intake, milk yield and value. Lucerne substituted commercial protein in the diet, especially in the case of maize or whole-crop replacement (MacPherson *et al*., 2021). Lucerne was critically an individual fodder crop that dairy farmer could always have in the farm. Under good management, yields were more than 8 tonnes per acre. Given that on average a cow consumed about 15kg per day on top of the grasses to satisfy its nutritional requirements, an acre was enough to feed 2 cows for one year. This was an immense saving given the high costs of commercial feeds (Rangoma, 2023). This fodder was a vital protein source for fattening and milk production and could be put together with other livestock feeds including those based on crop residues or hay (Yasabu, 2017).

2.15. MILK PRODUCTION

The minimum milk yield was estimated at 13 litres per cow per day and the average milk production of 17 litres daily was observed in Friesians cows, cross breeds averaged 10 litres per day while the local breeds were the least with 2 litres on daily basis (Kuleile *et al*., 2024). In Ethiopia, milk yield averaged 1.7 litres per cow per day over an average lactation period of 180 days. In terms of production system, the rural mixed crop-livestock dairy system produced the largest share of milk, contributing 72% of the total milk supply from 65% of the milking animals. Pastoral and agro-pastoral systems and the market-oriented systems contributed 24% and 4% of the total milk respectively (FAO, 2020).

Despite Kenya's great dairy advantage, daily milk production in Kenya was 8-10 litres per cow per day inconsiderably lower than 12.7 litres per cow per day or roughly 4 590 litres per cow per lactation released in South Africa (Mungube *et al*., 2019). South Africa's average milk production per cow per day was 16.1 litres in 2022 (DALRRD. 2023). Therefore, 300-day lactation length was used by Moran (2013) and he revealed that a cow reaching maximum at 20 litres per day could make 4000 litres per lactation while those which produced 30 litres per day had 6000 litres as milk yield in 300 days. However, Shija *et al*. (2022) standardized lactation milk yield to 305-days lactation period.

As stated by De Vries (2020), dairy cattle lifespan was estimated as 3 years after calving for the first time and what always confused the farmers was how long the cow could take in the group and two lactations were common. It has been indicated that dairy cows were in the herd for about 60 months or a little over 5 years, assuming age at first calving was 24 months and the calving interval was 13 months. In Canada for example, Dallago *et al*. (2024), the mean time that Holstein cows died spontaneously was 9.1 years. It resembled the efficient life of 6.8 years or about 6 lactations if normal age at first calving was estimated to be 27 months. Additionally, van Knegsel *et al.* (2024) explained that even though extending the voluntary weighting period could improve well-being and fertility of high-producing dairy cows, increasing the milking period resulted in reduction of crucial calving events and herewith opening for the high risk of health constraints.

Holstein-Friesian has been the main exotic dairy breed reared for milk production in Sub-Saharan Africa (SSA) (Opoola *et al*., 2019). The volume of milk production was determined by factors such as the methods of feeding, the season and number of cows. For instance, one farmer who owned about 11 dairy cows, mainly the Friesland breed, produced a maximum of 170 litres of milk per day to earn approximately M2600.00 per month (Rantšo and Makhobotloane, 2020). Dairy farmers in South Africa typically chose dairy breeds such as Holstein, Jersey, and Ayrshire for milk production. These breeds maintained high milk yields and adjusted well to different climatic conditions (SA Farmers Magazine. 2023).

CHAPTER 3

3.0. MATERIALS AND METHODS

3.1. STUDY AREA AND DURATION

According to Matsepe *et al*. (2021), Senqu River Valley is a narrow strip of land lying between an altitude of 1400 m and 1800 m and situated at 30º02’46.03” S and 28º21’40.79” E. The mountains are the biggest ecological region happening at height of 2000 m to 3400 m with coordinates of 29º31’59.85” S and 28º16’7.04” E. The Foothills are a strip of land seating between 1800 m and 2000 m above sea level with the coordinates of 29º00’3.79” S and 28º12’36.53” E whereas the Lowlands are a narrow belt of land where elevation ranges from 1400 m and 1800 m with coordinates of 29º36’2.32” S and 27º17’32.71” E [11, 12]. Proposal writing began in November 2023 to January 2024. Data collection was done from February to March 2024 in four agro-ecological zones of Lesotho. Analysis of data and results interpretation were made in April to June 2024 while write up was done in July to August 2024.

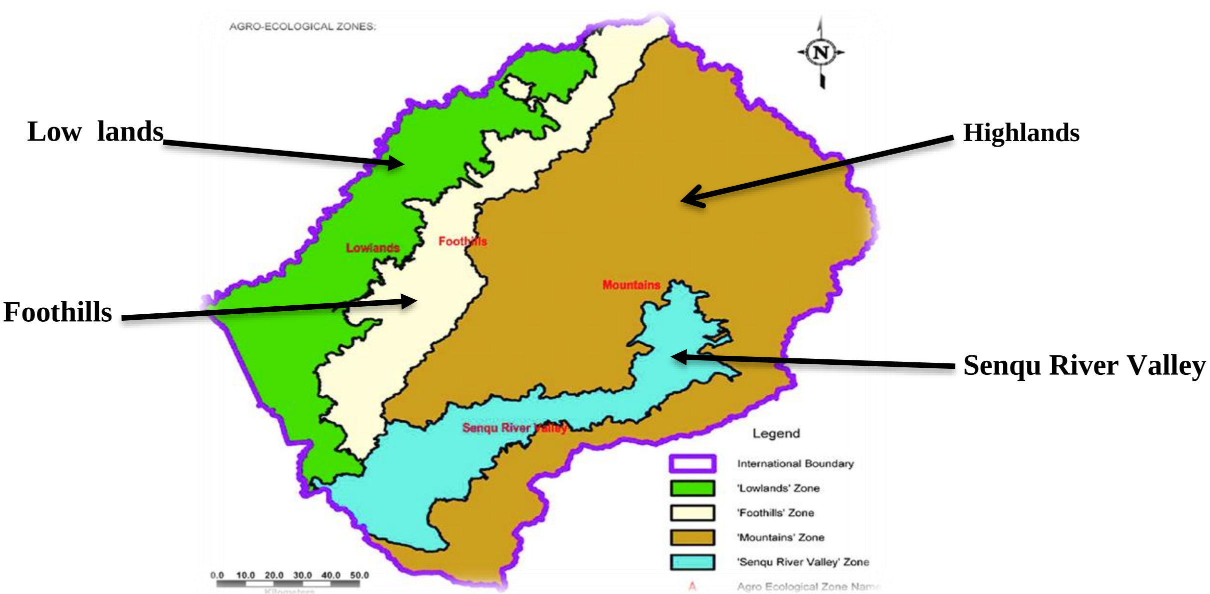

Figure 3. 1 Lesotho map demonstrating different agro-ecological zones

Source: Matsepe *et al*., (2021)

3.2. EXPERIMENTAL DESIGN AND SAMPLING METHOD

The plan of the study begun with the collection of farmer's lists and their phone numbers from Extension Agents (EA) and Districts Animal Production Officers (DAPO). The target was to interview about 305 farmers but due to the unavailability of others, 249 dairy farmers were found in four agro-ecological zone such as Low lands (165), Foothills (43), High lands (23) and Senqu RV (18). Most of the farmers reared between 1 to 5 dairy cows and there were a few who had around 10 dairy cows particularly those who lived in the Lowlands. Again, different breeds of dairy cows were randomly found and there were generally about 335 dairy cows from farmers who were interviewed within four agro-ecological zones. A cross sectional study was conducted using convenience sampling method in order to reach dairy farmers within the four Agro-ecological zones of Lesotho.

