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PREVALENCE OF LAMENESS, HOOF DISORDERS AND THEIR ASSOCIATED FACTORS AMONG GOATS IN LADANG ANGKAT FARMS

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CERTIFICATION

It is hereby certified that we have read this project paper entitled "Prevalence of lameness, hoof disorders and their associated factors among goats in Ladang Angkat Farms", by Jacky Tan Lit Kai , and in our opinion, it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirement for the course VPD 4999 – Final Year Project

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DEDICATION

This thesis is dedicated to my: -

Beloved Family

My mom
My dad
My brother

My supervisor & co-suporvisor

Dr. Mohammed Babatunde Sadiq
Dr. Siti Zubaidah Binti Ramanoon

My friends

Iman
Haris
Meera
Praveena
Shivnraj

&

DVM2024

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CONTENTS

	Page
TITLE…….……..	I
CERTIFICATION……,…….....	II
DEDICATION…….……....	III
ACKNOWLEDGEMENTS…….…...	IV
CONTENTS…….……...	V
ABSTRAK…….…….	VII
ABSTRACT…….….	VIII
1.0 INTRODUCTION…….…….	1
1.1 OBJECTIVE…….….....	2
1.2 HYPOTHESIS…….…….	2
1.3 PROBLEM STATEMENT…….…….	3
1.4 JUSTIFICATION……..……...	3
2.0 LITERATURE REVIEW……..……	4
2.1 Introduction to lameness ……..…….	4
2.2 Prevalence of lameness …….	4
2.3 Lameness assessment …….……...….	5
2.4 Impact of lameness ……	6
2.5 Animal-level risk factors of lameness in goats……..	7
2.6 Farm-level risk factors of lameness in goats…….....….	8
2.7 Lameness in ruminants in Malaysia Livestock Industry……	9
3.0 MATERIALS AND METHODS……...	11
3.1 Ethical statement……	11
3.2 Study design……..	11
3.3 Farm selection ……..	12
3.4 Herd selection…….……..	12
3.5 Farming system and husbandry ……..….	13
3.6 Feeding system…….…….	14
3.7 Study design flow……..……	15

3.7.1 Study design flowchart……. 15
3.7.2 Locomotion scoring……. 17
3.7.3 Age…….……. 18
3.7.4 Body Condition Scoring……..……. 19
3.7.5 Hoof length scoring…… 20
3.8 Data analysis…… 21

4.0 RESULTS…….. 22
5.0 DISCUSSION…… 28
6.0 CONCLUSION……. 31
7.0 RECOMMENDATION STUDY…….. 32
REFERENCES……. 33
APPENDICES…….……...

LIST OF FIGURES

Figure 1: Gender distribution of goats…….....22
Figure 2: Health status of goats…….....23
Figure 3: Hoof length of goats.....23
Figure 4: Locomotion score distribution of goats.....24
Figure 5: Prevalence of hoof disorders in lame goats…….....25
Figure 6: Distribution of lameness and hoof disorder in each farm.....26

LIST OF TABLES

Table 1: Age and BCS…….....22
Table 2: Farm characteristics of the study population.....24
Table 3: Distribution of foot affected.....25
Table 4: Univariable model for the association between animal-level factors…..27

ABSTRAK

Ketempangan adalah condisi yang mengugatkan pergerakkan haiwan dan adalah kebimbangan utama yang memberi imapk kepada produktiviti dan kesejahteraan kambing. Masalah kuku kambing adalah penyebab utama ketempangan kepada kambing. Namun, terdapat kekurangan maklumat mengenai lameness dan gangguan pada kuku dalam konteks penternakan kambing di Malaysia. Kajian ini mengkaji prevalens lameness, gangguan pada kuku, dan faktor-faktor yang berkaitan di kalangan kambing di Ladang Angkat. Satu kajian keratan rentas telah dijalankan di lima ladang yang dipilih secara berkesan. Sejumlah 100 ekor kambing telah dipilih secara rawak dan diperhatikan menggunakan skala penarafan pergerakan lima mata. Gangguan pada kuku telah diperiksa, dan data telah dikumpulkan mengenai ciri-ciri kambing dan ladang, termasuk umur, bangsa, jantina, skor keadaan badan (BCS), panjang kuku, jenis pengeluaran, saiz kumpulan ternakan, amalan pengurusan, rutin penjagaan kuku, jenis lantai, dan regimen pemakanan. Data dianalisis menggunakan statistik deskriptif dan model regresi logistik. Min (deviasi piawai) umur kambing adalah 2.35 (± 0.57) dan 53.0% mempunyai BCS yang buruk. Kejadian lameness adalah 23% (LS 3 dan ke atas) dan gangguan pada kuku adalah 54% (interval kepercayaan 95%; CI 4.2 – 30.8%) dan 54.0% (CI 95% 16.7-69.2%), masing-masing. Di antara kambing yang lumpuh, 87% mempunyai kuku yang tumbuh panjang. Lameness lebih kerap berlaku pada kaki belakang kiri (47.8%), diikuti oleh kaki belakang kanan (30.4%), kaki depan kanan (13%), dan kaki depan kiri (8.7%). Tiada perkaitan yang signifikan dicatatkan antara lameness dan umur, jantina, bangsa, BCS, atau status kesihatan. Walau bagaimanapun, hubungan yang kuat antara lameness dan panjang kuku menunjukkan bahawa kambing dengan kuku yang tumbuh panjang lebih cenderung lumpuh (Nisbah Odds; OR = 8.54; CI 95%: 2.31-31.56) berbanding dengan yang mempunyai panjang kuku normal. Tiga daripada ladang mengamalkan pengurusan intensif, manakala tiada daripada ladang mengamalkan penjagaan kuku. Penemuan ini menggambarkan prevalens yang tinggi bagi lameness dan gangguan pada kuku dalam ladang yang disampelkan dan keperluan untuk amalan penjagaan kuku secara proaktif dalam penternakan kambing.

