Dairy farmworkers' knowledge of risk factors and prevalence of bovine lameness in Kwa-Zulu Natal Province, South Africa

BY

SIBULELE MATSHETSHENI

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Department of Livestock and Pasture Science
Faculty of Science and Agriculture
University of Fort Hare
P/Bag X1314
Alice
5700
South Africa

University of Fort Hare
Together in Excellence

Supervisor: PROF. I.F. JAJA

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Declaration

I, Sibulele Matshetsheni, confirm that the aforementioned work is original and has not previously been published or produced for degree program requirements. This thesis acknowledges and lists any cited literature or works by others in its bibliographical section.

Sibulele Matshetsheni Date... 20 November 2024

Approved as to the style and content by:

Prof. I. F. Jaja Date... 20 November 2024

University of Fort Hare
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Abstract

Lameness is a crippling problem in the dairy industry, posing a significant welfare challenge and leading to premature culling. Lameness has been identified as the most severe welfare issue in dairy cows, and its observation is the most representative animal-based indicator of dairy cattle well-being. This study assessed the knowledge of dairy farmworkers regarding causes, risk factors, and clinical signs of bovine lameness in Kwa-Zulu Natal Province, South Africa and the seasonal prevalence of lameness in two different provinces of South Africa. The data was collected from 11 dairy farms using a questionnaire. The questionnaire was divided into five sections, the first of which contained demographic information (age, gender, experience, level of study), and the second contained farm information such as farm size and grazing method. However, section C discusses farm workers' knowledge of lameness and risk factors, Section D discusses clinical signs of lameness, and Section E discusses treatment and management of lameness. The data was collected in two local municipalities (Mpofana and Raymond Mhlaba). However, the computer software systems of four randomly selected dairy farms were used to collect retrospective secondary data for lameness and predisposing factors (2018–2022). The data's targeted parameters include breed, parity, weight, stage of lactation, diseases diagnosed (lameness), age, and milk production trends.

Significant seasonal variation in the incidence of lameness ($P < 0.05$) was observed with the highest prevalence (85.5%) occurring in summer compared with other seasons such as Autumn (15%). Respondents reported that a decrease in appetite (93%), reduced milk yield (94%), and increased lying time (90%) were the most common signs of lameness. Nevertheless, the results also demonstrated a significant ($P < 0.05$) correlation between knowledge of clinical signs of lameness and localities. The movement problem was related to age, gender, and occupation level ($P < 0.05$). The uMpofana municipality (KZN 58.8%) had higher prevalence compared to Raymond Mhlaba municipality (EC 41.2%). Cattle above nine years of age has the highest prevalence of lameness (36%), compared to 7-8-year-old (24%), 4-6-year-old (21.7%), and 1-3-year-old (14.3%) cattle. Additionally, the highest prevalence of lameness was observed during the summer season, followed by spring, winter, and Autumn. The strongest association is kept for the right front leg (RFL) ($p < 0.0001$), followed by the left front leg (LFL) ($p < 0.001$), right back leg (RBL) ($p < 0.001$), and left back leg (LBL) ($p < 0.001$). In conclusion, this study provides baseline information on several key factors influencing the prevalence of lameness in dairy cattle in various farms in uMpofana municipality (KZN) and Raymond Mhlaba municipality (EC). Furthermore, training is required in the dairy industry to improve farm workers' knowledge. In addition, farm workers' training and retraining are necessary for managing and mitigating bovine lameness. These findings could be used for farm managerial decision-making and epidemiological interventions.

Keywords: Season, milk yield, lameness, breed, parity, foot rot, knowledge, reduced milk yield, increased lying time.

Dedication

I dedicate this work to my son and family.

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List of Abbreviation

BCS	Body Condition Score
KZN	Kwa-Zulu Natal
WLD	White Line Disease
TSTU	Thin Sole-Induced Toe Ulcers
SU	Sole Ulcers
HU	Heel Ulcers
TU	Toe Ulcers
SP	Sole Punctures
ECP	Eastern Cape Province
DIM	Days in Milk
SCC	Somatic Cell Count
SPSS	Statistical Package for Social Sciences
DD	Digital Dermatitis
RMLM	Raymond Mhlaba Municipality
MM	uMpofana Municipality

CHAPTER 1

1.0 Introduction

1.1 Brief Background

The impact of the world's rapidly growing population on natural resources, particularly food security, has been well documented (Gorden and Plummer, 2010). The current South African human population is approximately 60.5 million (Statistics South Africa (Stats SA), 2021). However, it is expected to increase to 72.8 million people by 2050, as an example of the growth expected in Africa (Makgahlela *et al*., 2007). This growing population will increase nutritional demand, particularly for animal protein, and meeting this demand will impose additional burdens on livestock producers. South Africa has nearly 14 million cattle, with 1.6 million dairy (604,781 cows in milk) and 12.5 million beef cattle. Approximately 53% of the latter are in commercial systems, and the remaining 47% are in informal systems (Yawa *et al*., 2020).

The dairy industry is vital sector of livestock production in Africa since milk is the most commonly used protein (Bryden, 2012). The dairy industry is expected to grow by 26% by 2027, with the maize production industry expected to play a vital role in the growth of the dairy industry (Vercruysse *et al*., 2018). This is mainly attributed to the significant increase in maize yields and lower feed costs. However, the dairy industry has shortcomings and challenges that are largely external to the dairy cows. These include economic pressure – high demand for dairy products, climate change, and technological innovations (Thornton *et al.,* 2007). Dairy herd productivity in both large and small-scale farming systems is generally low. Among the leading causes of low herd productivity in the dairy industry are conditions such as lameness (Ózsvári, 2017a; Nyirenda *et al*., 2019; Medina-González *et al*., 2022a). Lameness, however, is regarded as one of the internal challenges the dairy industry faces worldwide.

Lameness is a common clinical condition that causes movement problems in dairy cows worldwide, thus decreasing appetite and milk production. It affects food availability and the global economy. The global population of dairy cows is estimated at one billion, producing 522 million metric tons of milk per year (Visser *et al*., 2020). The health of dairy cows significantly impacts the profitability of dairy farms worldwide, and lameness is regarded as one of the most crucial dairy cattle diseases (Sheferaw *et al.,* 2021). Lameness is a crippling problem in the dairy industry, posing a significant welfare challenge (Salfer *et al*., 2018a; Jewell *et al*., 2019a; Kang *et al*., 2020). These authors have recommended that understanding the risk factors and identifying associations between potential risk factors and lameness are critical for laying the groundwork for future intervention research. Increased time away from the pen, decreased cow comfort, tie-stall brisket boards, and no routine trimming were all risk factors for free-stall-housed cows. In addition, large herd sizes, slippery flooring, reduced lying surface comfort and low Body Condition Score (BCS), and the presence of hock injuries and overgrown claws are significant causes of lameness in dairy cattle (Opio *et al*., 2021a; Browne *et al*., 2022). Feed rail, alley design, and water trough design are additional risk factors for cows with no pasture access.

Various studies have reported lameness as the third leading cause of economic loss for dairy farmers, behind infertility and mastitis (van der Linde *et al*., 2010; Buch *et al*., 2011; Bruijnis *et al.*, 2013a; Langova *et al.*, 2020). Direct losses from lameness include increased culling rates, decreased reproductive performance, increased open days, and an increased risk of mastitis (Akpabio, 2015). Other researchers have reported that lame cows produced 1.12 L to 3.1 L less milk per day than ordinary healthy cows and took 12 days longer to get pregnant than non-lame counterparts, and these resulted in 1.7% involuntary herd culling (Davis-Unger *et al.*, 2019). Evidence of productivity loss due to lameness, such as premature culling, treatment costs, and milk loss, is necessary to persuade a skeptic farmer to consider changing the environment (Vargas-Bello-Pérez *et al.*, 2017; Silva *et al.*, 2021).

In dairy cows, lameness can vary significantly in severity and can arise weeks, or even months, after a metabolic disorder, making the detection of causality complex (Sheferaw *et al.*, 2021b). Lameness is a multifactorial disease. Infectious agents (e.g., foot rot), laminitis, conformational or other lesions (e.g., corkscrew claw, leg injury), and claw lesions such as white line disease (WLD), thin sole-induced toe ulcers (TSTU), sole ulcers (SU), heel ulcers (HU), toe ulcers (TU), sole punctures (SP), and thin soles are all primary causes (TS) (Sanders *et al.*, 2009a). Diet, high milk production, and poor body condition are risk factors for cows' lameness (Sanders *et al.*, 2009a). The prevalence of lameness is also affected by environmental factors such as housing type, stall surface, and season (Salfer *et al.*, 2018b; Rashad *et al.*, 2022a). Few studies have been conducted to determine the prevalence and risk factors associated with claw lesion-specific causes of lameness (Refaai *et al.*, 2013a; Ózsvári, 2017b; Wilson *et al.*, 2021). In a nutshell, lameness causes many problems in the dairy industry, for example, loss in economy, infertility, loss in productivity, BCS, and lastly lead to culling and morbidity (Sepúlveda-Varas *et al.*, 2018a).

Lameness has now become a major production disease in livestock farming as a result of several converging factors, affecting many terrestrial farmed animal species (Bruijnis *et al.*, 2013b; Supakorn *et al.*, 2018a; Wensman *et al.*, 2022). If left untreated, lameness can seriously damage an animal's health and welfare, even leading to the animal's premature culling or death (Refaai *et al.*, 2013a; Ózsvári, 2017b; Wilson *et al.*, 2021).

1.2 Problem statement

Lameness is ranked as the third most important cause of economic losses on dairy farms, after mastitis and reproduction disorders (Sepúlveda-Varas et al., 2018a; Medina-González et al., 2022b). Lame cows are more frequently affected by mastitis, metabolic disorders, and reduced fertility (Barker *et al.*, 2018a; Antanaitis *et al.*, 2021a). Lameness directly impacts farmers' income because it impairs productive performance and can significantly reduce animal longevity (Supakorn *et al.*, 2018a). In many cases, the therapeutic use of antibiotics for lameness compromises milk quality, leading to antibiotic residue in milk. On the other hand, the milking of dairy cows could be suspended following the application of antibiotics (Nalon and Stevenson, 2019a). The presence of antibiotics could lead to a reduction in milk yield because cows injected with antibiotics must wait for a withdrawal period. During this withdrawal, substantial financial resources and dairy products are lost, directly affecting the availability of protein (dairy) food resources. In most cases, cows with severe lameness are led to being culled because they cannot reproduce again even if their weight and body condition score drop due to the pain (Derso *et al.*, 2015; Wilson *et al.*, 2021). In South Africa, there is insufficient information about the risk factors for bovine lameness, its seasonal prevalence, and the effect on the body condition (BCS) of dairy animals, particularly at the communal level, even though most dairy farmer faces economic losses due to reduced milk production and treatment costs for lameness. Thus, in Kwa-Zulu Natal Province, South Africa, this study aimed to investigate dairy farmworkers' knowledge of risk factors and the prevalence of bovine lameness.

1.3 Justification

A careful investigation of the dairy production constraints for commercial and small-scale farmers would aid in developing a viable production plan to improve the country's dairy industry (Yigrem *et al.*, 2008a). Dairy products have been identified as animal-sourced foods with the potential to address the global challenge of childhood undernutrition, so research into the production challenges faced by dairy farms is necessary. With global dairy production and distribution expected to be 26% higher within a decade, dairy production constraints and their prevalence must be identified to realize the 26% growth that developing countries like South Africa will ignite. Milk demand is expected to increase by 1.9% simultaneously (Stott and Gourley, 2016a).

There is a need for research on the risk factors of bovine lameness, its seasonal prevalence, and its effect on the body condition score of dairy cattle. Mainly because the previously documented studies focused on the risk factors of lameness, there is a limited investigation of risk factors of bovine lameness and its seasonal prevalence and effect on BCS of dairy cattle (Sepúlveda-Varas *et al.*, 2018a). Thus, this study seeks to address the research gap to determine the impact of bovine lameness on the BSC of dairy and the risk factors caused by bovine lameness. In South Africa, there is insufficient information about the risk factors for bovine lameness, its seasonal prevalence, and the effect on the body condition (BCS) of dairy animals, particularly at the communal level, even though any dairy farmer faces economic losses due to reduced milk production and treatment costs for lameness

1.4 Objectives

The main objective is to investigate the risk factors of bovine lameness, its seasonal prevalence, and its effect on the body condition score of dairy cattle in Mooi River, South Africa.

1.4.1 Specific objectives

- Dairy farm workers' knowledge of causes, risk factors, and clinical signs of bovine lameness in Kwa-Zulu Natal Province, South Africa.

- ❖ Retrospective analysis of prevalence and risk factors of bovine lameness in dairy farms in uMpofana municipality Kwa-Zulu Natal and Raymond Mhlaba municipality Eastern Cape Province, South Africa.

1.5 Hypothesis

H_O: Dairy farm workers are knowledgeable about the risk factors of bovine lameness.

H_O: Retrospective prevalence and risk factors of bovine lameness in dairy farms in uMpofana municipality Kwa-Zulu Natal and Raymond Mhlaba municipality Eastern Cape Province, South Africa did not differ significantly between 2018 and 2022.

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CHAPTER 2

2.0 literature review

2.1 Introduction

The global population's influence on natural resources, mostly food security, has been properly documented. (Charlier *et al.*, 2014). South Africa’s population is estimated to be around 60.7 million (Stats SA, 2021) and is projected to increase from 60.7 to 72.9 million people by 2050, an illustration of the development expected in Africa (Makgahlela *et al.*, 2007). This growing population will increase food demand, particularly for animal protein, and this will make additional problems for farm producers. South Africa has nearly 14 million cattle, with 1.8 million dairy and 12.2 million beef cattle. Approximately 53% of the cattle are in the commercial systems, while the other 47% are in the semi and extensive system (Visser *et al.*, 2020). However, the dairy industry's growing concern is to improve dairy cattle welfare in anticipation of consumer demand for welfare-certified dairy products (Van Nuffel *et al.*, 2015; Charfeddine and Pérez-Cabal, 2017; Nalon and Stevenson, 2019; Villa-Mancera and Reynoso-Palomar, 2019). In dairy farming, lameness has an important welfare and economic impact. It is a condition that causes pain, discomfort, and decreased mobility in cows, leading to decreased milk yield, lower fertility, and an increased risk of culling (Christodoulopoulos, 2009; Stott and Gourley, 2016; Wensman *et al.*, 2022a).

A critical disease affecting dairy cows' well-being and growth is lameness. (Sepúlveda-Varas *et al.*, 2018; Diniso and Jaja, 2021). Moreover, lameness is regarded as the major factor affecting dairy cow production, because the reduced feed intake of the affected animals will automatically reduce milk production. Mild lameness causes discomfort in dairy cows, while major lameness can seriously impair reproduction performance and elevate the chances of a dairy cow being infertile and being culled. (Randall *et al.*, 2015). Economic losses and concerns about animal welfare should motivate farmers and the dairy industry to prioritize prevention over the treatment (Refaai *et al.*, 2013; Wynands *et al.*, 2021). Lameness leads to economic loss due to the antibiotics that need to be bought while treating them. As a result, national strategies should be in place to monitor lameness, locomotion, routine hoof trimming, and provide comfortable and sanitary housing. Prevention programs must be designed to address both infectious and non-infectious lameness (Akpabio, 2015).