3.3. DATA COLLECTION

Dairy farmers were directly interviewed through phone calls and a closed-ended questionnaire was used. The information was taken from reproductive traits such as conception rate, breeding interval and calving problems such as anestrus, abortion and dystocia. Data on daily management practices such as feeding strategies and reproductive health activities with injection before and after breeding inclusive were recorded. Mating methods were also part of data required including the type bulls which were utilized during breeding.

3.4. DATA ANALYSIS

Data was cleaned and entered into excel in accordance with the variables and then transferred to Statistical Package for Social Sciences (SPSS) Version 20 for analysis. The bar charts were produced to demonstrate the distribution of the farmers and breeds in different agro-ecological zones. Descriptive analysis was used to find the frequencies, mean, standard deviation, variance, maximum and S.E. Post hoc (Tukey and LSD) test was also used to establish the significance between mean differences. Moreover, crosstabs were also engaged on the part of categorical variables in which chi-square test and the percentages were found in order to determine the associations within different agro-ecological zones for each reproductive trait The confidence level was maintained as 95% which corresponds with 0.05 significant difference.

CHAPTER 4

4.0. RESULTS AND DISCUSSION

4.1. FARMERS, DAIRY BREEDS AND EXPERIENCE IN DAIRY PRODUCTION.

The findings of this study indicated that the majority of dairy farmers were located in the Low lands (66.3%) while the least were in the Senqu RV (7.2%) (Figure 4.1). The distribution of the farmers in the Foothills, Highlands and Senqu RV was significantly (p<0.05) lower than in the Lowlands. As demonstrated in table 1, the distribution of Friesian and Jersey was significantly (p<0.05) higher in the Lowlands and Foothills and the likelihood of an increased distribution of the other dairy breeds from Highlands and Senqu RV to the Lowlands and Foothills was significantly (p<0.05) low. There was no significant difference (p>0.05).

The large population of Basotho have migrated from remote areas of the country to the Lowlands hence the large percentage of dairy farmers were also found in the Lowlands. That was attributed to poor socio-economic development and insufficient service delivery in the Foothills, Highlands and Senqu RV. The reason why farmers preferred Friesian and Jersey over the other breeds was associated with traits such as friendliness, easy to manage and high milk yield. Therefore, the current results agreed with the report of LNDB (2022) where it was stated that Friesians and Jerseys were common dairy breeds in Lesotho. Again, SA Farmers Magazine (2023) explained that dairy farmers in South Africa typically selected Holstein, Jersey and Ayrshire typically for high milk production and adaptability to various climatic conditions. However, Consentini *et al.* (2021); Crowe *et al*. (2018) argued that dairy farmers preferred high producing cows at the detriment of reproductive efficiency and health factors.

The current results indicated that dairy farmers (47.6%) had an experience of ten (10) years of rearing cows for milk production in the Lowlands (44.0%), Foothills (54.1%), Highlands (69.6%) and Senqu RV (50.0%). The means differences in relation to farmer's experience in years were statistically insignificant (p>0.05) (Table 4.2). As illustrated in Figure 2.1 below, many dairy farmers were located in the Lowlands but those 44.0% had ten years' experience and that was associated with the fact that most of dairy farmers in the Lowlands were beginners in dairy production industry.

The findings of Utami *et al*. (2022) agreed with the current results in that farmer's experience ranged from 6-10 years in dairy production and that was associated with the smallholder dairy farming. However, the situational analysis report of LNDB (2022) disagreed with these findings by providing that the most experienced dairy farmers contained five (5) years' experience in dairy farming. Furthermore, Yaemkong *et al*. (2010) expressed that more experienced farmers provide cows with better management, better nutrition and better health care because of their higher knowledge of how to treat common diseases without calling veterinarians, thus keeping costs low.

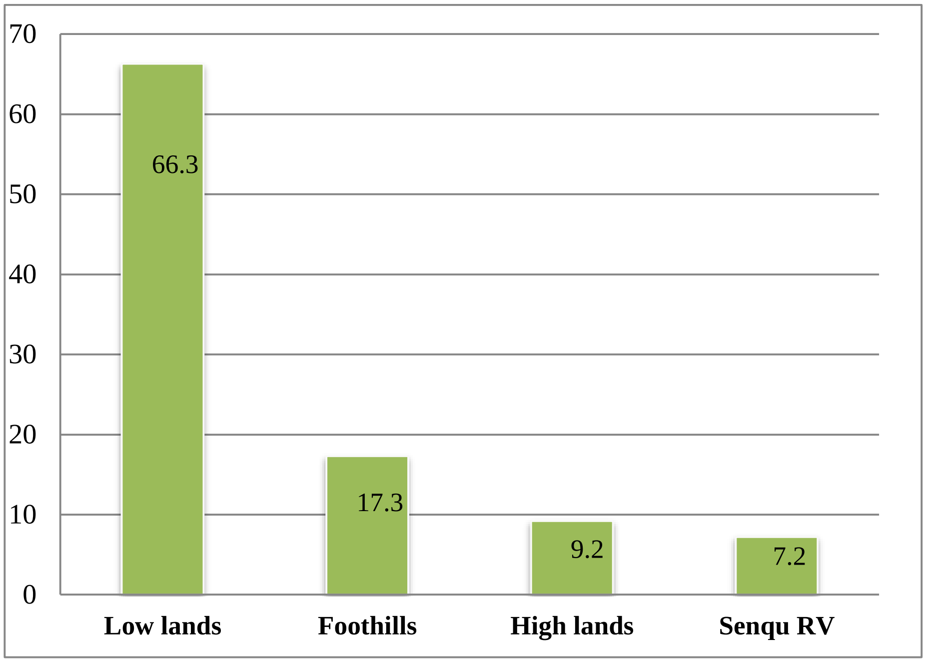

Figure 4. 1 Distribution of dairy farmers in four agro-ecological zones.

Table 4. 1 Dairy breeds profile per agro-ecological zone

Breeds	**Foothills %**	**High lands %**	**Low lands %**	**Senqu RV %**	**X^2 value**	**Sig**
Ayrshire	0.0	6.1	1.8	0.0	42.707[a]	0.000
Brown Swiss	5.6	27.3	13.3	17.4		
Cross breed	13.0	21.2	17.8	17.4		
Friesian	37.0	21.2	32.9	17.4		
Indigenous	9.3	12.1	0.9	17.4		
Jersey	35.2	12.1	33.3	0.4		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.

Table 4. 2 Statistical summary of dairy farmer's experience in dairy production

Years in Production

AEZ	Mean (Years)	SD	Variance	SE Mean	Maximum
Foothills	7[a]	3.353	11.245	0.511	10
High lands	9[a]	2.678	7.170	0.558	10
Low lands	7[a]	3.489	12.174	0.272	17
Senqu RV	8[a]	2.870	8.235	0.676	10

a Means in the same column with different superscripts differ significantly ($p<0.05$).