Kata kunci : Kambing , ketempangan , lumpuh , masalah kuku, Selangor.

ABSTRACT

Lameness is a condition that impairs animal locomotion and a major concern impacting goat productivity and welfare. Hoof disorders are the major causes of caprine lameness. However, there is a dearth of information on lameness and hoof disorders within Malaysia's goat farming context. This study investigated the prevalence of lameness, hoof disorders, and the associated factors among goats in Ladang Angkat Farms. A cross-sectional study was conducted in five purposively selected farms. A total of 100 goats were randomly selected and observed using a five-point locomotion scoring scale. Hoof disorders were examined, and data were collected on goat and farm characteristics, including age, breed, sex, body condition score (BCS), hoof length, production type, herd size, management practices, hoof care routines, floor type, and feeding regimen. Data were analysed using descriptive statistics and logistic regression models. The mean (standard deviation) age of the goats was 2.35 (± 0.57) and 53.0% had poor BCS. The prevalence of lameness was 23% (LS of 3 and above) and hoof disorders was 54% (95% Confidence interval; CI 4.2 – 30.8%) and 54.0% (95% CI 16.7-69.2%), respectively. Among the lame goats, 87% had overgrown hooves. Lameness was predominant on the left hindlimb (47.8%), followed by the right hindlimb (30.4%), right forelimb (13%), and left forelimb (8.7%). No significant association was recorded between lameness and age, sex, breed, BCS, or health status. However, a strong association between lameness and hoof length indicated that goats with overgrown hooves were more likely to be lame (Odds ratio; OR = 8.54; 95% CI: 2.31-31.56) than those with normal hoof length. Three of the farms practiced intensive management, while none of the farms practiced hoof care. These findings depict a high prevalence of lameness and hoof disorders in the sampled farms and the need for proactive hoof care practices in goat farms.

Keywords: Goats, lameness, hoof disorder, prevalence, Ladang Angkat.

1.0 INTRODUCTION

Lameness and hoof diseases are formidable challenges that impact both animal welfare and the economic viability of the global goat industry. Lameness, characterized by impaired movement and gait, poses significant implications ranging from diminished animal well-being to reduced productivity (Garvey, 2022). Hoof disorders emerge as primary contributors to lameness, exacerbating welfare concerns and hindering efficient livestock production (Jesse et al., 2018).

In the context of goats, lameness can arise from various causes, including trauma, overuse, and underlying hoof conditions (Garvey, 2022b). These conditions are broadly categorized as infectious and non-infectious hoof diseases (Jesse et al., 2018). Infectious hoof diseases, often caused by bacteria or fungi, have the potential to spread rapidly within goat populations, resulting in notable economic losses and compromised animal health (Bitrus et al., 2017). Conversely, non-infectious hoof ailments result from external factors such as inadequate diets, suboptimal hoof care, and environmental conditions (Ströbel et al., 2014).

Effective prevention and management of lameness and hoof diseases are crucial for maintaining optimal goat welfare, supporting productive livestock farming, and minimizing economic losses (Garvey, 2022). However, comprehensive data on the prevalence of these issues and their associated factors within specific geographic regions, such as Malaysia, are limited. Research endeavors addressing the hoof health of goats in Malaysia are therefore imperative for the development of targeted strategies to mitigate these challenges.