Recent research has found that certain animal-based welfare measures are linked to lameness, including leg hygiene, hock condition, and body condition (Sadiq *et al.*, 2021). Infectious diseases like foot fungus and digital dermatitis, as well as non-infectious causes a white line disease, injuries, and sole ulcers, can cause lameness in bovine (Refaai *et al.*, 2013; Sepúlveda-Varas *et al.*, 2018; Davis-Unger *et al.*, 2019; Nwankwo *et al.*, 2020). Furthermore, lameness decreases farm income and production (Hernandez *et al.*, 2001; Whay, 2002; Koenig *et al.*, 2005; Dairy, 2007; Langova *et al.*, 2020). It is also regarded as the most serious factor that affects the welfare, well-being, and productivity of cattle in dairy (Ózsvári, 2017; Gelasakis *et al.*, 2019a). Lameness clinically can manifest as a wide range of diseases, with 43 causes & over 80 potential hazards in some countries. Causes of lameness are season, age, parity, breed, milk yield, nutrition, herd size, etc. Also, it results from interactions between the animal and its surroundings, the farm system and management in place, and the animal's breeding characteristics. All of the above are potential factors that cause lameness in dairy farms (Ózsvári, 2017)

2.2 Etiology of lameness

Foot lesions cause the majority of lameness (Warnick *et al.*, 2001; Cramer *et al.*, 2008; Bruijnis *et al.*, 2013; Gelasakis *et al.*, 2019a; Antanaitis *et al.*, 2021; Wensman *et al.*, 2022b). Other limb disorders account for only 15% of all cases (Stott and Gourley, 2016). However, the foot lesion is mainly caused by laminitis; The lesion makes the hoof swollen, leading to abscess formation (Sanders *et al.*, 2009a). Furthermore, housing conditions, feeding, nutrition, environmental factors, and management practices may all be related to lameness (Griffiths *et al.*, 2018; Sheferaw *et al.*, 2021). The hoof disorder is often linked to chronic subclinical laminitis, digital dermatitis, and foot rot; it is believed that this disorder is primarily responsible for bovine lameness (Sadiq *et al.*, 2017a; Supakorn *et al.*, 2018; Gelasakis *et al.*, 2019a; Nalon and Stevenson, 2019; Wensman *et al.*, 2022a). Nevertheless, various infectious agents, such as bacteria, viruses, and fungi, can also be linked to cattle lameness (Nyirenda *et al.*, 2019). Lameness is often classified into infectious and non-infectious (Medina-González *et al.*, 2022).

2.2.1 Infectious causes of lameness

The source of the infection could be fungal, viral, or bacterial. (Gelasakis *et al.*, 2019b). Foot rot and septic arthritis are the most common bacterial diseases that cause lameness. However, it is regarded as the causal effect of infectious disease in feedlots and pastures. The bacteria *Fusobacterium necrophorum* typically causes foot rot, but other bacteria, such as *Dichelobacter nodosus*, *Trueperella pyogenes*, and *Arcanobacterium pyogenes* can also be involved (Kaler and Green, 2009; Gelasakis *et al.*, 2019a). These bacterial species are all common in soil and animal manure. Rather than the hoof itself, this infection affects the area between the toes (Refaai *et al.*, 2013; Anyanwu *et al.*, 2021). When these bacteria breach the skin's protective barrier as a result of constant wet conditions or abrasions, they cause a painful, necrotic infection between the toes (Newcomer and Chamorro, 2016).

2.2.2 Non-infectious causes of lameness

Poor living conditions, poor nutrition, such as hypovitaminosis, or other metabolic diseases, such as ketosis or hypoglycaemia, are some of non-infectious causes (Newcomer and Chamorro, 2016; Sadiq *et al.*, 2021). Lameness caused by subclinical ketosis is frequently not noticed until late in lactation (Daros *et al.*, 2020). However, the linked metabolic conditions serve as an initial catalyst during the transition period. Dairy breeds with clinical lameness at 71 days in milk have a 26% lower chance of conceiving than non-lame breeds. Excess body condition score (BCS) loss has similarly been associated with decreases in the digital cushion and a decrease in the fat pad (Sepúlveda-Varas *et al.*, 2018; Opio *et al.*, 2021). These lessen the soft tissue's ability to cushion impacts, which makes some cows more vulnerable to floor abrasion and the development of diseases like white line and sole (Thornton *et al.*, 2007; Weber *et al.*, 2013; Matson *et al.*, 2022). Cows in the sub-clinical ketosis state risk range are several times more likely to develop lameness than cows below the threshold level (Van Os *et al.*, 2019).

Environmental and genetic factors often cause lameness. Variation in foot diseases due to environmental factors can be further influenced by management practices and housing conditions (Jewell *et al.*, 2019). However, some studies have identified a genetic component influencing this trait (Buch *et al.*, 2011; Sepúlveda-Varas *et al.*, 2018; Silva *et al.*, 2021; Rashad *et al.*, 2022). Consequently, claw health can be improved not only by addressing environmental factors but also through selective breeding. For successful indirect selection, there must be a strong genetic link between the indicator trait and claw health, and the trait must be heritable (Sanders *et al.*, 2009a; Sepúlveda-Varas *et al.*, 2018; Davis-Unger *et al.*, 2019). Research has shown that 27% of foot problems in animals are associated with hygiene (Sheferaw *et al.*, 2021). Additionally, lameness is more common in barns with high relative humidity.

2.3 Diagnosis of lameness

In cows, locomotion scoring was previously used to evaluate the presence and severity of lameness. (Randall *et al.*, 2015). Movement-in-motion scoring has been done both manually and through video surveillance. Manual movement scoring has grown in popularity in recent years as a method of detecting lame cows on farms due to its simplicity, low cost, and non-invasive nature (Foditsch *et al.*, 2016; Salfer *et al.*, 2018). Lameness is perceived by visually assessing a cow's movement score (Browne *et al.*, 2022a). Moreover, the locomotion scoring can be used to measure the prevalence. While they walk through access lanes, entire herds can be easily scored (Somers *et al.*, 2005; Amory *et al.*, 2008; Elliott *et al.*, 2015; Sadiq *et al.*, 2017b; Wensman *et al.*, 2022b). Although the visual locomotion scoring system is dependent on time and can be time-consuming, it tends to be more affordable and easier to use as a standalone technology for detecting lameness compared to pedometers or more advanced accelerometers (Kang *et al.*, 2020). As a result, determining the presence of the swelling may serve as the initial phase in the diagnostic procedure for the layperson (Salfer *et al.*, 2018). Because the foot capsule is rigid and incapable of important expansion, lay personnel should be instructed to look for swelling in the tissues immediately proximal to the coronet (Van Os *et al.*, 2019). In most cases, lame animals must be moved, if probable, from areas of deep grass or mud onto a packed surface to aid in detecting foot swelling (Kang *et al.*, 2020).

2.4 Knowledge of dairy farmworkers regarding lameness risk factors

The role of dairy farmworkers in preventing and managing lameness is pivotal. Farmworkers who are knowledgeable about the causes and early signs of lameness can significantly reduce the prevalence of the condition through early intervention and appropriate management strategies. Formal education and training in animal health and welfare increase the likelihood that workers will recognize the signs of lameness and take timely corrective actions. A study showed that farmworkers with higher levels of formal education in animal health were better at detecting lameness early and implementing effective treatment protocols (Wilson *et al.*, 2021).

However, dairy farmworkers in many developing countries, including South Africa, often lack access to formal training. It was reported that farmworkers in rural areas, particularly in small-scale operations, have a limited understanding of hoof care and lameness prevention strategies (Jewell *et al.*, 2019). This knowledge gap leads to delayed diagnosis and ineffective treatment, which ultimately exacerbates the condition and increases the risk of severe outcomes for the animals.

2.5 Risk factors for the occurrence of lameness

Several research investigations have been conducted worldwide on risk factors for the existence of lameness (Maciej Serda *et al.*, 2013; Randall *et al.*, 2015; Beaver *et al.*, 2021; Medina-González *et al.*, 2022; Wensman *et al.*, 2022a). Most studies agreed that lameness is associated with various risk factors such as reproduction, floor type, parity, season, body condition, milk yield, breed, herd size, long hoof, (Khan *et al.*, 2009; Pritchard *et al.*, 2013; Refaai *et al.*, 2013; Solano *et al.*, 2015; Cook *et al.*, 2016; Wensman *et al.*, 2022b).

2.5.1 Age

Many studies report that lameness cases increases with increasing cow's age (Randall *et al.*, 2015). Culling practices influence the occurrence of lameness and its association with parity, but the increasing prevalence with age is not(Booth *et al.*, 2004; Sogstad *et al.*, 2005; Sanders *et al.*, 2009b; Pérez-Cabal and Alenda, 2014; Gelasakis *et al.*, 2019b). However, the more the age of the cow, the higher the chances of it being affected by lameness, and it is hard for the cow to recover again. Scarring of the corium regularly may result in irreversible damage. Other researchers have initiated that primiparous cows have the highest risk of sole haemorrhage (Sanders *et al.*, 2009a; Sepúlveda-Varas *et al.*, 2018). Nevertheless, some of the cows are at great risk due to poorer development of the digital cushion and having to adapt to the milking herd's increasing standing times as a low-dominance animal.

2. 5.2 Parity

In most cases, cows were more likely to become lame than primiparous cattle (Randall *et al.*, 2015). Lameness during the dry season was more common in primiparous cattle with a body condition score (BCS) of 3.0 to 3.5 (Jewell *et al.*, 2019). Additionally, the prevalence of lameness increased with parity. Cows in parities 3, 4, and 5 were 1.6, 3.3, and 4 times more likely to be lame, respectively, compared to cows in their first parity (Sanders *et al.*, 2009a; Randall *et al.*, 2015; Sadiq *et al.*, 2021). The most common factor associated with lameness was stall width relative to cow size and parity (Sadiq *et al.*, 2017a). Many farms permit daily exercise on pasture or in an exercise yard, but some do not (Espejo *et al.*, 2006; Jewell *et al.*, 2019). As a result, the design of a stall width can influence whether or not a cow is lame, injured, or dirty. However, lameness, injury, and mastitis are all painful conditions associated with management and stall width design (Buch *et al.*, 2011; Sepúlveda-Varas *et al.*, 2018; Silva *et al.*, 2021; Rashad *et al.*, 2022). These conditions reduce dairy cattle welfare and increase the likelihood of premature culling, lost production, and negative public attitudes toward the dairy industry (Pritchard *et al.*, 2013; Refaai *et al.*, 2013; Diniso and Jaja, 2021). The incidence of lameness varied by parity group: parity 1 accounted for 10.3% (of 1,224 cows), parity 2 for 24.5% (of 1,010 cows), and parity 3 for 34.0% (of 1,389 cows) (Sanders *et al.*, 2009a; Hund *et al.*, 2019). One study of dairy farms in southern Ethiopia reported an increase in lameness prevalence with increasing parity (Sheferaw *et al.*, 2021).

2.5.3 Season

Lameness incidence in cows rises during months of heavy rainfall and high ambient humidity (Refaai *et al.*, 2013). Summer had the highest mean prevalence of lameness, followed by winter, autumn, and spring. The mean prevalence during the summer and winter seasons was 18.6% and 25.0%, respectively (Foditsch *et al.*, 2016; Davis-Unger *et al.*, 2019; Diniso and Jaja, 2021). However, the likelihood of lameness increased as the average daily rainfall increased. Summer was the most common season for all lameness conditions studied (Sanders *et al.*, 2009a; Sepúlveda-Varas *et al.*, 2018; Davis-Unger *et al.*, 2019). The wet conditions created by cow-cooling systems and humidity are most likely the most important cause of seasonality, though other effects of heat stress may also play a role. Wet weather has been shown to increase the occurrence of lameness (Jewell *et al.*, 2019). In comparison to the earlier finding, others identified the dry period as a high-risk period for lameness development (Medina-González *et al.*, 2022). However, in other related studies, there was no statistically significant difference in the prevalence of lameness and claw disorders between winter and summer (Sanders *et al.*, 2009a; Hund *et al.*, 2019). Seasonal impacts on lameness in different regions differ due to differences in farming systems (Sanders *et al.*, 2009a).

2.5.4 Wounds of the Lower Limb

Infection of the digit's interior structures is common when digital wounds include the sole or vertical hoof wall (Knage-Rasmussen *et al.*, 2014). In most cases, such injuries result in visible swelling of the softer tissues close to the coronary band (Salfer *et al.*, 2018; Davis-Unger *et al.*, 2019). Lacerations of the heel and path typically result in enough cellulitis to cause visible foot swelling. According to the authors' experience, lacerations and puncture injuries to the distal limb that result in visible lameness are rarely minor in severity (Sogstad *et al.*, 2006; Jewell *et al.*, 2019). The rough or fractured concrete may result in some damage and wounds from punctures and must be repaired or replaced in order to leave a non-slip surface (Metre *et al.*, 2005; Blackie *et al.*, 2011). As deep digit sepsis is a common sequel of digital wounds, animals should be scheduled for an immediate veterinary examination. (Sepúlveda-Varas *et al.*, 2018; Gelasakis *et al.*, 2019a).

2.5.5 Breed

Though Jerseys and Ayrshires are thought to have been less prone to foot problems, no single breed outperforming the others in terms of overall performance, (Diniso and Jaja, 2021). The Brown Swiss is susceptible to corkscrew claws, laminitis, and sole ulcers, whereas Guernsey has the lowest white line score and the worst heel erosion and digital dermatitis (Blackie *et al.*, 2011; Wilson *et al.*, 2021; Rashad *et al.*, 2022). Jerseys appear to have harder feet and are less likely to experience lameness, which may be associated with black-horned cows being less susceptible to lameness. In addition, the black horn is hardier and does not grow at all, while the white horn grows and leads to uneven hoofs (Derso *et al.*, 2015). In most cases, Friesians have a white horn that grows high in length, which will also cause lameness due to uneven hoof shape. This is related to the growing interest in crossbreeding with red Scandinavian breeds. In addition, the high milk yield produced by Friesians can also lead to lameness because they have large udders (Foditsch *et al.*, 2016). Those udders lead to unbalanced back feet, and in terms of calcium, the more the milk yields, the lesser the calcium in the bones, simply because the animal will use its production of milk yield. In some cases, Friesians have unbalanced hoofs that cause more pressure on the other hoof and easily become lame compared to other breeds (Wilson *et al.*, 2021).

2.5.6 Milk yield

Milking cows, the fact that they do not develop lameness as a result of housing issues, are actually prone to develop lameness during the beginning of the lactation period (Wilson *et al.*, 2021; Rashad *et al.*, 2022). Numerous studies have demonstrated how lameness reduces milk yield (Warnick *et al.*, 2001; Green *et al.*, 2002b; Amory *et al.*, 2008; Cook *et al.*, 2016; Wensman *et al.*, 2022a). Lame cows do not graze, eat from the main bunk less frequently, and they spend almost all of their time resting down (Blackie *et al.*, 2011; Browne *et al.*, 2022a). When the cows aren't provided with enough nutrients each day, they lose weight and will be unable to produce milk (Tejeda and Kim, 2021). Pain caused by lameness will lower milk production (Barker *et al.*, 2018; Salfer *et al.*, 2018; Sadiq *et al.*, 2021). Not only is the quantity of milk reduced due to stress, but so is the quality. Studies have shown cows with lower Somatic Cell Count (SCC) (indicating healthy udders) often experience increased standing time after milking (Lawrence *et al.*, 2011; Gelasakis *et al.*, 2019b).This is because cows with healthy udders (low SCC) are less likely to experience mastitis, which causes discomfort and may lead to cows lying down more frequently to relieve discomfort. As a result, increased lying times in dairy cows caused by lameness might lead to increased mastitis and SCC in milk cows (Arnott *et al.*, 2017; Beaver *et al.*, 2021). Furthermore, prolonged lying times tend to lead to less consumption and nutritional intake in lame cows, resulting in lower milk yield due to less feeding intake (Nalon *et al.*, 2013; Beaver *et al.*, 2021). Clinically lame cows with a greater locomotion score had shorter feeding times, less silage intake, a shorter ruminating time, and lower feeding frequency when compared to non-lame cows (Newcomer and Chamorro, 2016; Sadiq *et al.*, 2021; Browne *et al.*, 2022a).

Furthermore, the relationship between hoof wellness and the production of milk is complicated (Sadiq *et al.*, 2021). Clinical lameness reduces milk yield for some time after the disease has begun (Alawneh *et al.*, 2011). Regardless, hoof infections are frequently linked to high levels of milk yield during the same or preceding lactation (Beaver et al., 2021; Wilson et al., 2021). Lame cows had comparable milk production prior to the lameness diagnosis in the same herd, lactation, and stage of lactation as non-lame cows (Supakorn *et al.*, 2018). Following the lameness diagnosis in the first herd, the milk yield of lame cows was lower by 1.5 kg/d on average for 2 weeks than the milk production of control cows (Davis-Unger *et al.*, 2019). However, the main reason for that is that lame cows have stress that will lead to less production of milk, and there will be high SCC (Matson *et al.*, 2022).