4.2. AGE AT PUBERTY AND CONCEPTION RATE

The findings of this study revealed that dairy cows (36.8%) in three agro-ecological zones such as Low lands (63.6%), Foothills (17.4%), High lands (14.1%) reached puberty at the age of 12 months. However, in the Senqu RV (21.7%) dairy cows reached puberty at the age of 10 months. As illustrated in table 4.3, the age by which heifers reached puberty was significantly (p<0.05) higher in the Senqu RV than in the other. These findings showed that the chance of an enlarged age at puberty from Senqu RV, Highlands and Foothills to the Lowlands was significant (p<0.05).

The findings of Stephen *et al*. (2022) agreed with the present results by indicating that heifers that reached reproductive maturity early after birth also conceived first within the herd. In support of that, Estill (2021) provided that heifers that reached puberty at younger age had longer lifetime productivity overall while Steele *et al*. (2023) stated that heifers with desirable breeding value for prolificacy property or fertility traits could attain reproductive maturity faster and possessed a higher pregnancy rate than heifers with undesirable genetic merit.

Table 4. 3 Statistical summary of age at puberty (Months) in dairy cows

AEZ	Mean	SD	Variance	SE Mean	Maximum
Foothills	14[a]	2.825	7.978	0.384	24
High lands	13[a]	2.195	4.818	0.382	20
Low lands	14[a]	3.437	11.814	0.229	28
Senqu RV	17[b]	5.218	27.225	1.088	26

ab Means in the same column with different superscripts differ significantly ($p<0.05$).

Utilization of AI in the Foothills was significantly (p<0.05) different from bull, in contrast, use of a bull for mating in the Lowlands, Highlands and Senqu RV was significantly (p<0.05) different from AI (Table 4.4). In the event that both mating methods were used, the bull was engaged as repeat mating following conception failure when in the first service cows were bred with AI. The results were insignificantly different (p<0.05).

The findings of Washaya *et al*. (2019) in Zimbabwe disagreed with the current study in that cows were pregnant when AI (77.6%) was used compared with natural mating (56.79%) and as such, AI technology could be used to substitute natural service. In the same manner, Temesgen *et al*. (2022) stated that cows with shorter calving to insemination interval and bred with AI had a higher chance of conceiving than cows with longer calving to insemination interval and bred naturally using a bull. However, Tadesse *et al*. (2022) stipulated that in order to improve conception rate, regular and close monitoring of dairy cows were necessary and encouraged that farmers be equipped with estrus detection techniques and the inseminators perfected accuracy in AI timing. Additionally, Fesseha *et al*. (2020) outlined causes of conception failure in dairy cows as wrong timing of insemination, heat detection problem, unskilled technician, management problem, unhygienic condition and various diseases. Both, Bulcha *et al*. (2022); Goraga *et al*. (2019) in Ethiopia agreed with the current results in the utilization of indigenous bulls for breeding.

As illustrated in table 4.4, repeat mating in the Lowlands and Foothills was significantly (p<0.05) higher than in the Highlands and Senqu RV when dairy cows were bred with AI. However, in the case of a bull, repeat mating was significantly (p<0.05) higher in the Highlands and Senqu RV than in the Low lands and Foothills. These findings also revealed that conception rate was zero in both Highlands and Senqu RV in the event that dairy cows were mated with AI. However, there was a significant difference (p<0.05).

In accordance with Ali (2021), the possible causes of unsuccessful fertilization were primarily related to uterine inflammation, imbalanced nutrition, particularly very small minerals and vitamin A, age of the dam, heat observation failure and endocrinal impairment, oocyte quality, oocyte development and associated factors. The other cause included genetic, endocrine and poor breeding strategies. Additionally, Adeyeye *et al*. (2020) stated that the reproductive parameters were affected by poor management practice, calving season, return to estrus, dystocia, abortion, retained placenta and uterine prolapse. However, Wrzecińska *et al*. (2021) provided that production systems such as housing systems, stress could Again, environmental pollutants such as pesticides, toxic metals and feed contaminated with mould or fungi could cause infertility.

In relation with poor conception rate with AI, the report of Hamid *et al*. (2021) in Ethiopia indicated that wrong insemination timing was one of the essential considerations that were detrimental to AI efficacy in dairy cows. Moreover, Pascal *et al*. (2021) in Rwanda outlined overall outstanding AI service delivery challenges as follows: (1) Inconsistent and obstructions in liquid nitrogen provision and other AI utensils, (2) the high prevalence of uterine infections (metritis/endometritis), (3) bad herd management practices by the farmer and (4) conception failure. The other AI challenges according to Mathewos *et al*. (2023) in Ethiopia were absence of AI technicians and AI service interruptions during both regular working hours and weekends or holidays.

According to these results, dairy farmer's knowledge of estrus signs increased significantly ($p<0.05$) in the Foothills, Lowlands and Senqu RV from those who were poor to the excellent farmers but in the Highlands, such knowledge dropped significantly ($p<0.05$) to where majority of farmers knew that when cow was on heat mucus comes out of vulva only. A few farmers knew nothing about heat signs within the agro-ecological zones (Table 4.4). There was significant difference ($p<0.05$).

It is confirmed by Gorman (2021) that inaccurate estrus detection decreased conception rate and determined economic loss. Furthermore, the findings of Ríos-Mohar *et al*. (2022) highlighted that efficiency in estrus detection could be obtained through stuff capacitation as well as experience and by employing estrus synchronization programs using F2α prostaglandin (PGF2α). Again, Napolitano *et al*. (2020) expressed that devices or sensors have been established for automatic estrus detection and those involved pedometers and neck-mounted collars that recorded physical activity and pressure-sensing tools that registered standing estrus.

Table 4. 4 Comparison of natural mating (bull) and artificial insemination (AI)

Category	Foothills %	High lands %	Low lands %	Senqu RV %	X^2 value	Sig
Mating methods						
AI	51.9	6.1	38.2	0.0	41.384[a]	0.000
Bull	31.5	84.8	45.3	87.0		
Both	16.7	9.1	16.4	0.0		
Repeat mating						
Conceived (AI)	18.5	0.0	19.6	0.0	43.170	0.000
Repeat (AI)	44.4	15.2	34.2	8.7		
Conceived (Bull)	29.6	51.5	33.8	73.9		
Repeat (Bull)	7.4	33.3	12.4	17.4		
Estrus (Heat) signs						
Signs on the body	11.6	56.5	8.5	0.0	66.477[a]	0.000
Behavioural signs	39.5	34.8	20.0	44.4		
All signs	46.5	8.7	70.3	50.0		
Do not know the signs	2.3	0.0	1.2	5.6		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.

4.3. AGE AT FIRST CALVING

The current study demonstrated that dairy cows (72.2%) in Lesotho have calved at the age of two (2) years and the means differences in relation to age at first calving in years were statistically insignificant (p>0.05) (Table 4.5). The findings of this study agreed with Steele **(**2021); Kusaka *et al*. (2023) in that a range of AFC on dairy cows was 22 to 25 months generally. The report by Hutchison *et al*. (2017) also agreed with the present study results in that Holstein and Brown Swiss AFC was 21 to 22 months and 20 to 21 months for Jersey. Again, Steele, 2020; Van Eetveld *et al*. (2020) expressed that achieving a range of 22–25 months AFC could assist in increasing both consistent milk yield, fertility and longevity within the herd.

In addition, Andrew (2021) outlined the benefits of a lower first calving age as an increase in the litres of milk produced over time, increase in cow's lifespan and decrease in heifer's rearing costs. However, Kusaka *et al*. (2022) stated that despite the fact that a low AFC could enhance the profitability during the first lactation, it could also increase calving problems and compromised the subsequent reproductive performance if accompanied by low body weight (BW). The report by Turiello *et al*. (2020) also added that cows calving for the first time at the above-mentioned dates needed the smallest time from calving to fertilization and also played a significant role in replacement cost.