The economic consequences of lameness and hoof disorders in goat farming are profound, escalating veterinary costs, reducing reproduction rates, and impairing meat or milk production (Ibishi et al., 2021). This impact is particularly pronounced in goat farming due to the unique anatomy and physiology of goat hooves, as well as specific breeding or management practices that may exacerbate these challenges compared to other livestock (Zhang et al., 2013). Furthermore, the importance of

considering geographic variations in the prevalence and nature of lameness and hoof diseases cannot be overstated. Factors such as climate, environmental conditions, and local farming practices in regions like Malaysia may influence the occurrence and severity of these issues in goats (Ibishi et al., 2021).

1.1 Objective

General Objectives

To assess the prevalence of lameness, hoof disorders, and their associated factors among goats in Ladang Angkat farms in Selangor, Malaysia.

Specific Objectives

1.1.1 To determine the prevalence of lameness of goats in Ladang Angkat Farms

1.1.2 To determine the relationship between lameness prevalence and hoof disorders

1.1.3 To determine the association between lameness and farm-level and animal-level factors

1.2 Hypothesis

H1 : There is no significant association between lameness and hoof disorders among goats in Ladang Angkat Farms, Selangor, Malaysia

H2: There is no significant association between prevalence of lameness and animal level factors among goats in Ladang Angkat Farms, Selangor, Malaysia.

H3: There is no significant association between the prevalence of hoof disorders and animal level factors among goats in Ladang Angkat Farms, Selangor, Malaysia.

1.3 Problem statement

Despite the global significance of these challenges, comprehensive data on the prevalence of lameness and hoof diseases, especially in specific regions like Malaysia, remain notably limited. This knowledge gap hinders the development of targeted strategies for effective prevention and management, impeding efforts to maintain optimal goat welfare, support sustainable farming practices, and minimize economic losses in the Malaysian goat industry. Addressing this gap is not only academically relevant but crucial for the advancement of sustainable goat farming practices and the enhancement of overall animal welfare in Malaysia.

1.4 Justification

There has been extensive researches of hoof diseases and welfare in cattle but limited information is found regarding hoof disorders in goats, especially in Malaysia. The significance of this research is to anticipate the effects of lameness that can impact animal welfare and production as well as explore the prevalence of lameness in goat farms in Malaysia that remain underreported. This study also underscores and assesses the association between factors that increase lameness. The study on the associated risk factors are to help implement effective control and prevention measures.

2.0 LITERATURE REVIEW

2.1 Introduction to lameness

Lameness and hoof diseases in goats are of substantial welfare and economic concerns, with far-reaching implications for both individual animal health of the goats and the broader livestock industry in general. These issues have garnered significant attention due to their potential to compromise animal well-being, productivity, and economic viability. Not only does lameness affect the welfare of the animal but it reduces the production ability of the goats when it comes to all ranges from meat production , breeding to milk production (Jaques et al., 2023). This severely impacts the economic potential of the goats as it interferes with growth and feeding.

2.2 Prevalence of lameness

Lameness, which is characterized by altered gait and movement is a result from a variety of factors including physical trauma, overexertion, and underlying hoof conditions as well as poor hoof health management practices which leads to the overgrowth of hoof length. The prevalence of lameness in goats has been reported to range from 5% to 15% (Browne et al., 2022), with variation influenced by factors such as management practices, housing conditions, and breed susceptibility emphasize that while lameness can stem from various causes, hoof disorders are often the underlying contributors. According to the research results, the prevalence of lameness in goats varies depending on the farm and the region. A study conducted in Germany found that not more than 1.6% of goats showed signs of mild and moderate lameness compared to 47.6% of goats having moderate claw overgrowth (Sporkmann et al., 2017).

The prevalence of lameness in goats is a critical aspect of their overall health and well-being, with implications for both individual animals and the broader agricultural industry. Understanding the prevalence of lameness is essential for implementing effective management strategies, ensuring optimal animal welfare, and sustaining productivity within goat farming systems. Several factors contribute to the prevalence of lameness in goats. Trauma, overuse, infectious agents, and non-infectious contributors such as suboptimal diets and environmental conditions play pivotal roles in the development of lameness. (Jaques, Turner, Vallée, Heuer, Deeming, et al., 2023)

Infectious hoof diseases, often caused by bacteria or fungi, can spread rapidly within goat populations, leading to notable economic losses and compromised animal health. On the other hand, non-infectious hoof disorders may result from inadequate hoof care practices, nutritional deficiencies, or exposure to harsh environmental conditions. (Groenevelt et al., 2015e)

2.3 Lameness assessment

Identifying lameness in goats is a critical aspect of effective herd management, as it directly impacts the well-being of individual animals and the overall health of the herd. Lameness, characterized by abnormal movement or gait, often manifests through observable signs such as limping, an uneven gait, and reluctance to bear weight on one or more limbs (Groenevelt et al., 2015b).