2.5.7 Floor-type

Free-stall housing, bedding, and floor composition are all factors that could lead to lameness (Sogstad *et al.*, 2005). Uneven flooring can cause foot trauma, and improper flooring can be extremely abrasive to hooves, particularly when it is new or wet (Metre *et al.*, 2005; Jewell *et al.*, 2019). Bitumen is one of the most corrosive substances on the hoof. It affects the white line of the hoof (Elelu and Eisler, 2018). Cattle can tolerate up to ten to twelve hours per day on concrete. Access to dirt lots or pastures daily will reduce hoof wear and allow the hoof to heal. Sharp gravel should be avoided in pastures and on roads as it may easily harm the soles of the feet of cows (Browne *et al.*, 2022a).

2.5.8 Cleanliness of floor

Cleanliness was linked to the occurrence of some of the evaluated foot lesions and lameness (Sadiq *et al.*, 2017a). The infectious form lesions like digital dermatitis and heel horn erosion were also strongly linked to filthy conditions (Refaai *et al.*, 2013). Animals kept in the corral for extended periods, and those with poor hygiene had twice the risk of lameness and digital dermatitis (Sadiq *et al.*, 2017a). Unsanitary foot conditions put cows at a higher risk of developing digital dermatitis, with a low cure rate and a high recurrence rate (Sadiq *et al.*, 2017a; Gelasakis *et al.*, 2019b; Browne *et al.*, 2022a).

Since cow cleanliness is a good general indicator of hygiene status, hygiene is regarded as the second extrinsic risk factor for lameness. Dry feet possess greater integrity compared to wet feet because the hoof horn and the skin obstacles within and above those claws are intact, decreasing the chances of bacteria occupying the tissue (Daros *et al.*, 2020). However, others found that there is no essential relationship between barn cleaning frequency and lameness, whereas they discovered that dairy cattle kept on wet and crackly floors were 4.32 times more likely to be lame than animals kept on clean and dry floors (Elliott *et al.*, 2015; Sadiq *et al.*, 2021).

2.5.9 Herd size and lameness in dairy cattle

Lameness is a common and significant welfare issue in dairy cattle, and its prevalence has been noted to be higher in larger herds. This phenomenon is often linked to the intensification of dairy farming practices, where larger herd sizes are characteristic of more industrialized systems (Wilson *et al.*, 2021). In these systems, cows are housed in sometimes overcrowded environments, with limited space for movement. This overcrowding, poor flooring conditions, and increased competition for resources like food, water, and rest can contribute to a higher incidence of lameness. In particular, the physical environment in which cows are housed plays a crucial role. Larger herds often lead to higher stocking densities, meaning cows are kept in more confined spaces. Insufficient room for each animal to move freely can increase the likelihood of injuries such as foot abrasions, sprains, and hoof infections, all of which contribute to lameness. Additionally, it is also a known risk factor for hoof health problems, including laminitis.

However, herd size alone does not fully explain the prevalence of lameness. Some research indicates that the difficulty in identifying lameness in large herds may be a contributing factor (Griffiths *et al.*, 2018; Matson *et al.*, 2022). As herd size increases, it becomes more challenging for farmers and farm workers to monitor each cow for early signs of lameness thoroughly. Early detection and intervention are key to preventing lameness from becoming a chronic issue, but with large herds, subtle signs may go unnoticed, leading to delayed treatment. Moreover, some studies suggest that livestock farmers may be more likely to cull lame cows in larger herds, particularly if those cows show signs of chronic lameness or if the time and resources required for treatment are too costly. Culling can be a strategy to maintain herd productivity. Still, it can also skew the apparent prevalence of lameness, as lame cows may be removed from the herd before their condition is fully addressed or diagnosed (Sadiq *et al.*, 2017a; Gelasakis *et al.*, 2019b; Browne *et al.*, 2022a). This selective culling reduces the number of animals exhibiting lameness in the population but may also prevent farmers from addressing the condition's underlying causes. Despite these factors, herd size may not be as significant as the available space per cow. Research suggests that the stocking density, or the amount of space allocated per cow, plays a more crucial role in the development of lameness than simply the overall size of the herd (Maciej Serda *et al.*, 2013; Nalon and Stevenson, 2019; Wensman *et al.*, 2022a). Adequate space per cow allows for better movement, reduces physical stress, and minimizes injuries that can lead to lameness. In contrast, overcrowded smaller herds may experience just as much or even more lameness due to the high competition for space and resources.

2.5.10 Body condition score

A low body condition score has been scientifically linked to lameness (Randall *et al.*, 2015). This observation might be explained by fat loss in the digital cushion of thin cows. However, some researchers have found a connection between body condition score and digital cushion thickness (Sepúlveda-Varas *et al.*, 2018). The digital cushion reduces corium compression during weight-bearing (Shearer *et al.*, 2015; Jewell *et al.*, 2019; Langova *et al.*, 2020). Therefore, the likelihood of claw horn lesions may rise because of adipose tissue loss within the digital cushion.

2.5.11 Nutrition

Cow nutrition causes or exacerbates certain types of lameness, most notably the effect of the hoof on the corium (Lawrence *et al.*, 2011; Gelasakis *et al.*, 2019b). The corium is a soft tissue area densely packed with blood vessels and nerves. These blood vessels deliver oxygen, amino acids (such as proteins that establish blocks), mineral substances, and other nutrients to the horn, which allows it to grow (Sepúlveda-Varas *et al.*, 2018). Keratin, a hard protein structure, is accumulated by living epidermal cells as they move slowly toward the outside of the foot (Metre *et al.*, 2005; Gelasakis *et al.*, 2019b; Antanaitis *et al.*, 2021). The significance of nutrition for the well-being of feet is obvious, yet the debate about the proper balance of nutrition and other factors continues in the veterinary field (Gelasakis *et al.*, 2019b).

The system for feeding may have an essential effect on limiting the flow of blood to the feet (Antanaitis *et al.*, 2021). The majority of lameness cases show up eight weeks after calving, with the highest foot lesions arising between sixteen and twenty-four weeks into lactation (Zhang *et al.*, 2014; Randall *et al.*, 2015; Foditsch *et al.*, 2016). Given that hoof growth takes approximately six to eight weeks, nutrition during the calving and early lactation may be important. Acidosis, protein content of the diet, vitamins, fibre digestion, and mineral levels are all important nutritional factors that influence lameness (Sepúlveda-Varas *et al.*, 2018). Acidosis is defined by a decrease in rumen pH, which indicates an excess of acid in the rumen. it is caused mainly by overfeeding the rumen with highly concentrated feed, particularly starch (Sepúlveda-Varas *et al.*, 2018).

2.6 The economic impact of lameness

Lameness directly affects animal health, which will lead to a decrease in milk yield and indirectly affects the dairy industry economically (Green *et al.*, 2002a; Aragaw and Tilahun, 2019; Browne *et al.*, 2022a). However, some studies stated that the more time lame cows spend lying on the floor, the higher the chances of developing bedsores and udder disorders (Pérez-Cabal and Alenda, 2014; Solano *et al.*, 2015; Salfer *et al.*, 2018). Furthermore, animals with foot infections will consume less, and such animals remain extra exposed to a negative energy balance (NEB) state. However, this will lead to severe secondary diseases like mastitis (Bechtol, 2014). It increases the vital concern in the field of animal health. However, lameness is one of the most common disorders that disturb animal production in the dairy (Medina-González *et al.*, 2022).

2.7 Prevention of lameness in dairy cattle

The farmer should consider only breeding cows with good locomotion, legs, and feet (Sadiq *et al.*, 2021). However, priority should be given to traits related to production. Second, choose to examine bulls for good traits such as good legs and other desirable traits for dairy cattle (Weber *et al.*, 2013; Sadiq *et al.*, 2021). Cattle with average legs and feet can thrive with proper care. It is advised that when the breeding continues, the cows with a history of lameness must be excluded simply because the genes may pass through (van der Linde *et al.*, 2010; Nalon *et al.*, 2013; Supakorn *et al.*, 2018; Twomey *et al.*, 2019). Use corrective mating when necessary. Eliminate animals suffering from chronic lameness (Akpabio, 2015; Browne *et al.*, 2022b). Finally, poor management can ruin good feet and legs, whereas good management can tolerate bad feet and legs. to avoid lame cows in the dairy, effective treatment should be done every day so that there will be a limited number of lame cows (Green *et al.*, 2002a). An accurate diagnosis allows for the most effective treatment and management changes to aid recovery (Alao *et al.*, 2017).

2.8 Control of lameness in dairy cattle

Every cow's locomotion should be checked daily (for example, throughout herding), and any serious and mild to moderate lameness should be treated effectively and quickly. (within 24 hours if the lameness is clinical) (Barker *et al.*, 2010; Weber *et al.*, 2013; Jewell *et al.*, 2019). During the housing period, the severely lame cows must be separated from the normal lame cows so that they can get proper treatment (Arnott *et al.*, 2017; Gelasakis *et al.*, 2019b; Hund *et al.*, 2019). However, studies agree that trimming the hoof twice a year is one of the good ways of limiting lame cows in a dairy before the dry off-season start and during the calving season (Foditsch *et al.*, 2016; Daros *et al.*, 2020). At least once a week, provide a footbath in the gates so that it can disinfect those foot that are contaminated with infections (Gelasakis *et al.*, 2019b). Provide dry, flat surfaces where the milkers are standing. They must be stable; even on the gravel, there must be level, no stone (Medina-González et al., 2022).

Table 2.1: Some studies conducted on knowledge of risk factors and prevalence of bovine lameness.

Continent	Country	Period	Farm Type	Lameness factors	No of animals	Breeds	Milk sessions	Feeding system	References
America	United State	2004 - 2007	Commercial	Seasonal	4915	Not specified	NS	TMR	(Sanders *et al.*, 2009a)
Europe	Germany	2003	Commercial	Genetics	5634	Holstein	NS	NS	(Koenig *et al.*, 2005)
America	America	2017 - 2020	Commercial	Hoof trimmer	NS	Not specified	NS	NS	(Wynands *et al.*, 2021)
Europe	United Kingdom	1997 - 1999	Commercial	Milk yield	900	Holstein	NS	NS	(Green *et al.*, 2002a)
Europe	Italy	2013	Commercial	Infectious disease	NS	Not specified	NS	NS	(Refaai *et al.*, 2013)
Europe	Scotland	2003 - 2011	Commercial	Low BCS	724	Holstein	3	TMR	(Randall *et al.*, 2015)

America	United State	2018	Commercial	Reproductive factors	9400	Not specified	NS	NS	(Jewell *et al.*, 2019)
Europe	Germany	2002	Commercial	Nutrition	NS	Not specified	NS	NS	(Langova *et al.*, 2020)
Asia	New Zealand	2007	Commercial	Lameness	823	Holstein	NS	Pasture based ry grass & clover	(Mason, 2017)
Europe	Europe	2019 - 2020	Commercial	Herd level/size	250	Not specified	NS	TMR	(Browne *et al.*, 2022c)

NS: not specified; TMR: total mixed ration

2.9 Summary and Recommendation

Lameness in dairy cows is a significant health, productivity, and welfare issue that reduces milk production, reproductive efficiency, welfare, and cow longevity. It ranks as one of the more prevalent dairy farm diseases, resulting in significant financial losses for the farmers and pain and discomfort for the dairy herds. It has multifactorial etiologies, and several coexisting factors influence its occurrence. There are numerous risk factors for lameness: housing, management, nutrition, genetics, and season. Prompt and early identification and management of lameness could improve the chances for a faster recovery, resulting in lower economic losses for farmers and better welfare for lame cows. As a result, dairy farm management should include early detection, prompt treatment, proper hoof care, and the provision of appropriate bedding materials.

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Chapter 3

Dairy farmworkers’ knowledge of causes, risk factors, and clinical signs of bovine lameness in Kwa-Zulu Natal Province, South Africa

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Abstract

Lameness has been identified as the most serious welfare issue in dairy cows, and its observation is the most representative animal-based indicator of dairy cattle well-being. The data was collected from 11 dairy farms using a questionnaire. The questionnaire was divided into five sections, the first of which contained demographic information (age, gender, experience, level of study), and the second contained farm information such as farm size and grazing method. However, section C discusses farm workers’ knowledge of lameness and risk factors, Section D discusses clinical signs of lameness, and Section E discusses treatment and management of lameness. The study assessed the knowledge of dairy farmworkers regarding causes, risk factors, and clinical signs of bovine lameness in Kwa-Zulu Natal Province, South Africa. The highest prevalence of lameness (85.5%) occurs in summer compared with other seasons such as Autumn (15%). Furthermore, the results for seasons were significant ($P < 0.05$). Respondents reported that a decrease in appetite (93%), reduced milk yield (94%), and increased lying time (90%) were the most common signs of lameness. Nevertheless, the results also demonstrated a significant ($P < 0.05$) correlation between knowledge of clinical signs of lameness and localities. The movement problem was related to age, gender, and occupation level ($P < 0.05$). Furthermore, training is required in the dairy industry to improve farm

workers’ knowledge. In addition, farm workers' training and retraining is necessary for managing and mitigating bovine lameness.

Keywords: Lameness, milk yield, foot rot, knowledge, reduced milk yield, increased lying time

3.1 Introduction

Lameness in dairy herds remains a serious problem, with global consequences for animal welfare, milk production, and farm economics (Mas-Coma *et al.*, 2005; Griffiths *et al.*, 2018; Wensman *et al.*, 2022a). Lameness is defined as any infectious or non-infectious foot or leg condition that impairs cow mobility, posture, and gait (Heinonen *et al.*, 2013; Weber *et al.*, 2013; Elliott *et al.*, 2015; Sadiq *et al.*, 2021). The most common cause of lameness in dairy cows is claw lesions, which can be non-infectious (white line disease, sole ulcer) or infectious (digital dermatitis, interdigital dermatitis, heel erosion, and interdigital phlegmon (foot rot) (Warnick *et al.*, 2001b; van der Linde *et al.*, 2010; Antanaitis *et al.*, 2021; Sheferaw *et al.*, 2021). Lameness in cows starts a negative chain reaction that has many consequences for both the farmer and the cow, including reduced milk yield (about 20% reduction), loss of reproduction, lack of weight gain, and, in some cases, animal culling (Randall *et al.*, 2015; Charfeddine and Pérez-Cabal, 2017; Gelasakis *et al.*, 2019; Villa-Mancera and Reynoso-Palomar, 2019).

Lameness has been identified as the most serious welfare issue in dairy cows, and its observation is the most representative animal-based indicator of dairy cattle well-being (Weber *et al.*, 2013; Nalon and Stevenson, 2019). Furthermore, lameness is one of the leading causes of economic loss on dairy farms (Bruijnis *et al.*, 2013; Langova *et al.*, 2020; Wensman *et al.*, 2022a). Lameness, along with mastitis and infertility, is a major cause of reduced animal welfare and a major constraint to the dairy industry (Arnott *et al.*, 2017; Wynands *et al.*, 2021; Wensman *et al.*, 2022a). Protracted calving intervals primarily cause losses, the costs of premature culling, decreased milk yield and quality, and other veterinary costs and treatments incurred by the dairy producer (Green *et al.*, 2002a; Pritchard *et al.*, 2013; Ózsvári, 2017; Gelasakis *et al.*, 2019). Claw disorders account for approximately 90% of all lameness in dairy cattle (Holzhauer *et al.*, 2006; van der Linde *et al.*, 2010; Nalon *et al.*, 2013). Cow-level factors implicated in the pathogenesis of claw lesions include parity, lactation stage, body condition score (BCS), and genetics, whereas herd-level factors include housing environment, management, and nutrition (Sanders *et al.*, 2009; Gudaj *et al.*, 2010; Buttchereit *et al.*, 2012; Häggman and Juga, 2013; Mburu Njoroge *et al.*, 2017; Sadiq *et al.*, 2021)

In terms of reducing herd productivity, lameness in dairy cows is second only to mastitis. In addition to productivity losses, lameness endangers the welfare of affected animals and is likely the most common cause of distress in dairy cattle (Christodoulopoulos, 2009; Supakorn *et al.*, 2018). Depending on the farm, location, and year of study, the annual incidence ranges between four and fifty-five cases per 100 cows per year (Davis-Unger *et al.*, 2019). Lameness reduces milk yield and increases the likelihood of culling (Green *et al.*, 2002a; Pritchard *et al.*, 2013; Gelasakis *et al.*, 2019). Consequently, the total cost of a case of lameness is far greater than the cost of treatment alone (Weber *et al.*, 2013; Cutler *et al.*, 2017; Wilson *et al.*, 2021).