Table 4. 5 Age at first calving in different agro-ecological zones

AEZ	Mean (Years)	SD	Variance	SE Mean	Maximum
Low lands	2.5[a]	1.066	1.136	0.072	13
Foothills	2.4[a]	0.755	0.570	0.122	5
High lands	2.3[a]	0.679	0.462	0.131	4
Senqu RV	2.3[a]	0.541	0.292	0.113	4

a Means in the same column with different superscripts differ significantly (p<0.05).

4.4. CALVING INTERVAL

The findings of this study indicated that most of dairy cows in the Lowlands (45.4%), Foothills (37.5%) and Highlands (37.5%) were bred at 3 months post-partum whereas in the Senqu RV (33.3%) and (27.8%) were bred in 2 and 3 months respectively. Consequent to that, a range from 2 to 3 months was established and the majority of dairy farmers in Lesotho bred their cows within that range post-partum, Therefore, this range was recommended in order to keep calving interval within 12 months. Again, in the Lowlands (36.5%) and Foothills (67.5%) the calving interval was 14 months while in the Senqu RV (55.6%), it was 12 months. However, in the High lands (39.4%), calving interval was 15 months. The current results have established the calving interval range of 12 to 15 months and the provision was that at least a dairy cow bore a calf every year, meaning that it would complete each milk production cycle within a year. The means differences in both heat post-partum and calving interval were statistically insignificant (p>0.05) (Table 4.6).

The study of Temesgen *et al*. (2022) in Etheopia disagreed with these results in that optimal calving interval of 12–13 months for dairy herds. Cows having small calving to insemination interval and mated with AI had a better chance to be fertilized than cows with larger calving to insemination interval and cows mated with a bull. High milk producing cows were easily impregnated; however, management operations and mating activities seemed to be very critical for the circumstances assessed herein due to low herd yield. Again, the findings of Bigirwa *et al*. (2019) in Ethiopia emphasized that calving to conception interval could not exceed 80 to 85 days if a farmer was to realize a 12 months calving interval. However, Wang *at el*. (2024) concluded that a huge calving interval in dams resulted in heifers with large body weight and decreased milk production.

Table 4. 6 Statistical summary of heat post-partum and calving interval in different agro-ecological zones

AEZ	Mean	SD	Variance	SE Mean	Maximum
Heat post-partum (Months)					
Low lands	4.3[a]	2.675	7.155	0.217	16
Foothills	4.7[a]	3.619	13.097	0.572	17
High lands	4.1[a]	2.297	5.274	0.406	12
Senqu RV	3.5[a]	1.689	2.853	0.398	8
Calving interval (Months)					
Low lands	13.7[a]	1.846	3.406	0.123	21
Foothills	14.0[a]	1.421	2.019	0.193	20
High lands	13.8[a]	2.031	4.127	0.354	21
Senqu RV	13.5[a]	1.265	1.601	0.264	17

a Means in the same column with different superscripts differ significantly (p<0.05).

4.5. REPRODUCTIVE HEALTH AND RELATED PROBLEMS

The results of the current study revealed that the majority of dairy farmers have not encountered reproductive problems such as abortion, dystocia, retained placenta and anestrus within the agro-ecological zones. There were totally no abortion and anestrus in the Senqu RV and Highlands respectively. Therefore, the chances for the occurrence of reproductive problems were significantly (p<0.05) low within the agro-ecological zones as the majority of dairy cows calved successfully. However, with regard to those few incidences of reproductive peculiarities, the probability of having abortion and retained placenta from the Foothills, Lowlands and Senqu RV to the Highlands increased significantly (p<0.05). Thus, the occurrence of both abortion and retained placenta in the Highlands was 15.2% and 12.1% while dystocia and anestrus in the Lowlands and Senqu RV were 8.9% and 8.7% respectively. The problem of dystocia from Highlands to Foothills, Lowlands and Senqu RV was significant (p<0.05) (Figure 4.2). In general, there was no significant difference (p>0.05).

The findings of Keshavarzi *et al*. (2020) indicated that successive performance of dairy cows depended on the type of abortion and the stage of pregnancy when it occurred. Usually, farmers easily determined the direct losses that materialized subsequent to abortion which was nothing other than pregnancy. On top of that, Keshavarzi *et al*. (2017) associated the loss with overall reduction of conception rate. Again, the report by Sigdel *et al*. (2021) provided that abortion would also result in the retention of fetal membranes and the development of endometritis which had been detrimental to reproductive performance and high veterinary and labour costs.

In disagreement with the current findings, Gaafar *et al*. (2011) stated that the percentage of dystocia occurrences was significantly ($P < 0.05$) higher with twinning than single calving while not significantly affected by the sex of born calves. Incidence of dystocia had immense effects on reproductive performance and milk yield. As indicated by Zoca (2023), a cow that had complications during parturition often retained fetal membranes followed by pyometra and dystocia could be a silent villain because of its effect on post-partum anestrus. Based on the findings of Keshipour *et al*. (2024), training in calving and dystocia management could effectively decrease the number of days open in dairy cows. Significantly higher occurrence of dystocia in traditional farms has been more than industrial ones and cows that had dystocia had longer time in open days than those that were not hit by dystocia.

The findings of Gaafar *et al*. (2010) provided that year and season of calving, cow's weight, number of parity, sex, weight of calves at birth, type of birth and feeding system had clear effects on occurrences of retained placenta and it displayed unfavourable effects on reproductive performance and milk yield of Friesian cows. Additionally, Mahnani *et al*. (2021) explained that harmful consequences of retained placenta on the milk yield was greater in the cows at the first stage of lactation than the cows in mid or late lactation. Nonetheless, Gautam (2023) reported postpartum anestrus as one of the main causes of infertility in dairy cattle. Even though a limited time of estrus cycle was common shortly after calving, the continuing anestrus beyond 60 days postpartum in dairy cows had been detrimental on the calving to conception interval. Postpartum anestrus was associated with delayed commencement of ovarian cyclicity after birth.