Additionally, goats with lameness may exhibit changes in posture, favoring one leg or assuming abnormal resting positions. Regular visual examinations are key to early detection, involving a careful inspection of hooves for signs of swelling, redness, or discharge, as well as checking leg joints for indications of discomfort or tenderness (Groenevelt et al., 2015).

2.4 Impact of lameness

The impact of these conditions is widespread, affecting animal welfare and industry profitability. Lameness often results in pain, discomfort, and reduced animal performance. This will ultimately reduce the animal's intake of feed which affects its nutrition. Additionally, the economic consequences of lameness and hoof diseases encompass decreased milk and meat output, compromised reproductive rates, and increased mortality rates (Jaques et al., 2023).

These challenges highlight the need for effective prevention and management strategies to mitigate these issues. Lameness in goats presents a multifaceted challenge with profound implications for both individual welfare and the broader goat farming industry. Affected goats endure pain, discomfort, and distress, hindering natural behaviors and raising ethical concerns about humane livestock management (Nonga et al., 2009).

The impact on productivity is substantial, with lameness directly influencing milk and meat production, reproductive rates, and overall growth (Juárez et al., 2003). Nutritional deficiencies resulting from compromised mobility further exacerbate the issue, while stress-induced vulnerability to diseases poses additional challenges. Economic consequences, including veterinary costs, potential culling, and market challenges due to diminished product quality, strain farm budgets and profitability. (Garvey, 2022)

Recognizing the multifaceted nature of lameness enables the development of comprehensive strategies to address its effects, prioritizing animal well-being, sustainable farming practices, and the economic viability of the goat industry. (Azarpajouh et al., 2020)

2.5 Animal-level risk factors of lameness in goats

Lameness in goats can be attributed to various factors and it is essential to consider animal-level factors that play a role in the overall health of the animal that when these factors are disrupted increases the risk of the likelihood of the goats to develop disorders that affect the limbs which results in the presentation of lameness.

Body Condition Score (BCS) is an important factor that affects lameness in goats. A study conducted on dairy cows found that cows with a BCS less than 2 are at the greatest risk of mild or severe lameness. Conversely, a BCS above 2.0 is correlated with a reduced risk of mild or severe lameness. (Randall et al., 2015). Although there is limited information on goats, a study on dairy cattle found that body condition score loss of >0.75 points in early lactation was associated with lameness in week 4 postpartum (Hut et al., 2021).

Study done by Browne et al., 2022a states that cow-level risk factors for increased lameness prevalence was age. Age can affect lameness in goats, but the relationship between age and lameness is not straightforward. The prevalence of lameness varies across different age groups, and the risk of lameness can change as goats grow older. During the rapid growth phase, young goats' bones and joints are still developing, and this can sometimes lead to imbalances or irregularities in bone and joint development, which may contribute to lameness. (Matthews, 2016). The causes of lameness in older goats can be similar to those in younger goats and include joint and bone issues, as well as systemic diseases such as Caprine Arthritis Encephalitis Syndrome (CAE). (Matthews, 2016). Other studies, by (Rowlands et al., 1985) and (Haskell et al., 2006) also claim that the risk of lameness increases with age . This is due to the changes in the functional anatomy of the hoof as the animals age, which includes the degeneration of the digital cushion (Räber et al., 2004).

An investigation on the pattern on lameness in dairy goats across the first two years of life was done by (Deeming et al., 2021). This study was to evaluate how lameness occurrence changes across the first two years of life in eighty female goats. It was shown that the highest proportions of goats classified as having lameness were observed at the 13-month (37.3%) and 25-month assessment (47.5%). The odds of a goat having an impaired gait were greater by a factor of 2.15 (95% CI: 1.02 – 4.54, P<0.05) at the 13-month assessment and 3.79 (95% CI: 1.90 – 7.57, P<0.001) at the 25-month assessment compared to the nine-month assessment. These assessments were following kidding, suggesting a potential parturition effect.

Hoof length of the goats due to lack of hoof care also plays a role as a risk factor in leading to lameness. Overgrown hooves lead to poor hoof conformation, which has been associated with an increased risk of hoof lesions and lameness in dairy goats. (Deeming et al., 2019b). Poor hoof conformation is associated with an animal′s susceptibility to hoof lesions and lameness (Boêttcher et al., 1997). Another study done in ewes showed results that ewes with poor hoof conformation were more likely to become lame (OR: 1.83 (1.24-2.67)).(Kaler et al., 2010)

2.6 Farm-level risk factors of lameness in goats

Apart from animal-level factors that increase the risk of lameness, farm-level factors such as the farm management practices and herd factors also play a role in the susceptibility of goats to exhibit lameness. Study done by Browne et al. (2022a) on cattle states that herd-level risk factors included farm management, herd size, and the farmers' perception of whether lameness was a problem on the farm which is followed by practices of hoof care , vaccination and deworming processes.