Clinical infectious lameness symptoms include fever, anorexia, decreased milk yield, pain, swelling, and paralysis (Heinonen *et al.*, 2013; Pritchard *et al.*, 2013; Salfer *et al.*, 2018; Davis-Unger *et al.*, 2019; Matson *et al.*, 2022). Few studies have been conducted on the prevalence of lameness in the dairy cow population, particularly in high-producing Holstein cows (Holzhauer *et al.*, 2006; Blackie *et al.*, 2011; Matson *et al.*, 2022). Thus, this study aimed to determine dairy farmer workers' knowledge of the prevalence and associated risk factors of lameness in KwaZulu Natal Province, South Africa.

3.2.0 Materials and Methods

3.2.1 Ethical considerations

An ethical clearance certificate (REC-270710-028-RA Level 01) with project number JAJ021SMAT01 was obtained from the University of Fort Hare Research and Ethics Committee (UFH-UREC) before the commencement of the data collection process.

3.2.2 Study site

The research was conducted primarily on 11 commercial dairy farms in Mooi River, KwaZulu Natal Province, South Africa, in three district municipalities. These districts are uMgungundlovu District Municipality, uMngeni District Municipality, and uMpofana District Municipality (Figure 3.1). However, Mooi River is a small town in KwaZulu- Natal, South Africa. It is 1 389, meters above sea level and 160 kilometers from the coast.

3.2.3 Study population

The first point of contact was visiting the dairies within the Mooi River, South Africa, to seek permission to conduct a study. During the visitation, farmers were informed of the study objective, inclusion criteria, and methodology before data collection began with all farmers at Mooiriver. Out of all the farmers that were present, 25 farms were chosen for the study. However, only 11 farms agreed to participate and were included in the final survey of the study. Each farm typically employed around 30 dairy workers, including managers, supervisors, general workers, and bulk tank workers. However, depending on the size of the farm, there were only 4 to 10 workers per milking session. As a result, 155 out of 160 respondents correctly responded to the survey.

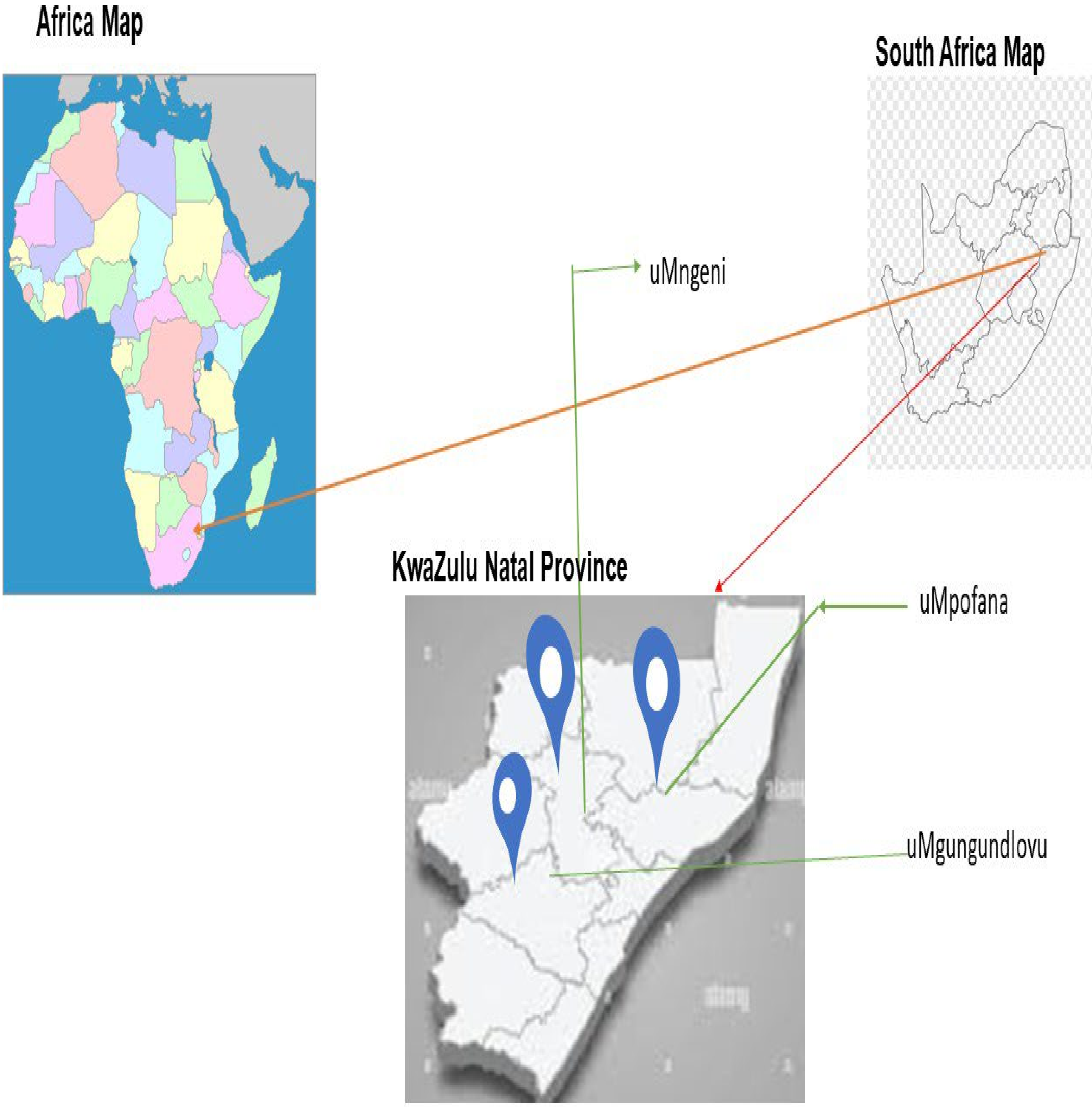

Figure 3. 1: Distribution of the study site

3.2.4 Data collection

Prior to data collection, a questionnaire was developed, validated, and piloted. The questionnaire was matched with similar studies conducted elsewhere (Browne *et al.*, 2022a). Five dairy workers and two students also validated the survey. The questionnaire was divided into five sections, the first contained demographic information (age, gender, experience, level of study), and the second contained farm information such as farm size and grazing method. However, section C discusses farm workers' knowledge of lameness and risk factors, Section D discusses clinical signs of lameness, and Section E discusses treatment and management of lameness. As a result, the questionnaire included closed-ended and open-ended questions, and participants were required to write the correct answer. Furthermore, the questionnaire was written in English. However, to make it easier for participants, it was translated into Isizulu, the participants' language during data collection. the questionnaires were administered by five trained enumerators to farm managers or owners, between November 2022 and March 2023,

3.2.5 Statistical analysis

The collected data were coded and entered into Microsoft Office Excel 2016. The IBM Statistical Package for Social Sciences (SPSS 26 version) was used to calculate the frequency and percentages of the demographic variables. 42 questions and statements were used to assess the respondents' knowledge of risk factors, clinical signs, treatment, prevention, and management of lameness. The chi-square test was used to establish statistical relationships between variables. The results were significant at $P \leq 0.05$.

3.3 Results

3.3.1 Demographic information

63.9% of respondents were males, while 36.1% were females. Most respondents were between 31 and 40 years of age (40%) compared to other age groups (Table 3.1). Sixty-nine percent of respondents were black. 55.5% were single, 32.9% were married, 10.3% were divorced, and 1.3% were widowed. Most of the respondents attained tertiary education (37.4%), and most respondents were general workers (40.6%). Furthermore, 39.4% of respondents had 2-4 years of experience in dairy (Table 3.1). Herringbone (36.7%) and rotary (37.4%) had the highest frequencies than parallel (28.9%) milking parlour. Jersey (16.8%), Friesland (7.7%), and Crossbreed (3.2%) were the most dominant breeds in these dairies, with the significance for these breeds being $P < 0.05$. Furthermore, herd size varied significantly ($P < 0.05$) (Table 3.2).

3.3.3 Association with farm locations

According to the current research findings, most participants (81%) understood the definition of lameness (Table 3.3). However, there was no association ($P > 0.05$) between localities and knowledge of lameness risk factors.

3.3.4 Association between farm locations and potential risk factors for lameness

The highest prevalence of lameness (85.5%) occurs in summer compared with other seasons, such as autumn (15%). Furthermore, the results for seasons were significant ($P < 0.05$). There was an association ($P < 0.05$) between farm localities and potential lameness risk factors. The association with lameness was significant ($P < 0.05$) in the untrimmed data. The results for parity were significant ($P < 0.05$). Most respondents agreed that Crossbred cows (53%) were more prevalent than Jersey (29%) and Friesland (18%). As shown in Figure 2, the fourth lactation cows were more susceptible (30%) to lameness than the other parity (3rd, 2nd, and 1st). In addition, respondents agreed that lameness was more prevalent in summer than in other seasons

Table 3.1: Demographic information of respondents (n=155)

Variables	Category	Frequency	Percentage
Gender	Male	99	63.9
	Female	54	36.1
Age	0 - 20	9	5.8
	21 - 30	56	36.1
	31 - 40	64	41.3
	Above 40	25	16.1
Ethnic	Black	107	69
	Coloured	19	12.3
	White	29	18.7
Marital status	Single	86	55.5
	Married	51	32.9
	Divorced	16	10.3
	Widowed	2	1.3
Education level	No formal education	18	11.6
	Less than Grade 12	23	14.8
	Grade 12	56	36.1
	Tertiary	58	37.4
Occupation	Owner	10	6.5
	Manager	22	14.2
	General worker	63	40.6
	Other	60	38.7
Experience	1- 2	1	0.6
	3- 4	61	39.4
	4 – 5	40	25.8
	Above 6	53	34.2

Table 3. 2: Type of milking parlour, breeds, herd size and type of management system (n=155)

Category	Variables		M1 (%)	M2 (%)	M3 (%)
Type of milking parlour	Rotary		26 (16.7)	23 (14.8)	8 (5.2)
	Parallel		2 (1.3)	35 (22.5)	3 (2)
	Herringbone		13 (8.4)	5 (3.2)	40 (25.8)
	Total		41 (26.5)	63 (40.6)	51 (32.9)
Breeds	Jersey		12 (7.7)	3 (2)	26 (16.8)
	Friesland		9 (5.8)	12 (7.7)	5 (3.2)
	Cross breed		3 (2)	5 (3.2)	3 (2)
	Others		17 (10.9)	43(27.7)	17 (10.9)
	Total		41 (26.5)	63 (40.6)	51 (32.9)
Herd size	1 - 100		3 (2)	2 (1.3)	2 (1.3)
	101 - 300		10 (6.5)	10 (6.5)	4 (2.6)
	301 - 600		2 (1.3)	4 (2.6)	4 (2.6)
	601 - and above		33 (21.1)	57 (36.8)	24 (15.5)
	Total		48 (30.9)	73 (47.1)	34 (22)
Type of management system	Pasture based	Yes	41 (26.5)	61 (39.3)	50 (32.3)
		No	0	2 (1.3)	1 (0.6)
	Total		41 (26.5)	63 (40.6)	51 (32.9)
	Zero grazing	Yes	26 (16.8)	23 (14.8)	37 (23.9)
		No	15 (9.7)	40 (25.8)	14 (9)
	Total		41 (26.5)	63 (40.6)	51 (32.9)

M1: uMgungundlovu, M2: uMpofana, M3: uMngeni

Table 3. 3. Knowledge of lameness and association with farm locations (n=155)

#	Questions	M1 (%)		M2 (%)		M3 (%)		Total (%)		X^2	P value
		Yes	No	Yes	No	Yes	No	Yes (%)	No (%)		
1.	Lameness is a severe welfare problem and a production limiting disease in dairy farming	36 (23.2)	6 (3.9)	60 (38.7)	2 (1.3)	45 (29)	6 (3.9)	141 (90.9)	14 (9.1)	4.5	0.103
2.	An untrimmed hoof is one of the main causes of lameness in dairy	31 (20)	10 (6.5)	56 (36.1)	7 (4.5)	43 (27.7)	8 (5.2)	130(83.8)	5 (16.2)	3.2	0.197
3.	The higher the increase in dairy rainfall, the higher the chance of lameness in dairy animal	35 (22.6)	6 (3.9)	60 (38.7)	4 (2.6)	46 (29.7)	4 (2.6)	141 (90.9	14 (9.1)	2.2	0.338
4.	Parity of an animal associated with lameness	32 (20.6)	9 (5.8)	52 (33.5)	11 (7.1)	40 (25.8)	11 (7.1)	124 (80)	31 (20)	0.4	0.807
5.	Wounds on claws or part of the limbs can cause lameness of lameness in the dairy animals	28 (18.1)	13 (8.4)	61 (39.4)	2 (1.3)	50 (32.3)	1 (0.6)	139(89.6)	16 (10.3)	21.9	0.01
6.1	The infectious foot problem causing lameness include the following: Foot rot	37 (23.8)	4 (2.6)	61 (39.4)	2 (1.3)	50 (32.3)	1 (0.6)	148 (95.5)	7(4.5)	3.6	0.162
6.2	Interdigital dermatitis	31 (20)	9 (5.8)	40 (25.8)	25 (16.1)	37 (23.9)	13 (8.4)	108(69.7)	47 (30.3)	2.7	0.256
6.3	Digital dermatitis	26 (16.8)	15 (9.7)	45 (29)	18 (11.6)	34 (21.9)	17 (10.9)	105(67.7)	50 (32.3)	0.7	0.680
6.4	Mortellaro's disease	26 (16.8)	15 (9.7)	43 (27.7)	20 (12.9)	32 (20.6)	19 (12.3)	101(65.2)	54 (34.8)	0.4	0.798
6.5	Foot and mouth disease	37 (23.9)	4 (2.6)	59 (38.1)	4 (2.6)	45 (29)	6 (3.9)	141 (90.9)	14 (9.1)	1.0	0.594

*Statistically significance at P ≤ 0,05; M1: uMgungundlovu; M2: uMpofana; M3: uMngeni; X^2: Chi-square

Table 3. 4: Association between farm locations and potential risk factors of lameness (n=155)

		Questions	M1		M2		M3		X^2	P value
1		In which season is lameness common: Summer	28.6		28.6		28.6			
	1.1	Spring	0.2		0.2		0.2			
	1.2	Winter	0.2		0.2		0.2			
	1.3	Autunm	4.3		4.3		4.3		14.5	0.001
			Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)		
2		An untrimmed hoof is one of the factors that cause lameness	36 (23.)	6 (3.9)	58 (37.4)	2 (1.3)	53 (34.2)	0	9.1	0.010
3		Lameness prevalence increased with the parity	36 (23,2	8 (5.1)	52 (33.5)	10 (6.5)	42 (27)	7 (4.5)	0.5	0.798
	4.1	In which parity is lameness common: First lactation	27 (17.4)	14 (9)	47 (30.3)	15 (9.6)	31 (20)	21 (13.5)	3.6	0.153
	4.2	Second lactation	34 (21.9)	7 (4.5)	52 (33.5)	11 (7.1)	36 (23.2)	14 (9)	2.3	0.309
	4.3	Third lactation	35 (22.5)	6 (3.9)	55 (35.4)	8 (5.2)	39 (25.1)	12 (13.5)	2.6	0.279
	4.4	Fourth lactation	32 (20.6)	9 (5.8)	59 (38.7)	4 (2.6)	46 (29.7)	5 (3.2)	6.1	0.047
5		Wounds of the lower limb increase the chance of lameness	33 (21.3)	8 (5.1)	60 (38.7)	3 (2)	49 (31.6)	2 (1.3)	9.0	0.01
6		Floor type	24 (15.5)	16 (10.3)	30 (19.4)	34 (21.9)	28 (18)	23 (14.8)	2.0	0.368
7		Animal breed is one of the risk factors for lameness	35 (22.5)	6 (3.9)	52 (33.5)	11 (7.1)	44 (28.4)	7 (4.5)	0.3	0.847
	8.1	Which of the following breeds is more affected by lameness: Jersey	17 (10.9)		3 (2)		24 (15.5)			
	8.2	Crossbreed	19 (12.3)		45 (29)		20 (12.9)			
	8.3	Friesland	4 (2.6)		16(10.3)		7(4.5)		33.3	0.01

*Statistically significant at P≤ 0.05; M1: uMgungundlovu; M2: uMpofana; M3: uMngeni; X^2: Chi-square