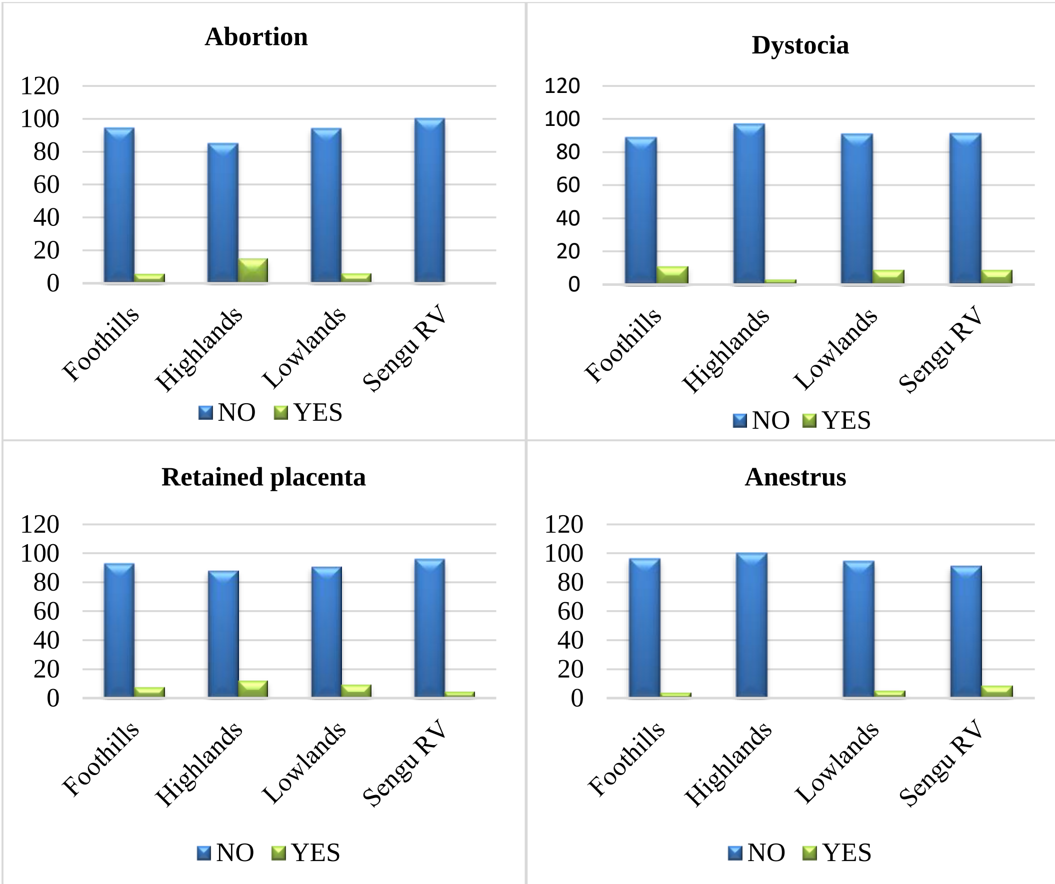

Figure 4. 2 Reproductive problems within the agro-ecological zones

4.5.1. Vaccination

As illustrated on table 4.3 below, the findings of the current study indicated that the majority of dairy farmers neither injected their cows before breeding nor provided treatment for uterine infections after calving. It was only in the Senqu RV where farmers did not provide treatment after the cow has given birth. However, in the event that injection was provided before breeding, there was a significant (p<0.05) increase from the Senqu RV, Foothills and Lowlands to the High lands with the last zone having 18.2%. The present results also demonstrated that dairy farmers in the Lowlands (15.6%) have treated their cows for uterine diseases after calving and commonly they used after birth pill. The incident showed a significant (p<0.05) increase from Foothills and Highlands to the Lowlands.

As reported by Gilbert (2016), after calving diseases were common in dairy cows and the incidences severely lessened fertility and induced risk of culling, making their prevention and management highly important. Furthermore, LeBlanc (2023) stated that postpartum uterine infections such as metritis and endometritis have been the main setback in extensive farming system at the moment and resulted in continuing economic losses. Therefore, the effective cure and prevention of uterine diseases in the peri- and post puerperal periods remained necessary. In the same way, Ghallab *et al*. (2023); Barański *et al*. (2022) recommended oxytetracycline for treatment of a wide range of microbes anaerobically on top of its effective action post-partum which has also made it appropriate for treatment of clinical endometritis by intrauterine infusion.

But Várhidi (2024) warned that the use of antibiotics as treatment was not enough, either due to their limited effectiveness or due to recent legislation aimed at cutting the use of antimicrobials and the other way opposite to antibiotics utilization was needed. By the way, Ingelheim (2020) showed that implementing a pre-breeding vaccination program could improve conception rate within a short time and cows could carry a healthy calf to term. In the same way, Wardynski, (2013) stated that the most appropriate time to vaccinate cows for reproductive infection was before breeding season if farmers really targeted to ensure that growing fetus was healthy. Hence cows would be well vaccinated and immunity optimized before breeding. As Maday (2018) stated, there was no 100 percent correct medication/vaccine and good management practices could not be substituted! Farmers were advised to maintain healthy animals around, treat and diagnose sick animals, vaccines given be recorded and up-dated recent problems within the herd.

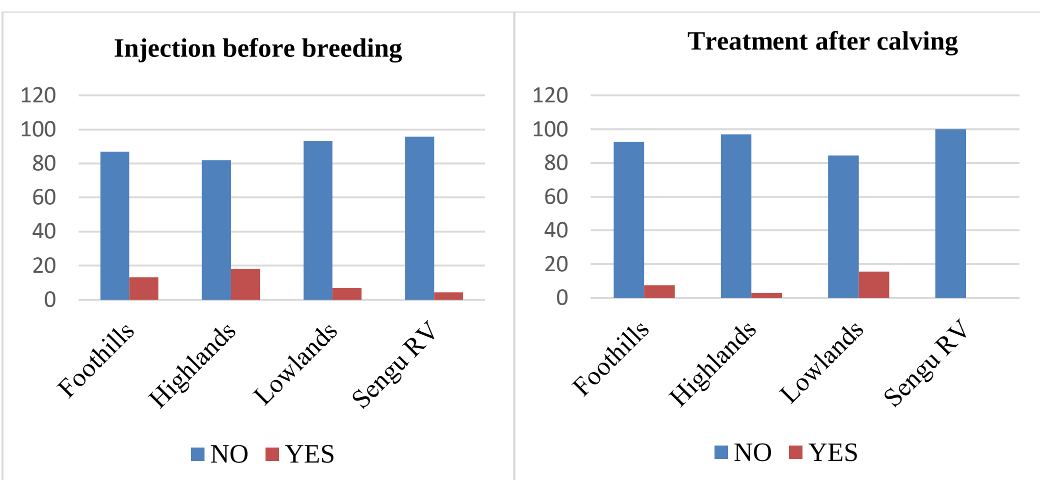

Figure 4. 3 Injections provided before breeding and treatment after calving

4.6. CONCENTRATES UTILIZATION IN FEEDING STRATEGIES

The findings of this study indicated that there were a handful farmers who could not formulate ration in different agro-ecological zones and that depicted a significant ($p<0.05$) increase from Foothills, Highlands and Lowlands to the Senqu RV (Figure 4.4). In agreement with these results, Kuleile *et al*. (2024) reported that majority of dairy farmers formulated ration even though they could not incorporate the recommended vitamin and mineral premixes in the mixtures, rather, they most of time used white salt as a source of mineral and vitamins. In support of that, Ibtisham *et al*. (2018) explained that minerals deficiency could alter the reproductive performance of the cows. Additionally, Brady *et al.* (2021) provided that nutrients balance could assist in the quick resolution of a range of physiological, endocrine and tissue remodeling processes required for good metabolic status and reproductive efficiency. The report by Karunanayaka *et al*. (2021) indicated that feeding Total Mixed Ration (TMR) to dairy cows was efficient and effective, especially improved production performances of dairy cattle in terms of milk production, milk composition, dry matter feed intake, feed utilization and reproductive performance. Therefore, Sundrum (2019) confirmed that this method ensured that each cow received a balanced diet in every bite.