Study done by Adams et al. (2017) shows that large operations in cattle farms had a lower within-herd prevalence of cows with locomotion score ≥2 when compared with small or medium-sized operations. This indicates that herd-size to be a factor in determining the prevalence of lameness.

Similarly , the farms in which operations on which cows were kept primarily on pasture had a lower percentage of locomotion score = 3 than those housed in free-stall or open/dry lot operations (Adams et al., 2017) .This is suggesting that the type of farm management practices whether semi-intensive or intensive farming to be a factor. Intensive farming where the cattle have no access to pasture leads to a higher prevalence of lameness.

In the same study by Adams et al., 2017, the frequency of hoof trimming was also associated with lameness ($P < 0.030$). Operations on which hoof trimming was performed only when cows were visibly lame had a lower lameness prevalence than operations that trimmed hooves at least once per lactation. This claim would be supported by another study that shows risk factors for increase in prevalence of lameness are free stall-housed cows with no routine trimming (Espejo and Endres, 2007).

The type of flooring surface in which the animals stand also plays a role in the prevalence of lameness. The use of sand bedding in cattle farms was associated with a lower within-herd prevalence of locomotion score ≥2 than straw/hay or dry/composted manure as the primary bedding material. Sand bedding was also associated with a lower within-herd prevalence of locomotion score = 3 than other bedding types except for rubber mats or mattresses. (Bran et al., 2018)

2.7 Lameness in ruminants in Malaysia Livestock Industry

A few bovine lameness researches have been conducted in Malaysia. In this case however , most of the data is reflective on the large ruminant sector of Malaysian farms and not conclusive of the whole sector as it is unable to accurately represent the small ruminant sector. This show the dearth of information in this area that can be improved on.

A study done by Sadiq et al. (2020) shows findings on cow-level and herd-level factors that are associated with lameness in dairy farms in Peninsular Malaysia.

Over the course of this study it has found a cow-level lameness prevalence of 34.2% (95% CI 22.2-50.0%). This study is reflective of the prevalence rate of lameness of cattle in Malaysia as the region in this study was conducted was 28 dairy farms located in Selangor. Claw lesions were recorded in 470 cows (46.9%), and claw overgrowth was also observed (Sadiq et al., 2020). This study however is conducted on cattles and no similar studies have been performed in goats.

Another study on the prevalence of lameness, claw lesions, and associated risk factors in dairy farms in Selangor, Malaysia. The study conducted by Sadiq et al., 2017 shows a cross-sectional study involving 251 lactating cows from eight farms in Selangor found that the overall prevalence of lameness was 19.1%, The prevalence of lameness in the individual farms were ranging from 10.0% at its lowest to 33.3% at its highest. It was also noted that 31.1% of cows had claw lesions, ranging from 16.3% to 40%. Claw lesions were recorded in 87.5% of the lame cows, with the highest prevalence in cows affected with sole lesions (54.2%) and white line disease (61.2%). The study also identified several risk factors associated with lameness and claw lesions. Lameness was associated with early lactation, injured hocks, and dirty legs hygiene, while the presence of claw lesions was associated with dirty legs hygiene and overgrown claws. (Sadiq et al., 2017b). This study contributes to the dearth of information in the ruminant sector however it does not compensate for the dearth of information among the small ruminant sector , mainly in goats.

Lameness in goats is a significant issue in the Malaysian Livestock Industry. However , there is limited research on lameness in goats. Few studies have been conducted to understand the factors contributing to lameness in goats and dairy cows in Malaysia. These studies aim to find the associated risk factors that lead to lameness.

3.0 MATERIALS AND METHODS

3.1 Ethical statement

The research protocol in this study was approved by the Institutional Animal Care and Use Committee of Universiti Putra Malaysia with the reference number of UPM/IACUC/AUP-U022/2023).

3.2 Study design

The cross-sectional study was carried out in Ladang Angkat farms registered with University Putra Malaysia (UPM) in the region of Selangor.

The inclusion criteria entailed farmers' consent, adequate herd size of goats in the farm and goats aged older than 1.5 years of age. In this study, the aim is to focus on a specific age group to ensure a more homogenous dataset, minimizing the inclusion of outliers at the extremes. This targeted approach aims to enhance the consistency and reliability of the data analysis by narrowing the age range and reducing potential variations associated with extreme age values.

Sample size calculation involves determining the number of participants needed for the study to achieve a specified level of precision and confidence. Factors such as population variability, confidence level, margin of error, desired power, and effect size are taken into considerations in the calculation. With the aid of EpiTools a comprehensive sample size calculation was done which resulted in an optimum level of 111 goats to be sampled.