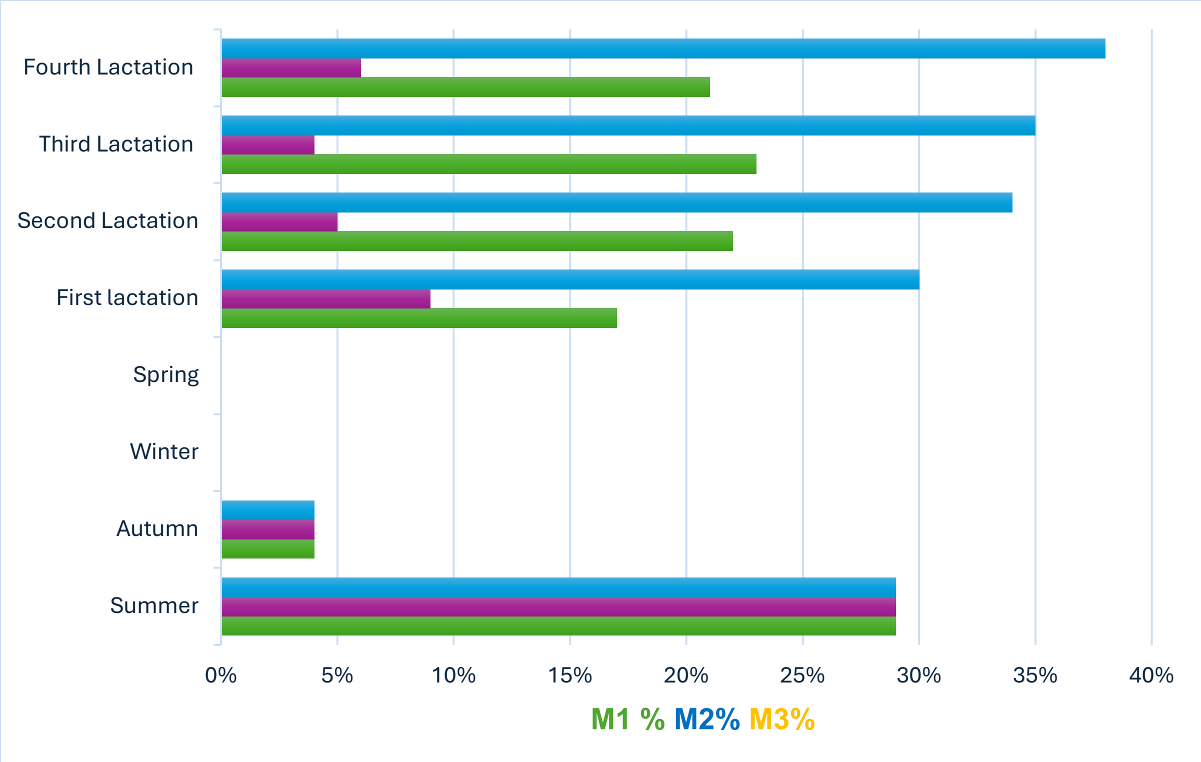

Figure 3. 2: Respondents views of lameness due to season and parity in three districts of Mooiriver, KwaZulu – Natal, South Africa

3.3.5 Knowledge of clinical signs, treatment, prevention, and management of lameness

The results of this study indicate that a decrease in appetite (93%) is a clinical sign of lameness (Table 5). Nevertheless, the results also demonstrate a significant ($P < 0.05$) correlation between knowledge of clinical signs of lameness and localities. Other clinical signs included decreased milk yield (93%), which was statistically significant ($P < 0.05$). The data presented in Figure 3.3 show that most participants were aware of the clinical signs of lameness. This study found that the participants in all three localities recognized these clinical signs of lameness. Additionally, fewer respondents were unaware of the clinical signs of lameness. Most participants (91%) acknowledged that lameness should be treated by applying a block to the unaffected claw (Table 3.6). However, others believed treating lame cows with Savlon was critical (88%). The correlation between farm localities, application of the block to unaffected claws, and treatment with Savlon was significant ($P < 0.05$).

Several participants (96%) in the current study (Table 3.7) believe that not allowing animals to travel long distances can prevent lameness. The interaction between prevention and farm localities was significant ($P < 0.05$). While other respondents agreed on trimming hooves twice a year (90%) and scrubbing manure in the feed pad (91%), they disagreed on scrubbing manure in the feed pad to avoid infectious diseases. Furthermore, majority of respondents believed that all concrete should be grooved to prevent cows from slipping (89%), and the variance was significant ($P < 0.05$).

The movement problem was related to age, gender, and occupation level ($P < 0.05$) (Table 8). However, demographic information (ethnicity, marital status, and occupation level) was significant ($P < 0.05$) when associated with decreased appetite. Furthermore, foot rot and increased lying time were correlated with age and occupation level ($P < 0.05$).

Table 3. 5 Dairy farmers (n=155) knowledge of the clinical sign of lameness

Questions	M1 (%)		M2 (%)		M3 (%)		Total (%)		X^2	P value
	Yes	No	Yes	No	Yes	No	Yes	No		
Movement problem	38 (24.5)	4 (2.6)	62 (40)	2 (1.3)	46 (29.7)	3 (2)	**146 (94.2)**	9 (5.8)	3.8	0.147
Decreases appetite	35 (22.6)	7 (4.5)	62 (40)	1 (0.6)	48 (30.9)	2 (1.3)	145 (93.5)	10 (6.5)	10.6	0.005
Reduces milk yield	36 (23.2)	6 (3.9)	61 (39.4)	2 (1.3)	49 (31.6)	1 (0.6)	146 (94.2)	9 (5.8)	8.2	0.017
Loss of mobility	38 (24.5)	4 (2.6)	61 (39.4)	2 (1.3)	44 (28.4)	6 (3.9)	**143 (92.3)**	12 (7.7)	3.3	0.190
Foot rot	39 (25.1)	2 (1.3)	61 (39.4)	2 (1.3)	48 (30.9)	3 (2)	**148 (95.5)**	7 (4.5)	0.5	0.780
Increase lying times	36 (23.2)	5 (3.2)	62 (40)	1 (0.6)	42 (27.1)	9 (5.8)	140 (90.3)	15 (9.7)	8.7	0.013
Reduces reproductive ability	37 (23.9)	4 (2.6)	59 (38.1)	4 (2.6)	47 (30.3)	4 (2.6)	**143 (92.3)**	12 (7.7)	0.6	0.748
Reduce body weight	37 (23.9)	3 (2)	60 (38.7)	3 (2)	49 (31.6)	3 (2)	**146 (94.2)**	9 (5.8)	0.6	0.732
							*Pass mark 4.69(58.56%)			

*Statistically significant at P≤0.05; M1: uMgungundlovu; M2: uMpofana; M3: uMngeni; X^2: Chi-square (Correct answers are highlighted in bold.
*pass mark has been computed by the addition of percentages in which most of respondents correctly answered the question and divided by 100)

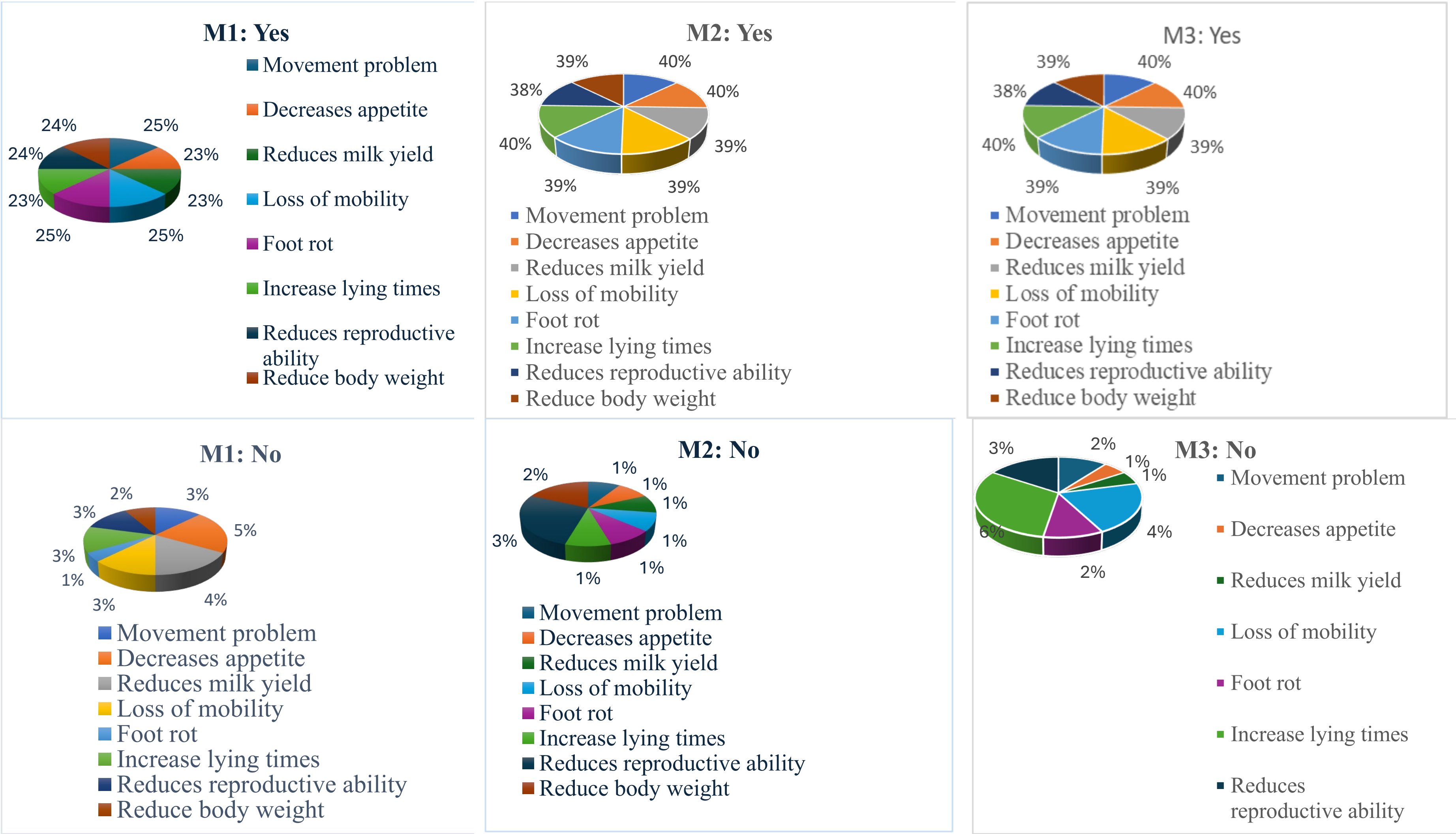

Figure 3.3: Bar chart of respondent on knowledge of clinical signs of lameness

Table 3. 6 Dairy farmworkers (n=155) knowledge of treatment of lameness

#	Questions	M1 (%)		M2 (%)		M3 (%)		Total		X^2	P value
		Yes	No	Yes	No	Yes	No	Yes	No		
1	Trimming regular	33 (21.3)	8 (5.2)	60 (38.7)	3 (2)	45 (29)	6 (3.9)	138 (89)	17 (11)	5.6	0.061
2	Apply bandage on the affected claw	33 (21.3)	7 (4.5)	62 (40)	2 (1.3)	46 (29.7)	5 (3.2)	141 (90.9	14 (9.1)	8.2	0.017
3	Apply block on unaffected claw	37 (23.9)	5 (3.2)	52 (33.5)	10 (6.5)	39 (25.2)	12 (7.7)	128 (82.6)	27 (17.4)	1.6	0.451
4	Foot bath	39 (25.2)	2 (1.3)	61 (39.3)	2 (1.3)	47 (30.3)	4 (2.6)	147 (94.8)	8 (5.2)	1.3	0.532
5	Antibiotics	36 (23.2)	5 (3.2)	61 (39.3)	2 (.3)	49 (31.6)	2 (1.3)	146 (94.2)	9 (5.8)	4.2	0.123
6	Treating with savlon	30 (19.4)	11 (7.1)	58 (37.4)	5 (3.2)	49 (31.6)	2 (1.6)	137 (88.4)	18 (11.6)	13.0	0.001
7	Trim and put a plank in severely trimmed leg	33 (21.3)	8 (5.2)	58 (37.4)	5 (3.2)	47 (30.3)	4 (2.6	138 (89)	17 (11)	4.2	0.124

*Statistically significant P≤0.05; M1; uMgungundlovu; M2: uMpofana; M3: uMngeni; X^2: Chi-square

Table 3. 7 Dairy farmers (n=155) knowledge of the prevention and management of lameness

#	Questions	M1 (%)		M2 (%)		M3 (%)		**Total**		**X^2**	P value
		Yes	No	Yes	No	Yes	No	Yes	No		
1	Do not allow animals to travel long distance	37 (23.9)	4 (2.6)	63 (40.6)	0	48 (30.9)	3 (2)	148 (95.4)	7 (4.6)	5.8	0.055
2	Do not allow animals to mix with contaminated animals	35 (22.6)	6 (3.9)	61 (39.4)	2 (1.3)	48 (30.9)	3 (2)	144 (92.9)	11 (7.1)	5.1	0.077
3	Spray infected pastures	36 (23.2)	5 (3.2)	54 (34.8)	9 (5.8)	41 (26.5)	10 (6.5)	131(84.5)	24 (15.5)	1.1	0.585
4	Trimming hoofs twice a year	32 (20.6)	9 (5.8)	58 (37.4)	5 (3.2)	49 (31.6)	2 (1.3)	139(89.7)	16 (10.3)	8.6	0.013
5	Early identification of lame cows	36 (23.2)	5 (3.2)	58 (37.4)	5 (3.2)	46 (29.7)	5 (3.2)	140 (90.3)	15 (9.7)	0.5	0.772
6	Feeding proper nutrition for thin (Poor BCS) animals	32 (20.6)	9 (5.8)	57 (36.8)	6 (3.9)	46 (29.7)	5 (3.2)	135(87.1)	20 (12.9)	4.1	0.131
7	Scrub the manure in the feed pad to avoid infectious diseases	34 (21.9)	7 (4.5)	57 (36.8)	6 (3.9)	50 (32.3)	1 (0.6)	141 (91)	14 (9)	6.3	0.042
8	Apply footbath every week	36 (23.2)	5 (3.2)	59 (38.1)	4 (2.6)	49 (31.6)	2 (1.3)	144 (92.9)	11 (7.1)	2.5	0.294
9	All concrete should be grooved to prevent cows from slipping	32 (20.6)	9 (5.8)	58 (37.4)	5 (3.2)	48 (31)	3 (2)	138 (89)	17 (11)	7.0	0.030

*Statistically significant at P≤0.05; M1; uMgungundlovu; M2; uMpofana; M3: uMngeni; X^2: Chi-square

Table 3. 8: Association between demographic information and dairy farmworkers (n=155) knowledge in clinical signs of lameness

Demography	Movement problem	Decrease appetite	Reduce milk yield	Loss mobility	Foot rot	Increase lying time	Reduce reproduction	Reduce body weight
Age	0.001*	0.003*	0.282	0.511	0.016*	0.030*	0.020*	0.683
Gender	0.048*	0.307	0.545	0.907	0.330	0.703	0.124	0.725
Ethnic	0.515	0.032*	0.128	0.361	0.476	0.526	0.284	0.255
Marital status	0.709	0.012*	0.013*	0.710	0.552	0.499	0.892	0.814
Experience	0.107	0.927	0.596	0.110	0.180	0.110	0.501	0.468
Education level	0.375	0.949	0.592	0.013*	0.236	0.219	0.240	0.500
Occupation	0.050*	0.001*	0.763	0.929	0.052*	0.045*	0.864	0.709

*Statistically significant (P ≤ 0.05)

3.4 Discussion

The current study revealed that 63.9% of respondents were males than females (36.1%). This could be because most of the work done in dairy farming are energy demanding, such as hoof trimming and other farm practices. 83.2% of the respondents were between 21 and 40 years old. This could be the preferable age in the dairy industry and the energetic group. These results are consistent with those reported in the Eastern Cape Province, South Africa, and other countries (Pérez-Cabal and Alenda, 2014; Villa-Mancera and Reynoso-Palomar, 2019; Diniso and Jaja, 2021), who reported the need to include youth and energy as one of the requirements in dairy farming. Most respondents used a pasture-based dairy system rather than zero grazing and knew that the pasture-based system and type of milking parlour were associated with incidences of lameness. Cow constant walking on uneven terrain and long distances to access grazing areas and water sources predispose the foot to lameness (Solano *et al.*, 2015; Hund *et al.*, 2019; Kang *et al.*, 2020). Walking strains cattle hooves and leads to lameness. These results are consistent with those reported in the United States of America, which reported that the environment and type of management system may also contribute to the prevalence of lameness (Wynands *et al.*, 2021).