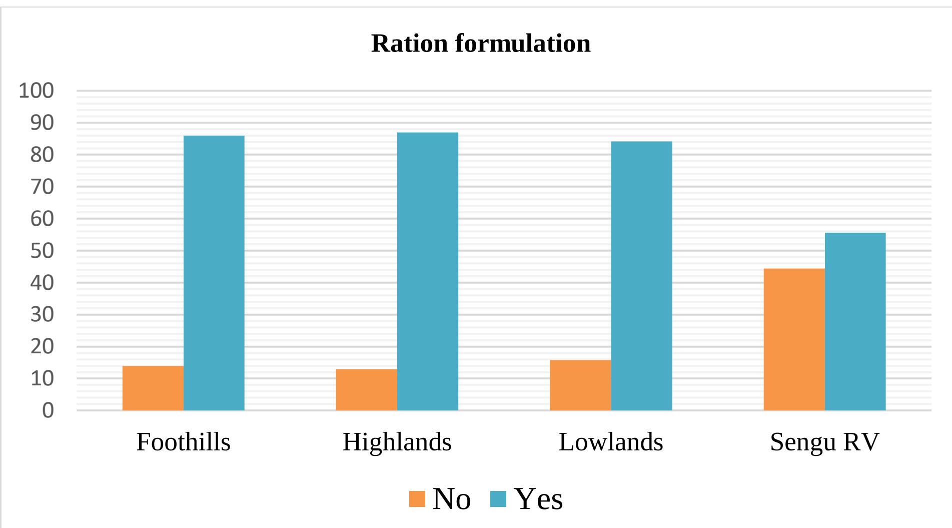

Figure 4. 4 Ration formulation in different agro-ecological zones

The findings of the present study have revealed that dairy farmers were feeding with concentrates such as energy concentrates, protein concentrates, bulky feeds and supplements in all agro-ecological zones. Even though maize appeared as the main source of energy in all agro-ecological zones, its usage in the Lowlands was significantly ($p<0.05$) lower than in the other agro-ecological zones and that could be relatively attributed to the accessibility of commercial feeds in the Lowlands. For instance, Hominy chop as a by-product feed was totally unavailable in the Highlands and Senqu RV but it was used in the Foothills (10.8%) and Lowlands (13.8%). Bran was also utilized at the rate of 50% in the Senqu RV than the other agro-ecological zones (Table 4.7). There was no significant difference ($p>0.05$).

According to Mekuriaw (2023), deficiency of dietary energy nutrients in early lactation and transition period was spontaneous for the high yielding dairy cows. The consequences of NEB on dairy cows were reduced milk yield, ill-looking and infertility; therefore, that reduced the value of dairy farming. Again, Sammad *et al.* (2022) provided that a balanced energy diet starting from 21 days was beneficial in successful perinatal transition of dairy cows. Precisely, Ali (2021) associated reduced conception rate or repeated breeding with imbalanced nutrition, particularly inadequate minerals and vitamin A supply.

Current results showed that generally the main source of protein was lucerne (58.6%) and its utilization increased significantly ($p<0.05$) in the Highlands than in the other agro-ecological zones. while Brewery by-product (18.7%) indicated a significant increase ($p<0.05$) in the Low lands (table 4.7). The results of this study suggested that various protein concentrates were consolidated in feeds mixtures by the farmers in different agro-ecological zones. As illustrated in table 4.7 below, even though grazing was a common practice by Lesotho dairy farmers, maize stalk was the primary bulky feed within the agro-ecological zones and that was associated with the fact that it was easily produced. There was a significant difference ($p<0.05$).

According to Gross (2022), feeding of cows with even high-quality herbage and on well-managed pastures could energetically support only milk production levels up to around 30 kg/day. However, Sethy *et al*. (2019) disagreed with the findings of this study in that feeding higher-fibre concentrates which enabled higher intake reduced milk yield compared to higher starch rations pasture feeding containing more fibre to the animals. But the other feed constituents such as protein and minerals were critical in a well-managed pasture. In agreement with the present results, Botha (2022) stipulated that natural pasture was more beneficial when managers do away with fertilizers but re-seeded properly in order to maintain the plant balance.

In his report, Gross (2022) outlined classical types of roughage used as feedstuffs in dairy cow nutrition include grazed such as pasture and rangeland, preserved forms such as silage, hay, besides crop residues and byproducts such as straw, hulls from soy and sunflowers. With regard to the use of maize stock, it was just a bulky feed like grass/pasture feeding without energy, protein and trace minerals required by dairy cows. In situations where farmers depended on such kind of feed source, supplementation was critical in order to cater for nutrients unavailable in maize stock. However, Kim *et al*. (2021) indicated that a balanced nutrition maintained normal ovarian cycles and enhanced reproductive performance during transition time and postpartum.

However, MacPherson *et al*. (2021) supported the use of silage as the current findings indicated by stating that substituting grass silage with lucerne silage in lactating cow feed indicated an increase in dry matter intake, milk yield and value. Addition of lucerne silage in the diet would decrease the need for purchased protein, especially where it was replacing whole-crop cereal or maize silage. Furthermore, Rangoma (2023) regarded lucerne as the only vital fodder crop that a dairy farmer should access. He also stated that under proper management yields could be more than 8 tons per acre. Given that on average a cow could feed about 15kg per day on top of the grasses to satisfy its nutritional requirements, an acre was enough to feed 2 cows for one year. This was a great saving as commercial feeds were expensive. In agreement with lucerne feeding, Yasabu, (2017) explained it as an important source of protein for animal fattening and milk production and could be mixed with other livestock feeds including those based on crop residues or hay.

Table 4. 7 Summary of the concentrates types utilized by dairy farmers

Feed source	Foothills %	High lands %	Low lands %	Senqu RV %	X^2value	Sig.
Energy concentrates						
Bran	32.4	42.1	39.9	50.0	5.760[a]	0.451
Maize	56.8	57.9	46.4	50.0		
Hominy chop	10.8	0.0	13.8	0.0		
Protein concentrates						
Lucerne	48.6	83.3	57.2	70.0	26.104[a]	0.010
Brewery by-product	13.5	0.0	23.9	0.0		
Layer excreta	5.4	11.1	0.7	10.0		
Soya	13.5	0.0	8.0	0.0		
Sunflower	18.9	5.6	10.1	20.0		
Bulky feed						
Grazing	16.3	17.4	14.5	1.6	19.547[a]	0.021
Hay	11.6	13.0	24.8	11.1		
Maize stalk	51.2	60.9	52.1	33.3		
Sorghum/ legume chaff	20.9	8.7	8.5	11.1		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.

As depicted in table 4.8 below, dairy meal was the significantly (p<0.05) utilized feed supplement particularly in the Lowlands (73.9%) while Sengu RV (38.9%) was the least. Furthermore, the great number of dairy farmers in the Senqu RV (61.1%) could entirely not provide supplementary feeding whereas the Lowlands (17%) had the least farmers. There was a significant difference (p<0.05). The findings of this study indicated that white salt was the most utilized mineral supplement within the agro-ecological zones followed by brown salt mix even though it indicated a significant (p>0.05) decrease in the foothills. However, utilization of mineral blocks showed a significant (p<0.05) increase from the Highlands, Lowlands and Senqu RV to the Foothills. The current findings also demonstrated that winter-lick usage was significantly (p<0.05) high in the Highlands and Lowlands than in the Foothills and Senqu RV. Generally, there was no significant difference (p>0.05).

The report by Bates *et al*. (2022) demonstrated that even though minerals were required in small quantities, copper and selenium were critical for triggering immune response pre-partum and trace mineral supplementation (TMS) would decrease the incidences of uterine infections. Lately, injecting with TMS having zinc, manganese, selenium, copper and chromium was correlated with calf illness and death over the first 140 days of life. Again, Jones (2022) stipulated that in beef and dairy herds, zinc and selenium deficiency were connected with retained placenta.