A total of 100 goats were sampled in the study. The sampling technique employed was a random sampling technique for the selection of participants in this study. Random sampling involves the unbiased and chance-driven selection of individuals from the population. This is aimed to achieve a representative and fair sample,

minimizing the risk of systematic bias. Random sampling helps ensure that each member of the population has an equal opportunity to be included in the study, enhancing the generalizability of the findings to the broader population. This method also reduces the likelihood of inadvertently introducing any patterns or preconceived notions into the sample selection process, contributing to the overall validity of the research results

The sampling process aimed to capture a representative subset of the goat population in these farms, allowing for a comprehensive assessment of lameness prevalence. Within this framework, lameness scoring was employed as a diagnostic measure and goats identified with lameness scores of 2 and above were considered to be lame whilst score 1 indicated no forms of lameness observed.

3.3 Farm selection

The study locations were selected due to the proximity to the researcher's institution, and accessibility in obtaining prompt approval for farm visits. A total of 5 goat farms were contacted and have agreed to take part in this study. In order to reduce the potential for bias during farm selection, farms were contacted without prior knowledge of the farm's owner and they were informed about the study objectives, inclusion criteria, methodology, and voluntary participation.

The farms were visited from 5th of August 2023 to 21st of September 2023. The selection of these farms was strategic, driven by considerations of accessibility for UPM students involved in the research, ensuring a practical and efficient execution of the study.

3.4 Herd selection

A sample size calculation for proportions was used to determine the number of goats to be assessed from each farm. This was estimated based on herd size,

expected prevalence of 20% (Christodoulopoulos, 2009), 95% confidence interval (CI), and 5% precision level. This resulted in the required sample size of 111 goats.

This study mainly focused on middle aged goats (older than 1 year old) since there is a greater level of lameness incidence during the period, and goats above the age of 4 were not present in any of the farms visited. A total of 100 goats were observed from the 5 farms selected. Of these farms in Selangor each farm was sampled with the amount ranging from 12 goats to 25 goats from one farm. This variation in the range can be attributed to the lack of goats in the farm as most of the farms practiced the preference of rearing sheep.

3.5 Farming system and husbandry

The goats were housed in open housing systems where the farm was run on intensive to semi-intensive settings where they were allowed to roam and feed on grass once a day.As most of the farms were open housing systems , this meant that the ventilation for the houses were adequate to remove moisture and odors and provide fresh air.

The housing of the goat house was made of wooden planks that were elevated to allow for the feces to accumulate under the house.The floors were well-drained, clean, and dry with no bedding. The floors had gaps in between that allowed for proper drainage and prevented the retention of water in the houses. The roof of the goat houses were made of zinc to protect from the not weather with no other forms of insulation for the building.

The goat farms were separated into different housing units. Most of the farms were managed by 1-3 workers. The goats were kept in a separate pen from the sheeps and were grouped based on separation of the goats were done based on separating different age groups, sexes, and sick goats to prevent fighting and disease transmission.

Fencing was also done in farms that practiced semi-intensive systems and allowed their goats to roam and feed on grass. The farm installed secure fencing to keep goats safe from predators and to prevent them from escaping. The fencing was tall and sturdy, as goats are known for their climbing ability.

3.6 Feeding system

The farm's husbandry practices revolved around a well-thought-out approach to feeding and maintaining the well-being of the animals. The primary diet for the goats comprised specially formulated forage pellets, ensuring a balanced and nutritionally rich source of sustenance.

To facilitate efficient feeding and watering, the design of the farm included strategically located areas that were easily accessible and distinct from the resting and sleeping zones. This separation not only promoted cleanliness but also contributed to the goats' overall comfort. Clean and fresh water was made available consistently, facilitated by the implementation of automatic waterers. This innovation not only ensured a continuous supply of water but also added a layer of convenience for the goats, allowing them easy access whenever needed.

In the feeding areas, the use of feeders was a key aspect of the husbandry strategy. These feeders were thoughtfully designed to minimize wastage and protect the feed from the elements, particularly keeping it dry. This approach not only optimized the efficiency of feed utilization but also contributed to cost-effectiveness by reducing unnecessary waste.

The emphasis on accessible water, efficient feeding practices, and the careful design of feeding and resting areas collectively reflects a commitment to the well-being of the goats. By integrating these thoughtful husbandry practices, the farm aimed to create an environment that supports the health, comfort, and overall thriving of the goat population. These considerations underscore the importance of

sound husbandry practices in ensuring the welfare and productivity of the animals on the farm.