In the current study, the majority (81%) of the respondents were knowledgeable about bovine lameness, while 19% were not. This could be due to farm training and awareness campaigns about conditions such as lameness and mastitis that lead to the culling of dairy cattle. These results aligned with those reported in the Eastern Cape Province (Diniso and Jaja, 2021). This suggests a good level of awareness and understanding of the disease among farmers and producers in the study population. This study found that most participants (81%) understood the definition of lameness (Table 3.3). Wounds on claws or parts of limbs can cause lameness in dairy animals; these findings are consistent with those reported in Europe (Maciej Serda *et* *al.*, 2013; Nalon and Stevenson, 2019; Wensman *et al.*, 2022a). Many studies agree that the high prevalence of lameness is frequently caused by claw wounds (Knage-Rasmussen *et al.*, 2014; Foditsch *et al.*, 2016; Griffiths *et al.*, 2018; Hund *et al.*, 2019). The underlying pathogenesis of chronic wounds may also cause different aetiologies of wounds to be affected by bacteria in different ways (Sogstad *et al.*, 2006). Infection of the deep structures of the digit frequently results from digital wounds, such as those on the sole or vertical hoof wall. Typically, these wounds cause the soft tissues close to the coronary band to swell visibly (Knage-Rasmussen *et al.*, 2014; Han and Ceilley, 2017; Puca *et al.*, 2021).

The current study revealed that most respondents agreed that lameness was more prevalent in the summer than in other seasons. This could be because summer is characterized by high rainfall, and the impact of these rainfalls may cause wetness and mud. This may increase hoof injuries in dairy cows and bacterial infections (Randall *et al.*, 2015; Newcomer and Chamorro, 2016). The current results align with those reported elsewhere in Australia (Stott and Gourley, 2016). Most respondents agreed that untrimmed cattle were more likely to experience lameness than trimmed ones. This could be because hair and untrimmed hooves may retain dirt and pathogens (Warnick *et al.*, 2001b; Pérez-Cabal and Alenda, 2014; Charfeddine and Pérez-Cabal, 2017). These results are similar to those reported in Europe, Ethiopia, and Asia (Vargas-Bello-Pérez *et al.*, 2017; Nalon and Stevenson, 2019; Sheferaw *et al.*, 2021).

Nonetheless, the current study's respondents agreed that the Friesland is a breed prone to lameness. These outcomes are consistent with those presented in the Netherlands (Somers *et al.*, 2005; van der Linde *et al.*, 2010). Furthermore, numerous studies have found that the Friesland breed is more prone to lameness than other breeds because of its large udder and long hoof (Alawneh *et al.*, 2011; Häggman and Juga, 2013; Nalon *et al.*, 2013; Jaja *et al.*, 2017; Antanaitis *et al.*, 2021). According to other studies, lameness also affects crossbreeds because they carry the Friesland gene (Koenig *et al.*, 2005; Barker *et al.*, 2010; Buch *et al.*, 2011; Pérez-Cabal and Alenda, 2014; Supakorn *et al.*, 2018).

According to this study, increasing parity increases the likelihood of lameness in dairy cows. As a result, these findings are similar to those reported in Canada, where lameness prevalence increased with increasing parity; compared with first parity, cows in parity 2, 3, and 4 had a higher prevalence of lameness (Cutler *et al.*, 2017; Jewell *et al.*, 2019; Matson *et al.*, 2022). Because older cows produce more milk than the first lactating cows, there is a greater chance of lameness developing as the cow ages. Other researchers have found that cows in the third to fourth parity are more likely to become lame in Finland (Sarjokari *et al.*, 2013).

In the current study, most respondents were knowledgeable about clinical signs of lameness. The study suggests that the respondents had an average level of knowledge (60-71%) regarding the clinical signs of lameness, with a pass rate of 5.6 out of 8. This finding is consistent with the results of other European studies, which also reported that many farm workers have a basic understanding of the clinical signs of lameness in cows (Nalon and Stevenson, 2019; Wensman *et al.*, 2022b). Specifically, the movement problem has been identified as one of the most recognized clinical signs of lameness among farm workers (Heinonen *et al.*, 2013; Browne *et al.*, 2022b). This is likely because cows are observed daily as they enter and exit the milking parlour, which provides ample opportunity for farm workers to identify movement problems in cows.

Lame cows consume less feed because they spend so much time lying down, which lowers their milk production (Sadiq *et al.*, 2017b; Beaver *et al.*, 2021). These results precisely coincide with those presented in New York (Warnick *et al.*, 2001a; Foditsch *et al.*, 2016; Wynands *et al.*, 2021). According to other studies, lameness is the main factor that reduces milk production

(Pérez-Cabal and Alenda, 2014; Karshima *et al.*, 2018; Daros *et al.*, 2020; Wilson *et al.*, 2021). Milk reduction is one of the clinical signs of lameness in Switzerland (Alao *et al.*, 2017; Antanaitis *et al.*, 2021). Feed intake may decrease even more because of the increased pain brought on by being unable to stand or move to eat, which could lead to a further decline in milk production. However, some studies agree that the lower the feed intake, the lower the milk production (Buch *et al.*, 2011; Bruijnis *et al.*, 2013; Barker *et al.*, 2018; Daros *et al.*, 2020).

The majority of respondents agreed that bandaging the affected claw was the best way to treat lameness. These findings are comparable to those reported in other countries such as Europe, Mexico, America, and Asia (Randall *et al.*, 2018; Siles-Lucas *et al.*, 2021; Wensman *et al.*, 2022a). However, some studies suggest that the bandage should be removed within 24 hours because it can cause infection in the claw (Heinonen *et al.*, 2013; Foditsch *et al.*, 2016; Charfeddine and Pérez-Cabal, 2017; Sadiq *et al.*, 2017a). At the same time, some claim that another treatment for lame cows is the application of savlon in the affected claw (Davis-Unger *et al.*, 2019; Anyanwu *et al.*, 2021; Wilson *et al.*, 2021). Salvon offers a treatment option for lameness that maintains milk production, avoids antibiotic use, and eliminates the need for a milk withdrawal period.

The prevention and management of lameness in dairy cows are critical for avoiding premature culling of lame cows (Whay, 2002; Sadiq *et al.*, 2021; Wilson *et al.*, 2021). It is stated that dairy cows are not permitted to travel long distances because doing so will damage their hoofs and reduce milk yield. Furthermore, hoof trimming is recommended twice a year by a hoof care centre or veterinarian (Van Nuffel *et al.*, 2015; Cutler *et al.*, 2017; Langova *et al.*, 2020). These findings are consistent with those reported in China, Asia, the United Kingdom, and the United States (Green *et al.*, 2002b; Salfer *et al.*, 2018; Supakorn *et al.*, 2018; Sadiq *et al.*, 2021). Hoof trimming reduces the likelihood of the herd becoming lame. Bovine lameness prevention necessitates a multifaceted approach that includes proper nutrition, regular hoof trimming, clean and dry living conditions, footbaths, minimizing standing time, and genetics (Somers *et al.*, 2005; Arias-Pacheco *et al.*, 2020; Wensman *et al.*, 2022b). By implementing these strategies, dairy farmers can reduce the risk of lameness and improve their herds' overall health and welfare (Lawrence *et al.*, 2011; Solano *et al.*, 2015; Beaver *et al.*, 2021).

3.5 Conclusion

This study assessed dairy farmworkers' knowledge of the causes, risk factors, and clinical signs of bovine lameness in South Africa's Kwa-Zulu Natal Province. In the current study, the level of education had no bearing on the knowledge of lameness and its application to increase productivity. However, despite having access to 17 risk factors for lameness, farm workers could only name four: summer, parity, untrimmed hooves, and wounds on the lower limbs. This highlights their lack of understanding of lameness. Furthermore, training is required in the dairy industry to improve farm workers'' knowledge. In addition, farm workers' training and retraining is necessary for managing and mitigating bovine lameness.

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Chapter 4

Retrospective analysis of prevalence and risk factors of bovine lameness in dairy farms in uMpofana municipality, Kwa-Zulu Natal, and Raymond Mhlaba municipality, Eastern Cape Province, South Africa.

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Abstract

Lameness is a crippling problem in the dairy industry, posing a significant welfare challenge and leading to premature culling. The data was collected in two local municipalities (uMpofana and Raymond Mhlaba). However, the computer software systems of four randomly selected dairy farms were used to collect retrospective secondary data for lameness and predisposing factors (2018–2022). The data's targeted parameters include breed, parity, weight, stage of lactation, diseases diagnosed (lameness), age, and milk production trends. The study aimed to determine the seasonal prevalence of lameness in two different provinces of South Africa. The highest prevalence was observed in uMpofana municipality (KwaZulu-Natal 58.8%) compared to Raymond Mhlaba municipality (Eastern Cape 41.2%). Among cattle above nine years of age, the prevalence of lameness was the highest (36%), compared to 7-8-year-old (24%), 4-6-year-old (21.7%), and 1-3-year-old (14.3%) cattle. Additionally, the highest prevalence of lameness was observed during the summer season, followed by spring, winter, and autumn. The strongest association is kept for the right front leg (RFL) ($p < 0.0001$), followed by the left front leg (LFL) ($p < 0.001$), right back leg (RBL) ($p < 0.001$), and left back leg (LBL) ($p < 0.001$). In conclusion, this study provides baseline information on several key factors

influencing the prevalence of lameness in dairy cattle in various farms in uMpofana municipality and Raymond Mhlaba municipality. The study findings could be used for farm managerial decision-making and epidemiological interventions.

Key words: Season, milk yield, lameness, breed, parity, dairy cows

4.1 Introduction

Lameness in dairy cows refers to a painful condition resulting from disorders in the locomotor system, leading to impaired deviation from normal gait or posture (Cook *et al.*, 2016; Langova *et al.*, 2020). Lameness in dairy cows is usually caused by claw lesions, which include white line disease, sole ulcer, sole haemorrhage, and interdigital difficulties. These lesions are all non-infectious(Bruijnis *et al*., 2013; Christodoulopoulos, 2009; Gelasakis *et al.,* 2019). The consequences of lameness in dairy cows significantly impact their welfare, productivity, and overall health. This disease led to premature culling and reduced milk yield (Leach *et al.*, 2010; Knage-Rasmussen *et al.*, 2014). In many cases, the predisposing factors commonly associated with lameness are incorrect claw trimming, a long distance to the milking parlour, the pressure applied by the hardman when moving them, and a poor walking surface (Heinonen *et al*., 2013; Supakorn *et al*., 2018). Other studies agreed that the higher the number of lame cows in the dairy, the lower the milk yield. Furthermore, lameness is a painful condition that causes many behavioural challenges in animals, including decreased feed intake, increased lying time, and reduced milk yield (Griffiths *et al.*, 2018; Diniso and Jaja, 2021). As do the somatic cells and the bacteria, these challenges also increase. More importantly, this will affect the dairy industry and food security. Suppose the lame cows are injected with antibiotics that have a withdrawal period. However, it will lead to dumping milk down the drain simply because the antibiotic-laced milk will harm human consumption (Daros *et al*., 2020). This discovery led to the conclusion that rather than comparing cumulative yields, an estimate of milk loss should be calculated by calculating the deviation from the lactation curve of daily results to assess the impact of lameness on milk production (Bechtol, 2014; Foditsch *et al.*, 2016; Kumar, 2021).

Even after medical treatment, it results in substantial, long-lasting discomfort and has a significant financial impact (Van Os *et al.*, 2019). Lameness' implications for reproduction are one of the main ways it reduces productivity, and it also affects fertility throughout the entire reproductive cycle (Blackie *et al.*, 2011; Main *et al.*, 2012). They have demonstrated that preventing lameness would have reduced the number of cows with delayed cyclicity by 71%. Lame cows had 3.5% higher chances of not resuming cyclicity within 60 days of calving than non-lame cows (Alawneh *et al.*, 2011; Beaver *et al.*, 2021). Despite the ovarian activity in returning lame cows, anestrus in lame animals will likely need to be treated because of the cyclic delay (Hund *et al*., 2019; Vargas-Bello-Pérez *et al*., 2017).

Lame cows exhibit compromised estrous behaviour even when ovarian activity has recovered. According to some studies, lame cows had reduced conception rates, mounted less frequently, and displayed estrus less strongly (Sheferaw, Abebe, Megersa, Amenu, *et al*., 2021; Silva *et al*., 2021; Vargas-Bello-Pérez *et al*., 2017). Additionally, at the commencement of the breeding season, anestrous cattle are made to ovulate. Finally, there are differences in how lame cows are managed. Lame cows are frequently taken out of the leading herd and milked only once a day in New Zealand (Antanaitis *et al*., 2021; Ongwech *et al.,* 2022; Sheferaw, Abebe, Megersa, & Amenu, 2021). Adopting this management approach for lame cows, in conjunction with providing pasture, can potentially reduce the severity of lameness and its negative effect on fertility. In terms of prevalence, studies have shown that approximately one quarter of cows are lame at any given time, with around 55 cases of lameness per 100 cows annually (Sanders *et al*., 2009).In the United Kingdom, the prevalence of dairy cow lameness is estimated to be around 22.1%. This issue is not unique to the UK, as worldwide figures indicate that over 250 million dairy cattle produce around 600 million tonnes of milk annually, with lameness being a significant concern in countries like the United States, India, and China (Jewell *et al.*, 2019; Kang *et al.*, 2020; Matson *et al.*, 2022). Studies focusing on bovine lameness in South Africa are relatively scarce. Therefore, the current study aims to document the prevalence and risk factors commonly associated with bovine lameness.

4.2 Material and Methods

4.2.1 Ethical clearance

Before the data collection started, the University of Fort Hare Research and Ethics Committee (UFH-UREC) obtained an ethical clearance certificate (REC-270710-028-RA Level 01) with project number JAJ021SMAT01.

4.2.2 Research design and study area

Using a longitudinal study methodology, the study was conducted on dairy farms in uMpofanan Municipality, uMngeni Municipality, and Raymond Mhlaba Municipality. These are the two municipalities used in the study in different provinces; for example, uMpofana is in KwaZulu-Natala, while Raymond Mhlaba is in Eastern Cape Table 4.1 provides an overview of the study farms' descriptions. However, it is widely acknowledged that these South African provinces have the biggest dairy farms. Additionally, compared to other provinces in the nation, the EC and KZN have the most dairy cows, with an average of 764 to 1000 cows per farm (Matson *et al.*, 2022). The research farms are described in Table 4.1.

4.2.3 Data collection

In four randomly selected dairy farms, computer software systems version 5.3 (Afi-milk, Kibbutz Afikim, Israel) was used to collect retrospective secondary data for lameness and predisposing factors (2018–2022). This software was designed for herd management on modern dairy farms and offers a fully integrated system that includes cow monitoring, herd management software solutions, Parlor automation, and data management & analysis tools. The data's targeted parameters include breed, parity, weight, stage of lactation, diseases diagnosed (lameness), age, and milk production trends. Furthermore, the data was generated from the dairy software (Afimilk version 5.3) and then transferred to Microsoft Excel 2016 for cleaning and coding to facilitate statistical analysis.

4.2.4 Statistical analysis

The frequency lists function of R was used to determine frequencies for categorical variables and descriptive statistics for continuous variables. The chi-square test was employed to ascertain associations between the categorical variables such as year, breed, age, season, and parity. The multivariable predictors were used to determine the prevalence of lameness between the two municipalities. A multilevel logistic regression model determined the association between leg lesion position and lameness prevalence score. The correlation coefficient was used to determine the association between different variables. All the statistical analyses were conducted at a 5% significance level using R software version 4.2.3 (R Core Team, 2023).

Table 4.1: A table containing summaries of a study's sites.