As illustrated in table 4.11, there was poor mineral balance in the feeding strategies of dairy farmers and Tufarelli *et al*., (2024) expressed that in order to prevent metabolic deficiencies such as ketosis and hypocalcemia in dairy cattle, diet therapy, appropriate feeding and anticipatory supplementation were necessary. Additionally, Ibtisham *et al*. (2018) explained that lack of minerals in diet had negative effect on dairy cow's reproductive performance. The findings of Rabiee *et al*. (2010) also demonstrated that organic minute mineral supplementation could increase production and reproduction in milking dairy cows. However, the publication of Kuleile *et al*. (2024) agreed with the results of this study in that dairy farmers in Lesotho were supplementing with white salt and expressed that supplementing with ordinary white salt was not enough when considering that a dairy cow requires 17 minerals and 3 vitamins. Therefore, the report associated high reproductive failures among dairy cows in Lesotho such an anoestrous, long calving interval and poor conception rates to mineral and vitamin deficiencies. White salts supplements in dairy cows only supplied only sodium and chlorine.

Table 4. 8 Statistical summary of feed and mineral supplements utilization

Feed source	Foothills %	High lands %	Low lands %	Senqu RV %	X^2 value	Sig.
Feed supplementary						
Dairy meal	60.5	69.6	73.9	38.9	20.865[a]	0.002
Grains/cereals	7.0	4.3	9.1	0.0		
No supplement	32.6	26.1	17.0	61.1		
Minerals used						
Brown salt mix	7.0	21.7	25.5	16.7	22.345[a]	0.099
Mineral blocks	18.6	8.7	8.5	5.6		
Molasses	4.7	4.3	6.1	0.0		
Premix	9.3	0.0	4.2	0.0		
White salt	51.2	47.8	38.8	72.2		
Winter lick	9.3	17.4	17.0	5.6		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.

4.7. MILK YIELD PER COW IN 300 DAYS

With regard to milk production, the findings of this study indicated that the majority of dairy cows in the Low lands (18.6%), Foothills (31.8%) and High lands (37.5%) were producing an average of 10 litres of milk per day except in the Senqu RV (63.6%) where production decreased significantly (p>0.05) to 5 litres of milk per day (Table 4.9). However, a range of 10-14 litres of milk was produced per day on average. The findings of the current study revealed that the litres of milk per day increased significantly (p<0.05) from both Senqu RV and High lands to the Foothills and low lands. Milk yield was evaluated on the basis of 300 days per lactation and an average milk yield was 3306.93 litres per cow. The mean differences were statistically significant (p<0.05).

The study conducted by Kuleile *et al*. (2024) agreed with these findings in that the average milk production was 13 litres per cow per day and Friesians cow's daily production was 17 litres per day on average. But cross breeds produced 10 litres per day while indigenous cow's yielded 2 litres per day (Tables 4.12 and 4.13). However, FAO (2020) findings in Ethiopia disagreed with the current study in that an average of 1.7 litres per cow per day over an average lactation period of 180 days. Likewise, Mungube *et al*. (2019) in Kenya's also disagreed with this study's results by publishing that 8-10 litres of milk per cow per day were produced and were below 12.7 litres per cow per day or roughly 4 590 litres per cow per milking time reported in South Africa. Similar approach of 300-day lactation length was used by Moran (2013) and he revealed that a cow peaking at 20 litres per day could produce 4000 litres per lactation while a peak of 30 litres per day was equal to a 6000 litres full lactation milk yield. Once more, Shija *et al*. (2022) standardized lactation milk yield to 305-days lactation period.

The present findings unveiled that dairy cows in the Low lands (18.9%), Foothills (43.2%) and High lands (31.3%) took 2 lactations (600 days in milk production) while those in the Senqu RV (17.4%) had 4 lactations. On average dairy cows took 3 lactations before they could be culled (Table 4.9). The current results also indicated that dairy cows in the Low lands (40.5%), Foothills (56.8%) and High lands (40.6%) took 7 months in lactation but in the Senqu RV 5(21.7%) they took 5 months in lactation. According to this study, dairy farmers especially in the Low lands were milking for 7 months and despite that, in the Senqu RV, farmers were taking 5 months lactation period.

As stated by De Vries (2020), dairy cattle productive lifespan averaged approximately 3 years after first calving and the major concern in dairy industry has been the length of time cows remain in the herd. The common average number of lactations for a dairy cow was 2.8. This said that dairy cows stayed in the herd for probably 60 months or a little over 5 years, in anticipation that age at first calving is 24 months and the calving interval is 13 months. In Canada for example, Dallago *et al*. (2024), the mean time that Holstein cows die spontaneously was 9.1 years. It resembled the efficient life of 6.8 years or about 6 lactations if an average age at first calving of 27 months was estimated. Additionally, van Knegsel *et al.* (2024) explained that even though extending the voluntary weighting period could improve health and fertility of high-producing dairy cows, increasing the milking period results in reduction of crucial calving events and herewith opening for the high risk of health constraints.

Table 4. 9 Statistical summary of milk production in four (4) agro-ecological zones

AEZ	Mean	SD	Variance	SE. Mean	Maximum
Litres per cow per day					
Foothills	15^{a}	7.555	57.071	1.028	30
High lands	10^{b}	5.848	34.195	1.018	27
Low lands	15^{a}	6.661	44.364	0.444	35
Senqu RV	9^{bc}	3.555	12.636	0.741	15
Milk yield per cow in 300 days					
Foothills	3711^{a}	2381.293	5670558.665	324.053	9800
High lands	2526^{b}	1504.353	2263077.016	265.934	7140
Low lands	3436^{a}	1795.405	3223478.361	119.961	9600
Senqu RV	2185^{b}	1808.311	3269988.439	377.059	7420
Months in lactation					
Low lands	7.37^{a}	1.981	3.923	0.134.	14
Foot hills	7.39^{a}	2.489	6.196	0.375	14
High lands	7.59^{a}	2.487	6.184	0.440	12
Senqu RV	6.17^{a}	2.657	7.059	0.554	15
Number of lactations per cow					
Low lands	3.82^{a}	2.563	6.496	0.172	14
Foot hills	3.70^{a}	2.707	7.329	0.408	12
High lands	3.06^{a}	1.831	3.351	0.324	8
Senqu RV	4.83^{a}	2.741	7.514	0.572	14

Abc Means in the same column with different superscripts differ significantly (p<0.05).

As illustrated in table 4.10 below, a Friesian cow was the highest milk producer per day in comparison with the other breeds in the Foothills and Lowlands. Friesian yield in the Highlands and Senqu RV was significantly (p<0.05) lower and the possibility of the increased production to the Low lands and Foothills was significant (p<0.05). However, milk yield of a Jersey cow per day was slightly higher than that of Friesian in the Senqu RV only whereas in the highlands cross breed produced more litres of milk per day than any other breed. A jersey yield was significantly (p<0.05) lower in the Highlands and the chance of increased milk to the Lowlands was significant (p<0.05). In addition, Cross breed milk yield was significantly (p<0.05) lower in both Foothills and Senqu RV and the probability of increased production to the Lowlands and Highlands was significant (p<0.05). There was no significant difference between the means for both Brown-Swiss and Indigenous breeds.