3.7 Study design flow

The assessment of goat health involved a comprehensive evaluation that included scoring for lameness using a predetermined lameness scoring scale to distinguishing between non-lame and lame goats. During the observation, various parameters were documented, including Body Condition Score (BCS), parity, reproductive status, health status, hoof lesions, hoof length, and the farm history. The lameness scoring scale ranged from 1 to 5, any goat scoring >2 and above was categorized as lame and subjected to further classification based on the severity of lameness. The process began with an initial observation from a distance and these lame goats were carefully restrained for a closer examination of the hooves. Once restrained, a meticulous examination of the hooves was conducted, and the observed patterns were documented. Special attention was given to identifying any lesions or deformities in the hooves that could potentially contribute to the causes of lameness in the goats.

3.7.1 Study design flowchart

In the comprehensive assessment of lameness among the selected goat population, a rigorous methodology was employed, involving multiple observers who conducted locomotion scoring (LS) assessments. The procedure, designed to ensure accuracy and reliability, entailed allowing the goats to traverse a walkway while applying the five-point LS system developed by Deeming et al. (2018). Any goat exhibiting a locomotion score (LS) of ≥ 2 was unequivocally categorized as lame, thereby establishing a standardized criterion for lameness determination.

To enhance the robustness of the locomotion scoring, particular attention was given to the procedural details. LS evaluations were meticulously recorded only after the goat completed two or more strides at a normal pace on a flat surface. This

precautionary measure aimed to provide a consistent and even surface, thus minimizing the influence of external variables on the scoring process.

Beyond locomotion scoring, a spectrum of animal-based measures was systematically examined to enrich the dataset. Body condition score (BCS), a crucial indicator of overall health and nutritional status, was appraised with a refined approach based on the method developed by Ngwa et al. (2007). The scoring system incorporated 0.5 increments, allowing for a nuanced assessment. Notably, goats with BCS ≤ 2.0 were categorized as being in poor condition, those with BCS ≥ 2.5 and ≤ 4 were deemed to be in good condition, while a BCS ≥ 4 indicated over-conditioning.

Gender differentiation was achieved through meticulous observation of the genital region, ensuring the accurate categorization of sampled goats as either male or female. Health status, a multifaceted aspect of the assessment, was comprehensively evaluated during a detailed physical examination. This encompassed scrutiny for clinical signs beyond those indicative of lameness, thus providing a holistic perspective on the goats' overall well-being.

Hoof length, a pivotal element in lameness assessment, was scrutinized using a refined 3-point scoring scale, as per the methodology established by Prado et al. (2022b). This meticulous evaluation facilitated the categorization of hooves as either possessing normal length or being properly trimmed (score 1), slightly overgrown (score 2), or significantly overgrown (score 3).

Subsequent to the aforementioned assessments, all fore and hind limbs of the animals underwent meticulous examination for the presence of any lesions. To ensure clarity in visualization, hooves were diligently cleaned using a hoof pick, thereby facilitating the identification and documentation of any lesions that might be present. This thorough examination of each element in the assessment process contributed to the comprehensive understanding of lameness factors in the studied goat population.

3.7.2 Locomotion scoring

Lameness scoring stands as a systematic and crucial method employed to assess and quantify the degree of lameness in animals, a practice especially relevant in the context of goat husbandry. This method offers a standardized approach to evaluate the gait and movement of goats, providing a reliable means to identify lameness and gauge its severity. Numerous lameness scoring systems have been developed, each contributing to consistent and objective assessments. One widely adopted system is the locomotion scoring scale, which categorizes animals based on their observed gait and behavior.

In the specific context of the research investigating the prevalence of lameness and hoof diseases among goats at Ladang Angkat Farms, the utilization of a lameness scoring system is poised to be a fundamental component of the methodology. This system serves as a valuable tool to categorize goats into different levels of lameness, facilitating a detailed analysis of associated factors and prevalence rates within the studied goat population.

The lameness scoring scale, typically ranging from 1 to 5, provides a comprehensive framework for characterizing the varying degrees of lameness. Each numerical score corresponds to a specific level of impairment:

- Score 1: At this level, goats exhibit a normal gait, walking with a smooth and coordinated motion, displaying no discernible signs of lameness. This score serves as a reference point for healthy locomotion.
- Score 2: Goats with a score of 2 manifest mild alterations in their gait, such as a slightly uneven step or minor stiffness in movement. While lameness is present, it is considered mild at this stage.
- Score 3: Moderate lameness is evident in goats with a score of 3. These individuals show noticeable reluctance to bear weight on one or more limbs during movement, indicating a more pronounced level of impairment.