Farm	Municipality	Herd size	Breeds	Feeding system	Grasses and legumes	Mean annual rainfall	Milk production/day
A	MM1	1569	Jersey, Crossbreed, Friesland	Pasture based and Silage	Fescue, Ryegrass, White clover	More than 800mm	15 000 – 25 000
B	MM2	2000	Crossbreed, Friesland, Jersey	Pasture based with dry pastures and silage	Oats, Kikuyu, Ryegrass, Plantain	410 – 1450mm	20 000 – 30 000
C	MM1	890	Friesland, Jersey, Crossbreed	Pasture based with silage	White clover, Cocksfood, Fescue, Lucerne, Chicory, Kikuyu	More than 800mm	10 000 – 20 000
D	MM2	900	Jersey, Friesland, Crossbreed	Pasture based with dry pasture and silage	Plantain, Fescue, Ryegrass, White Clover, Kikuyu	410 – 1450mm	10 000 – 20 000
E	RMLM	847	Friesland, Jersey, Crossbreed	Pasture based	Clover, plantain, chicory lucerne ryegrass	500 – 600mm	10 000 – 20 000
F	RMLM	1400	Crossbreed, Friesland, Jersey	Pasture-based	Ryegrass, Lucerne, Kikuyu, Clover, Plantain	500 – 600mm	15 000 – 25 000

MM1: uMpofana Municipality, MM2: uMngeni Municipality, RMLM: Raymond Mhlaba Municipality

4.3 Results

The highest prevalence of lameness was observed in 2019 compared to other years, namely 2018, 2020, 2021, and 2022. Furthermore, the highest prevalence was observed in KZN (58.8%) compared to EC (41.2%). Among cows above nine years of age, the prevalence of lameness was the highest (36%), compared to 7-8-year-old (24%), 4-6-year-old (21.7%), and 1-3-year-old (14.3%) cattle. Similarly, cattle between their 4th and 8th parities had the highest prevalence (53.3%) of lameness compared to cattle between the 1st and 4th and those in the 8th and above parities. Friesland cattle displayed the highest prevalence of lameness (55%) when compared to Jersey (24.4%) and crossbred (18.6%) cattle. Additionally, the highest prevalence of lameness was observed during the summer season, followed by spring, winter, and autumn, as presented in Table 4.2. Moreover, in Table 4.3, the multivariable analysis indicates several factors significantly influence the prevalence of lameness in dairy cattle in these South African provinces. Parity ($p < 0.001$), season ($p < 0.0001$), and DIM ($p < 0.0001$) appear to be particularly strong predictors of lameness, with breed ($p < 0.001$) and age ($p < 0.0001$) having less pronounced effects.

In Table 4.4, the data revealed a significant association between leg positions and the prevalence of lameness. The strongest association is observed for the right front leg (RFL) ($p < 0.0001$), followed by the left front leg (LFL) ($p < 0.001$), right back leg (RBL) ($p < 0.001$), and left back leg (LBL) ($p < 0.001$). These findings highlight the importance of considering leg position when assessing and managing lameness in dairy cattle. Lastly, Table 5.5 shows a strong positive correlation ($p = 0.001$) between parity and lesion position. A slight positive correlation ($p = 0.02$) exists between weight and leg position. The data also reveals a significant correlation between lameness leg position and age, emphasizing the interplay between these factors in understanding and addressing lameness issues in dairy cattle.

Table 4.2 compares the prevalence of lameness in two provinces (uMpofana and Raymond Mhlaba) from 2018 to 2022.

Variable	Category	Freq	Percentage %	X^2	P value
Year	2018	158	18.7	10.59	0.05
	2019	228	27.3		
	2020	168	19.9		
	2021	121	14.3		
	2022	167	19.8		
Municipality	uMpofana	591	70.1	27.756	0.001
	Raymond Mhlaba	253	29.9		
Farm	A	154	18.2	11.76	0.01
	B	189	20.8		
	C	143	17.7		
	D	141	17.5		
	E	128	15.8		
	F	92	11.4		
Age	1-3	121	14.3	10.438	0.05
	4-6	183	21.7		
	7-9	240	28		
	>9	300	36		
Parity	1-4	200	23.7	26.647	0.001

	4-8	450	53.3		
	>8	194	23		
Breed	Friesland	464	55	25.769	0.001
	Jersey	223	24.4		
	Crossbred	157	18.6		
Season	Winter	149	18	15.657	0.01
	Spring	207	25		
	Summer	361	42		
	Autumn	127	15		
DIM	10-110	100	12	17.443	0.003
	111-210	195	23		
	211-310	341	40		
	>310	208	25		

Significant at ** P < 0.001, and * P < 0.05 and NS, not significant at P > 0.05, DIM: days in milk

Table 4.3 Multivariable predictors of lameness in dairy farm herds in uMpofana and Raymond Mhlaba municipalities

	Estimate	Std. error	t value	P value
Intercept	4.39	2.01	8.467	< 0.0001
Breed	1.87	0.12	-0.331	0.001
Parity	-2.37	0.41	-3.418	0.001
Age	-0.29	0.62	-0.412	0.0001
Weight	0.42	0.11	-0.149	0.05
Season	3.48	2.18	9.518	< 0.0001
DIM	3.07	0.69	8.348	< 0.0001

Sign codes : 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1, DIM : days in milk

Table 4.4 Multilevel logistic regression model determines which leg lesion positions were associated with prevalence lameness scores.

Leg position	Estimate	Lower 95% Cl	Upper 95% Cl	Std. error	Odd ratios	P value
Intercept	-1.434	-1.608	-1.312	0.142	1.21	0.001
RFL	2.401	0.218	4.989	1.108	14.02	< 0.0001
LFL	0.316	-0.014	0.301	0.246	7.30	<0.001
RBL	0.621	0.014	1.121	1.424	5.40	< 0.001
LBL	1.435	0.625	2.160	0.206	1.20	0.001

RFL: Right front leg, LFL: Left Front Leg, RBL: Right Back Leg, LBL: Left Back Leg

Table 4.5 Correlations between parity, lesion position, weight, age, breed, season, and days in milk

	Parity	Position	Weight	Age	Breed	Season	DIM
Parity	-						
Position	3.05***	-					
Weight	0.58**	0.02*	-				
Age	0.44***	0.22**	-0.39*	-			
Breed	0.68***	0.46**	0.62***	0.10*	-		
Season	0.14*	0.67***	0.13*	0.29**	0.54**	-	
DIM	0.28**	0.01*	0.24***	0.51**	-0.41**	0.23**	-

Significant at ** P < 0.001, and * P < 0.05 and NS, not significant at P > 0.05, DIM: days in milk

4.4 Discussion

The current study revealed that the highest prevalence of lameness in 2019 compared to other years (2018, 2020, 2021, and 2022) could be attributed to weather conditions, such as excessive rainfall or drought, which can impact the prevalence of lameness in cattle. For instance, wet and muddy conditions increase the risk of foot-related issues like hoof rot and digital dermatitis, leading to higher lameness rates. These results are similar to those reported in Mexico, Asia, and Ethiopia (Foditsch *et al.*, 2016; Sadiq *et al.*, 2017; Van Os *et al.*, 2019).

The current study revealed that the prevalence of lameness varied with farms. Farm B had the highest prevalence of lameness compared to other farms. This could be due to management practices such as hoof trimming, lack of veterinary services, overcrowding, and inadequate foot hygiene practices, which can increase the risk of lameness. These results were similar to those highlighted. The current study unveiled variations in the prevalence of lameness across different local municipalities. Specifically, uMpofana (KZN) exhibited a notably higher prevalence of lameness than Raymond Mhlaba. This disparity can be attributed to these two regions' distinct environmental conditions. KZN is renowned for its consistently hot and rainy climate throughout the year. It is plausible that these specific environmental conditions contribute to an elevated infection rate.

The findings demonstrate a significant contrast in lameness prevalence among different age groups of cattle. The highest occurrence of lameness, at 36%, was observed in cattle aged over nine years. Conversely, younger age groups exhibited lower lameness rates, with 7-8-year-old cattle at 24%, 4-6-year-old cattle at 21.7%, and 1-3-year-old cattle at 14.3%. This variability in lameness prevalence among age groups can be attributed to the prolonged exposure of older cattle to environmental and physical stressors over time (Heinonen *et al.*, 2013; Randall *et al.*, 2015; Refaai *et al.*, 2013). However, environmental conditions play a crucial role in altering infectious disease patterns, particularly in the context of lameness in dairy cows. Moist and wet environments can significantly impact the prevalence of lameness by creating a favorable breeding ground for pathogens that cause foot–related lameness (Huxley, 2013). Pathogens such as *Dichelobacter nodusus, Fusobacterium necrophorum, Treponema spp*., and *Actinomyces* pyogenes are significant contributors to foot-related lameness in dairy cattle. These pathogens thrive in most conditions and can lead to diseases like foot rot (Van Koppen & Hartmann, 2015). These outcomes align with findings from Ireland, where the prevalence of lameness was reported to increase with the age of the animals.

Moreover, the present study highlights that lameness was notably more frequent in cattle between their 4th and 8th parities compared to other parity groups. Furthermore, it suggests an increasing prevalence of lameness with parity. These results parallel those reported in Austria (Archer *et al.*, 2010). Several studies have shown that the prevalence of lameness increases with increasing parity. Lameness (visual locomotion score ≥3) was more common in cows with parity >1 (48.2%) than in those with parity 1, according to studies conducted elsewhere (Barker *et al.*, 2010; van der Linde *et al.*, 2010; Weber *et al.*, 2013). Cows in parities 4 and higher have 2.46 times increased odds of being diagnosed as lame compared to first lactation animals. Older cattle have a higher prevalence of non-digital dermatitis (DD) lameness, potentially related to their higher parity. The increased risk of lameness with parity can be attributed to several factors: Repeated calving and lactation cycles can take a toll on the cow's body, weakening the digital cushion and increasing the risk of claw horn lesions like sole ulcers and white line disease. Older cows are more likely to have experienced previous lameness episodes, predisposing them to future lameness. Thinner digital cushions are associated with higher lameness prevalence (Archer *et al.*, 2010; Buch *et al.*, 2011; Charfeddine and Pérez-Cabal, 2017).

Additionally, the highest lameness prevalence was consistently observed during the summer, in contrast to the other three seasons. This could be attributed to elevated temperatures and increased rainfall, which might trigger or favor the pathogens responsible for lameness (Amory *et al*., 2008; Griffiths, Grove White, *et al*., 2018). The weather in KwaZulu-Natal (KZN) and Eastern Cape (EC) during the summer is characterized by elevated temperatures and increased rainfall, which may contribute to a higher prevalence of lameness in dairy cows. In Durban, KZN, the average temperature ranges from 22°C to 28°C in the summer, with precipitation ranging from 1.9mm to 5.5mm. Summertime temperatures in the Eastern Cape can average up to 30 °C, ranging from 10 to 50 mm of rainfall (Solano *et al.*, 2015). The high temperatures and precipitation during the summer can potentially trigger or favour the pathogens responsible for lameness, leading to a higher prevalence of this condition in dairy cows during this season. Ireland and Australia have also reported similar results (Rahim *et al.*, 2017; Negut *et al.*, 2018; Alsaaod *et al.*, 2019). This study underscores that seasonal factors, particularly those associated with hot and wet conditions like summer, are significant predictors and risk factors for lameness.

Furthermore, the current study disclosed variations in lameness prevalence among cattle breeds. Friesland cattle displayed the highest prevalence of lameness when compared to Jersey and crossbred cattle. Moreover, the breed of cattle can influence their susceptibility to lameness due to various factors related to their conformation, genetics, and management practices. Due to variations in hoof structure, body weight distribution, and susceptibility to particular hoof lesions, some breeds may be more prone to lameness than others (Buch *et al*., 2011; Pritchard *et al*., 2013; Shearer *et al*., 2015). For example, dairy cattle breeds like Holsteins are known to have a higher prevalence of lameness compared to beef cattle breeds due to their larger body size, higher milk production levels, and potential genetic predispositions to hoof issues like digital dermatitis and sole ulcers (Huxley, 2013; Charfeddine and Pérez-Cabal, 2017; Legg *et al.*, 2019).

Additionally, differences in breeding goals and selection criteria among breeds can impact their resilience to lameness, with some breeds bred for specific production traits that may inadvertently increase their susceptibility to lameness-related issues. Therefore, breed-specific factors such as conformation, weight distribution, genetic predispositions, and management practices significantly determine the likelihood of lameness in cattle. These findings align with those reported in Ireland and Switzerland (Gorden and Plummer, 2010; Bran *et al.*, 2018). Thus, the results from this study strongly indicate that breed is a predictor of lameness.

The current study revealed that the prevalence of lameness in milk significantly increases with age. In the first 150 days of lactation, lame cows produce 161 – 183 kg less milk than their non-lame herd mates, demonstrating a negative correlation between lameness and milk yield. In addition, it could be attributed to the severity of the lameness infection (Buch *et al.*, 2011; Chen *et al.*, 2016; Newcomer and Chamorro, 2016). The research indicates that severe lameness may result in a more extended period of milk production, an increased likelihood of mastitis infections, and a reduction in milk yield.

There is a significant association between leg positions and the prevalence of lameness in dairy cattle, with the strongest association observed for the right front leg in the current study. However, it could be because the front legs of cattle bear a substantial portion of their body weight, with the right front leg often carrying more weight due to factors such as body conformation and the habits of the animals. This uneven weight distribution can increase stress on the right front leg and increase the risk of lameness. Moreover, this contrasts with studies in Austria and Switzerland, which reported severe infection of lameness in the back legs, mainly due to kicking during milking(Bechtol, 2014; Foditsch *et al*., 2016; Kumar, 2021; Sadiq *et al.,* 2017). While no specific breed is universally known for kicking during milking, certain individual cows within any breed may exhibit this behavior. However, some anecdotal evidence suggests that certain high-strung or nervous breeds, such as Holstein, may be more likely to kick during milking compared to others (Alawneh *et al*., 2011; Main *et al*., 2012; Van Os *et al.,* 2019).

4.5 Conclusion

The regional disparity in lameness rates in cattle in dairy farms at uMpofana, which is showing a notably higher prevalence than in cattle in dairy farms at Raymond Mhlaba, underscores the impact of distinct environmental conditions. Furthermore, our results revealed significant variations in prevalence across different age groups, with older cattle exhibiting higher lameness rates. Parity also played a role, with cattle in their 4th to 8th parities showing a notable increase in lameness prevalence. Additionally, the seasonal variation in lameness, with higher rates in the summer, underscores the influence of weather conditions as potential triggers for lameness.

Notably, breed-specific susceptibility to lameness was evident, with Friesland cattle being more prone to lameness than Jersey and crossbred cattle. Lastly, the association between lameness prevalence and days in milk highlights the importance of early detection and management. During the summer months with high rainfall, it is crucial to implement strategies to mitigate wetness and mud issues. Creating dry bedding areas and installing effective drainage systems are critical to address this. Dry bedding areas are essential for absorbing excess moisture, especially urine, to prevent the formation of mud. By combining these strategies, you can significantly reduce the impact of wetness and mud during the rainy summer month.

4.6 References

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Chapter 5

5.1 General discussion, conclusion, and recommendations

Bovine lameness poses a considerable challenge to the dairy industry worldwide, significantly impacting animal welfare, productivity, and economic viability. Lameness in dairy cows is a multifactorial condition influenced by various factors ranging from genetic predisposition to environmental and management-related aspects (Rahim *et al.*, 2017; Legg *et al.*, 2019; Nalon and Stevenson, 2019). However, risk factors associated with clinical signs of lameness in dairy cattle in Mpofana and Raymond Mhlaba municipalities are not known.

The study's central hypothesis was that dairy farm workers' knowledge of risk factors, clinical signs, and retrospective analysis of bovine lameness in dairy farms located in two municipalities was adequate. Understanding the prevalence of bovine lameness is crucial for implementing effective prevention and management strategies to mitigate its adverse effects on individual animals and dairy herd performance (Main *et al.*, 2012; Stott and Gourley, 2016; Sheferaw *et al.*, 2021; Medina-González *et al.*, 2022).

In Chapter 3, dairy farmworkers' knowledge of the causes, risk factors, and clinical signs of lameness in dairy cattle was thoroughly investigated. The study reveals a consensus among respondents that lameness is more prevalent in the summer compared to other seasons. This observation is attributed to the environmental conditions typical of summer, such as high rainfall leading to wetness and mud. These conditions were thought to increase the likelihood of hoof injuries and bacterial infections in dairy cows (Sepúlveda-Varas *et al.*, 2018).