The current findings were supported by Opoola *et al*. (2019) in that cows' milk accounts for 80%, of which half was produced in Eastern Africa, followed by Central and Southern Africa while Western Africa produces the least amount of milk. Holstein-Friesian was the main exotic dairy breed used for milk production in Sub-Saharan Africa (SSA). However, Rantšo and Makhobotloane (2020) indicated that the volume of milk produced by farmers depended on factors such as the methods of feeding, the season and number of cows. For instance, one farmer who owned about 11 dairy cows, mainly the Friesland breed, could produce a maximum of 170 litres of milk per day.

Table 4. 10 Average daily milk production per breed per agro-ecological zone

AEZ	Friesian	Jersey	BrownSwiss	Cross Breed	Indigenous
Low lands	17.51^{a}	15.59^{a}	14.57^{a}	14.26^{a}	8.00^{a}
Foothills	21.35^{ab}	14.20^{ab}	11.00^{a}	9.00^{b}	7.00^{a}
High lands	10.50^{c}	10.75^{b}	13.44^{a}	14.00^{a}	8.00^{a}
Sengu RV	12.00^{c}	12.57^{ab}	10.75^{a}	9.25^{b}	7.50^{a}

abc Means in the same column with different superscripts differ significantly (p<0.05).

CHAPTER 5

5.1. CONCLUSION

On the basis of the current study results, it is concluded that:

(1) Dairy cow's reproductive performance is very efficient and also confirms that dairy cows in Lesotho are very fertile. This is drawn on the basis of the number of successive pregnancies and high conception rates.

(2) The major limiting factor on reproductive efficiency of dairy cows was the quantity and/or quality of feeds availability to the dairy cows.

(3) Dairy farmers who attempt to formulate rations at their own backyards lack knowledge and skills hence they produce rations without due consideration for animal requirements and such mixtures do not contain specific nutrient quantities and/or qualities.

(4) Despite the fact that dairy cows have shown the potential of being fertile, milk production was still below optimum and that has been attributed to different considerations like poor feeding strategies, insufficient knowledge of milking hygiene, engagement of indigenous bulls at the expense of using high quality semen for AI.

5.2. RECOMMENDATIONS

(1) In order to make sure that the breeding interval is reduced to at least 12 months, management techniques such as artificial insemination and estrus synchronization should be employed.

(2) Dairy farmers should also consider the idea of establishing the breeding season for dairy cows as that can elevate management and implementation of strategic planning will be somehow easier. In fact, all dairy farmers in Lesotho should start implementing similar approaches in key areas such as health, nutrition, breeding, etc.

(3) The policy on dairy production be clearly drafted so that some management aspects should be enforced.

(4) Milk collection centers should be constructed in every district and every farmer be encouraged by the policy to take milk to the milk collection centers in order to increase milk availability per year.

(5) Two to three dairy breeds should be chosen such as Friesian, Jersey together with Brown Swiss and dairy farmers be legislatively compelled to rear only these breeds.

(6) Dairy farmers be subsidized by the government so that they shall produce fodder for feeding the cows as that will reduce the cost of feeding and increase milk production.

CHAPTER 6

REFERENCES

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APPENDICES

Appendix 1: A questionnaire

Dairy farmers experience

1. Name of the farmer……………………………………………
2. District…………………………………Agro-ecological zone………………………….
3. How long have you been in dairy production? …………………..

Breeds and milk production

4. Which breeds are owned by the farmer?

Breed	Friesian	Jersey	BrownSwiss	Ayrshire	Guernsey	Crossbreed	Indigenous
Number							
Birth weight							
Weaning weight							
Number of lactations							
Months per lactation							
Number of litres per day							
Milk yield per lactation							

5. Which milking method do you use? Hand ☐ Machinery ☐
6. Do you have production record? Yes ☐ No ☐

Puberty and conception rate

7. What is age at puberty? One year ☐ Two years ☐
8. What mating method do you use? AI ☐ Bull ☐
9. If bull is used, give its breed name……………………………………….........
10. Have your cow experienced repeated mating? Yes ☐ No ☐
11. Have you ever used estrus synchronization? Yes ☐ No ☐
12. Have you ever had cows with anestrus condition? Yes ☐ No ☐
13. What do you use for estrus detection? Observation ☐ A device ☐
14. If the answer in "13" above is observation, what are the estrus signs?
    a) Behavioural signs such as restless, noise, mounting others, aggressiveness, etc
    b) Body reactions such as swollen and pinkish/red vulva, mucus discharge, ruffled hair, etc
    c) Mentioning all signs of estrus
    d) Knowing nothing about the estrus signs

Calving age and calving interval

15. What is the age at first calving? One year ☐ Two years ☐

16. What is the first heat post-partum? 1 month ☐ 2 months ☐ 3 months ☐

Prevalence of diseases and major problems

17. Which reproductive problem(s) have occurred in your farm from the list provided below?

a) Abortion ☐ b) Dystocia ☐ c) Retained placenta ☐ d) Stillborn ☐

18. Do you use herd health plan as a management tool? Yes ☐ No ☐

19. If yes, which diseases do you vaccinate for? …………………………………

20. Have you ever had reproductive disease? Yes ☐ No ☐

21. If yes, mention one or two? ....

22. How did you treat the disease? Traditional medic ☐ Injection by: Self ☐ or Vet ☐

23. Do you vaccinate cows before breeding? Yes ☐ No ☐

24. If yes, which diseases do you vaccinate against? ....…………………………………………

Types of concentrates utilized in feeding strategies

25. What feeding/production system do you use?

a) Intensive ☐ b) Semi-intensive ☐ c) Extensive ☐

26. Do you formulate ration? Yes ☐ No ☐

27. If yes, what nutrients do you use in the mix?

Nutrients used	Quantity

28. Give the concentrates used…………………………………

29. Do you use mineral supplements? Yes ☐ No ☐

30. If yes, Tick the one you use on the table below with (√).

Minerals	Common salt	Winter lick	Summer lick	Molasses	Premix	Calcium	Others
Choice							

Appendix 2: Reproductive problems in four agro-ecological zones.

Category	Foothills %	High lands %	Low lands %	Senqu RV %	X^2 Value	Sig.
Abortion						
No	94.4	84.8	94.2	100.0	6.109[a]	0.106
Yes	5.6	15.2	5.8	0.0		
Retained placenta						
No	92.6	87.9	90.7	95.7	1.203[a]	0.752
Yes	7.4	12.1	9.3	4.3		
Anestrus						
No	96.3	100.0	94.7	91.3	2.722[a]	0.436
Yes	3.7	0.0	5.3	8.7		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.

Appendix 3: Summary of injections provided before breeding and treatment after calving

Category	Foothills %	High lands %	Low lands %	Senqu RV %	X2 value	Sig.
Injection before breeding						
No	87.0	81.8	93.3	95.7	6.720[a]	0.081
Yes	13.0	18.2	6.7	4.3		
Treatment after calving						
No	92.6	97.0	84.4	100.0	9.462[a]	0.024
Yes	7.4	3.0	15.6	0.0		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.

Appendix 4: Dairy farmers who formulate rations in different agro-ecological zones.

Category	Foothills %	High lands %	Low lands %	Senqu RV %	X2 value	Sig.
No	14.0	13.0	15.8	44.4	10.187[a]	0.17
Yes	86.0	87.0	84.2	55.6		

Significance level (0.05). X^2 = chi square. Sig = significance value. RV = Senqu River Valley.