The study suggests that the increased prevalence of lameness in summer is likely due to environmental factors like rainfall, which create conditions conducive to hoof injuries and bacterial infections. Moreover, it aligns with findings from studies conducted in Australia, indicating a consistent pattern across different regions (Jewell *et al.*, 2019; Matson *et al.*, 2022).

Chapter 4 dealt with a retrospective analysis of bovine lameness's prevalence and risk factors in dairy farms in uMpofana municipality, Kwa-Zulu Natal and Raymond Mhlaba municipality, Eastern Cape Province, South Africa. The study reveals a significant difference in lameness prevalence among different age groups of cattle. Older cattle over nine years showed the highest occurrence of lameness at 36%, while younger age groups exhibited lower rates. Specifically, 7-8-year-old cattle had a lameness rate of 24%, 4-6-year-olds at 21.7%, and 1-3-year-olds at 14.3%.

This variation suggests that older cattle are more susceptible to lameness, likely due to prolonged exposure to environmental and physical stressors over time (Kang *et al.*, 2020; Ongwech *et al.*, 2022; Rashad *et al.*, 2022). Several studies support this idea, indicating that age-related factors contribute to lameness prevalence (Barker *et al.*, 2018; Antanaitis *et al.*, 2021b; Sheferaw *et al.*, 2021).

The study also highlights a notable increase in lameness frequency among cattle between their 4th and 8th parities compared to other parity groups. However, it suggests a correlation between lameness prevalence and parity, with an increasing trend observed as parity increases. Similar findings have been reported in studies conducted in Austria and Ethiopia, further supporting the idea that parity is a significant factor influencing lameness in dairy cattle (Yigrem *et al.*, 2008; Visser *et al.*, 2020; Sheferaw *et al.*, 2021a; Silva *et al.*, 2021). The study's results align with previous research conducted in Ireland, Austria, and Ethiopia.

These studies also observed age-related and parity-related variations in lameness prevalence, indicating a global consensus on the factors influencing lameness in dairy cattle. This consistency strengthens the reliability of the study's findings and underscores the importance of considering age and parity when addressing lameness prevention strategies (Hund *et al.*, 2019; Wynands *et al.*, 2021).

Another finding from the study is that untrimmed cattle are more prone to lameness than regularly trimmed cattle (Wynands *et al.*, 2021). Furthermore, it was attributed to the presence of hair and untrimmed hooves, which can harbour dirt and pathogens. Previous research conducted in various regions, including Europe, Ethiopia, and Asia, supports these findings, suggesting a global consensus on the importance of hoof trimming in preventing lameness (Yigrem *et al.*, 2008; Randall *et al.*, 2015; Griffiths *et al.*, 2018b; Davis-Unger *et al.*, 2019). The study's results are consistent with previous research conducted in different parts of the world, indicating a universal understanding of the factors influencing lameness in dairy cows (Kaler and Green, 2009; Archer *et al.*, 2010; Barker *et al.*, 2010; Shearer *et al.*, 2015).

This consistency adds credibility to the study's findings and suggests that interventions to reduce lameness should consider seasonal variation and hoof-trimming practices. The null hypothesis was that the prevalence and risk factors of bovine lameness did not differ significantly between 2018 and 2022 was rejected. The study found the highest prevalence of lameness in 2019, which indicates a significant difference in prevalence across the years.

5.2 Conclusion and Recommendation

In conclusion, the study underscores the seasonal variation in lameness prevalence, the impact of environmental factors such as rainfall, the importance of hoof trimming in preventing lameness, and the consistency of these findings with previous global research. This research provides insights into the age- and parity-related variations in lameness prevalence in dairy cattle, supported by prior research. They suggest that older cattle and those in certain parity groups are more prone to lameness, highlighting the necessity of tailored management practices to mitigate lameness risk in different demographic groups of cattle. These individualized care and management practices may involve more frequent monitoring and preventative measures for older cattle and those in certain parity groups.

Given the highlighted seasonal variation in lameness prevalence, dairy farmers should implement specific management strategies tailored to different seasons. For instance, during the summer months, characterized by high rainfall, measures should be taken to reduce the impact of wetness and mud, such as providing dry bedding areas and proper drainage systems.

Dairy farmers should focus on implementing environmental management practices to mitigate the impact of environmental factors like rainfall on lameness prevalence. These practices may also include maintaining clean and dry walking surfaces, regularly cleaning barns, and proper ventilation to reduce humidity levels. The importance of hoof trimming in preventing lameness cannot be overstated. Dairy farmers should prioritize regular hoof trimming practices to maintain hoof health and reduce the risk of lameness, especially in older cattle and higher parity groups.

Dairy farmers need to recognize the age- and parity-related variations in lameness prevalence highlighted by the research. Tailored management practices should be implemented to address the specific needs of different demographic groups of cattle. However, it may involve more frequent monitoring and preventative measures for older cattle and those in certain parity groups.

Further research and collaboration within the dairy industry can help deepen our understanding of lameness and refine management practices. Continued monitoring of lameness prevalence and collaborative efforts to share best practices and innovative solutions can contribute to ongoing improvement in prevention and management. This collective action and continuous improvement are crucial for the dairy industry to effectively address the challenge of bovine lameness.

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Appendix A

University of Fort Hare
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INDIVIDUAL INFORMATION SHEET AND INFORMED CONSENT FORM

(AGES 18 YEARS AND ABOVE)

Please note:

This form is to be completed by the researcher(s) as well as by the interviewee before the commencement of the research. Copies of the signed form must be filed and kept on record

(To be adapted for individual circumstances/needs)

Title of Study: Dairy farmworkers' knowledge of risk factors and prevalence of bovine lameness, in Kwa-Zulu Natal Province, South Africa

Dear participant,

My name is Sibulele Matshetsheni, and I am studying/working at the University of Fort Hare.

I am conducting research on Dairy farmworkers' knowledge of risk factors and prevalence of bovine lameness, in Kwa-Zulu Natal Province, South Africa (name of the study).

(**Purpose of Study** (Explain purpose of study using lay terms)

We would like you to allow us to conduct a brief (approximate time) interview with you about

The dairy farmworkers' knowledge of risk factors and prevalence of bovine lameness. The outcomes of the study will improve the farmworkers knowledge on bovine lameness and its risk factors.

(**Study Procedure** (Explain all procedures using layperson's terms).

The study will be conducted primarily on 10 commercial dairy farms in Mooi River, Kwa-Zulu Natal Province mainly in two district municipalities namely: Mpofana, and Umgungundlovu district municipality. A retrospective secondary data for lameness will be used also a questionnaire survey will be used.

Some questions may be of a personal and/or sensitive nature. I will be asking some questions that you may not have thought about before. We know that you cannot be certain about the answers to these questions, but we ask that you try to think about these questions. When it comes to answering questions there are no right and wrong answers.

Please understand that **your participation is voluntary,** and you are not being forced to take part in this study. The choice of whether to participate or not, is yours. However, we would really appreciate it if you do share your thoughts with us. If you choose not to take part, you will not be affected in any way whatsoever. If you agree to participate, you may stop me at any time and tell me that you don't want to go on with the interview. If you do this there will also be no penalties and you will NOT be prejudiced in ANY way.

The information will remain confidential. This means that your name and address will not be linked in any way to the answers you give. We study and report on the answers given by all the people we interview and not on an individual basis. The research data will be anonymous – with all personal respondent information removed and will be archived at the University.

At the present time, we do not see any risks in your participation. The risks associated with participation in this study are no greater than those encountered in daily life.

There are no immediate benefits to you from participating in this study. However, this study will be helpful in finding out --------

Risk-Benefit Ratio (benefits hoped for from this study and the risks involved for the participant):

The study will help dairy farmworkers to get knowledge about risk factors of lameness ad way to minimis the lameness in the herd. However, even in the Africa or worldwide will benefits because the paper will be published.

Who to contact if you have been harmed or have any concerns?

This research has been approved by the Inter-Faculties Research Ethics Committee (IFREC) as per delegated authority of the University Research Ethics Committee (UREC). If you have any complaints about ethical aspects of the research or feel that you have been harmed in any way by participating in this study, please call the IFREC Administrator, [Aphiwe Jadezweni, 040 602 2561 and ajadezweni@ufh.ac.za]

Reporting and Complaints

If you have questions at any time about this study, or if you have concerns/questions you may contact the researcher/project leader whose contact information is provided on the first page. If you have questions regarding your rights as a research participant, or if problems arise which you do not feel you can discuss with the researcher/project leader, please contact the IFREC Chairperson, Dr A Nyika on [040 602 2516 and ANyika@ufh.ac.za] or the UREC Chairperson, Dr N Taole-Mjimba on [043 704 7507 and nTaole-Mjimba@ufh.ac.za].

If you have concerns or questions about this study, please feel free to contact the project coordinators: **Researcher/Project Leader:**

Name: Sibulele Matshetsheni

Department: Livestock and Pasture

Address:

Phone: 0781280919 / 0617678890

Email: 201715795@ufh.ac.za

INFORMED CONSENT FORM

(Edit as Required)

I (name of participant) ………………………………………………………………………………. have been informed about the study by (provide name of researcher/ project leader/ fieldworker) …………………………………………………………...............

I understand the purpose, procedures, and risk-benefit ratio of the study.

I have been given opportunity to ask questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any procedurals that I would usually be entitled to.

I have been informed about any available compensation or medical treatment if injury occurs to me as result of study-related procedures

I understand that I will be given a copy of this informed consent.

I understand that if I have any questions or complaints about my rights as a study participant, or if I may have concerns about any aspect of the study or the researcher/s then I may contact the Chairperson of the Inter-Faculty Research Ethics Committee, Dr. Aceme Nyika or Chairperson of University Research Ethics Committee, Dr N Taole-Mjimba (details available from the Researcher or by contacting the University of Fort Hare or Website www.ufh.ac.za)

Participant signature: ………………………………………………………………………

Consenting for Audio Recording– when necessary

YES / OR

Participant signature: ………………………………………………………………………

Witness signature: ………………………………………………………………………...

(To be altered according to the study)

Translator signature: ……………………………………………………………………………...

(To be altered according to the study)

Data curation – I understand that the information that I provide will be stored electronically and will be used for research purposes now or at a later stage (to be altered according to the study)

Participant signature: ……………………………………………………………………………

Date: …………………………………

Section A: Demographic information

1. Gender: Male☐ Female ☐ Other ☐
2. Age : < 21 ☐ 21-30 ☐ 31-40 ☐ > 40
3. Tribe: Black ☐ Coloured ☐ White ☐ Other ☐
4. Marital status: Single ☐ Married ☐ Divorced ☐ Widowed ☐
5. Education level: No formal education ☐ < Grade 12 ☐ Grade 12 ☐ Tertiary ☐
6. What is your current occupation? Owner ☐ Manager ☐ General worker ☐
   Other ☐ ,If other, please specify..
7. Experience in dairy farming (years): 1. ≤ 2 ☐ 2-4 ☐ 4-6 ☐ 6 and above ☐

Section B: Farm information

1. Name of the farm			Municipality	
2. Type of milking parlour	Rotary	Parallel	Tandem	Herringbone
3. Dairy breeds	Cross breed	Jersey	Friesland	Other
4. Herd size	1 – 100 ☐	101 – 300 ☐	301 – 600 ☐	601 and above ☐
5. The farm is pasture based	Yes		No	
6. The farm is zero grazing	Yes		No	

Section C: The knowledge of lameness and risk factors

Answer the following question regarding **knowledge of lameness** to the best of your ability by clicking the right answers.

		Yes	No
1	Lameness is a severe welfare problem and a production-limiting disease in dairy farming.		
1	Untrimmed hoof is one of the main causes of lameness in dairy		

2	The higher the increase in daily rainfall, the higher the chances of lameness in the dairy animal		
3	Parity of an animal associated with lameness		
4	Wounds on claws or the part of the limbs can cause lameness in dairy cows.		
5	Infectious foot problems can cause lameness		
	5.1 Click Yes or No if you can identify or have heard about the following infectious foot problem: A – E:		
	a) Foot rot		
	b) Interdigital dermatitis		
	c) Digital dermatitis d) Mortellaro's Disease		
	e) Foot and mouth disease		

Answer the following to the best of your ability regarding **the risk factors of lameness** that are common on your farm (Tick the correct answers)

		Yes	no
1	In which season is lameness common .		
	1.1 Summer		
	1.2 Spring		
	1.3 Winter		
	1.4 Autumn (Fall)		
2	Untrimmed hoof is one of the factors a that couse lamenes		
3	Lameness prevalance increased with the parity (number offspring).		
	3.1 In which parity is lameness common? Choose the right answer by clicking Yes or No		
	a) In young heifers (calves)		

	b) In Heifers		
	c) In cows		
4	Wounds of the Lower Limb		
5	Floor type		
6	Animal breed is of the risk factors of lameness.		
	Which of the following breed is more affected with lameness:		
	a) Jersey		
	b) Cross breed		
	c) Friesland		
	d) Other		

Section D: knowledge of clinical signs of lameness

Answer the following question regarding **knowledge of clinical signs of lameness** to the best of your ability by clicking the right answers.

		Yes	No
1	Lameness causes movement problem		
2	It decreases appetite		
3	Lameness reduce milk yield		
4	Loss of mobility		
5	Standing imbalanced		
6	Foot rot		
7	Lameness is also associated with increased lying times		
8	Reduces reproductive ability		
9	Reduce body wieght		
10	Results to premature culling of the affected animal		

Section E Treatment and management of lameness

Answer the following to the best of your ability regarding the kinds of treatment you frequently use on your farm (Tick the correct answers)

		Yes	No			Yes	No
1	Trimming regular			6	Treating with savlon		
2	Apply bandage to the affected claw			7	Trim and put a plank in severely trimmed leg		
3	Apply block on unaffected claw						
4	Foot bath						
5	Antibiotics						

Answer the following to the best of your ability regarding the kinds of prevention you frequently use on your farm (Tick the correct answers)

		Yes	**No**
1	Not allow animals to travel long distance		
2	Not allow animals to mix with contaminated animals		
3	Spray infected pastures		
4	Trimming hoofs twice a year		
5	I identifying lame cow early		
6	Feeding proper nutrition for tin (poor body condition score) animals		
7	Scrub the manure in feed pad to avoid infectious diseases		
8	Apply footbath every week		
9	All concrete should be grooved to prevent cows from slipping		

Appendix B

University of Fort Hare
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ETHICS CLEARANCE
REC-270710-028-RA Level 01

Project Number: JAJ021SMAT01

Project title: **Dairy farmworkers' knowledge of risk factors and prevalence of bovine lameness, in KwaZulu Natal Province, South Africa.**

Qualification: Master of Science in Agriculture: Animal Science

Student name: Sibulele Matshetsheni

Registration number 201715795

Supervisor: Dr I Jaja

Department: Animal Science

Co-supervisor: N/A

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby grant ethics approval for JAJ021SMAT01. This approval is valid for 12 months from the date of approval. Renewal of approval must be applied for BEFORE termination of this approval period. Renewal is subject to receipt of a satisfactory progress report. The approval covers the undertakings contained in the abovementioned project and research instrument(s). The research may commence as from the 11/11/22, using the reference number indicated above.

Note that should any other instruments be required, or amendments become necessary, these require separate authorisation.

Please note that UREC must be informed immediately of

- Any material changes in the conditions or undertakings mentioned in the document.
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The student must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

UREC retains the right to

- Withdraw or amend this approval if o Any unethical principal or practices are revealed or suspected; o Relevant information has been withheld or misrepresented; o Regulatory changes of whatsoever nature so require; o The conditions contained in the Certificate have not been adhered to.

- Request access to any information or data at any time during the course or after completion of the project.

Your compliance with Department of Health 2015 guidelines and any other applicable regulatory instruments and with UREC ethics requirements as contained in UREC policies and standard operating procedures, is implied.

UREC wishes you well in your research.

Yours sincerely

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Dr N Taole-Mjimba
Chairperson: University Research Ethics Committee 11 November 2022

Appendix C

Dairy farmworkers.docx

ORIGINALITY REPORT

12%	11%	4%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	vital.seals.ac.za:8080 Internet Source	3%
2	assets.researchsquare.com Internet Source	2%
3	Submitted to University of Fort Hare Student Paper	1%
4	www.ufh.ac.za Internet Source	1%
5	www.researchsquare.com Internet Source	1%
	SIBULELE MATSHETSHENI, Ishmael Festus	1

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