- Score 4: At this stage, goats exhibit severe lameness, displaying significant difficulty in walking and an increased reluctance to move. This stage reflects a substantial impact on the goats' mobility.
- Score 5: The highest level of lameness, represented by a score of 5, indicates severe impairment. Goats at this level are often unable or unwilling to bear weight on a limb while standing or walking, signifying a critical condition demanding immediate attention.

3.7.3 Age

Dental aging is a method of estimating the age of goats based on the wear and development of their teeth. It is a relatively accurate method for goats up to about four years of age. (Zeder & Lapham, 2010). This intricate process involves the gradual transition from deciduous teeth to permanent teeth, presenting a window for estimating a goat's age, particularly during the initial four years of its life. The lower front teeth, in particular, emerge as critical indicators for estimating a goat's age (Eubanks, 2012). The eruption and subsequent wear of these teeth serve as reliable markers, providing essential information about the goat's developmental stage.

Eruption of Permanent Teeth

- 1-1.5 years old: The first pair of permanent incisors erupts. First year (kid) All teeth are small and sharp and will gradually be replaced by larger, permanent teeth.
- 1.5-2 years old: The second pair of permanent incisors erupts. Second year (yearling) The goat loses the two middle front teeth when it is around 12 months old, and they are replaced by larger, permanent teeth.
- 2.5-3 years old: The third pair of permanent incisors erupts. Third year (2-3 year-old) The teeth next to the middle pair are replaced by permanent teeth when the goat is about 24 months old.

- 3.5-4 years old: The fourth pair of permanent incisors erupts. Fourth year (4 year-old) The goat now has six permanent teeth, with only one pair of kid teeth remaining.
- >4 years old: The full set of permanent incisors erupts

3.7.4 Body Condition Scoring

Body condition scoring (BCS) in goats is a valuable management tool that aids in assessing the nutritional status and overall health of individual animals within a herd. The scoring system typically ranges from 1 to 5, with each point representing a different level of body condition. This method provides a subjective yet standardized way to evaluate the amount of fat and muscle on a goat's body.

- Score 1 (Emaciated): Goats with a BCS of 1 are extremely thin, lacking muscle and fat cover. Their skeletal features are prominent, and there is a noticeable absence of flesh along the backbone and ribs.

- Score 2 (Thin): Goats with a BCS of 2 exhibit thinness with minimal fat cover. The ribs are easily palpable, and the backbone is visible. These goats may have a slightly sunken appearance in their flank area.

- Score 3 (Moderate): A BCS of 3 indicates a goat with a moderate and balanced body condition. The ribs are palpable but not overly prominent, and there is an appropriate amount of fat cover over the backbone.

- Score 4 (Fat): Goats with a BCS of 4 have a noticeable layer of fat covering the ribs and backbone. The animal appears plump, with a rounded appearance in the flank area. However, the ribs can still be felt with moderate pressure.

- Score 5 (Obese): A BCS of 5 represents an overweight goat with excess fat deposits over the ribs, backbone, and tailhead. The animal has a round and bulging appearance, and the ribs are difficult to feel due to the thick fat cover.

3.7.5 Hoof length scoring

Hoof length scoring in goats is a practical and visual method to assess the condition of a goat's hooves. A 3-point scoring system by (Prado et al., 2022b), ranging from 1 (normal/properly trimmed) to 3 (very overgrown), is commonly used to evaluate the length of the hooves and to identify potential issues. This scoring system is a valuable tool for goat keepers to maintain optimal hoof health and prevent problems associated with overgrown hooves.

Score 1 (Normal): Hooves with a score of 1 are considered normal. They exhibit an appropriate length that aligns with the natural growth rate of the hooves. The hoof walls are well-trimmed, and the sole and heel are at a suitable length, providing a solid and even base of support for the goat. The visual Indicators include ,the hoof wall is in line with the sole and heel , there are no visible signs of excessive growth and the goat moves comfortably and displays a natural gait.

Score 2 (Slightly Overgrown):Hooves with a score of 2 indicate a slight overgrowth that requires attention but is not yet severe. The length of the hoof walls, sole, or heel may be slightly extended beyond the ideal length. While the overgrowth is noticeable, it has not reached a critical point that hinders the goat's mobility or causes significant discomfort. The visual Indicators include some elongation of the hoof walls, sole, or heel is observed , the overgrown areas are noticeable but not extreme and the goat may exhibit subtle signs of discomfort or altered movement.

Score 3 (Very Overgrown): Hooves are significantly overgrown, requiring prompt attention. The length of the hoof walls, sole, or heel is well beyond the normal range, affecting the goat's mobility and potentially leading to discomfort, lameness, or other hoof-related issues.Visual indicators include hoof walls, sole, or heel are visibly and significantly overgrown , the overgrowth is pronounced, impacting the natural shape of the hoof and the goat may display lameness, reluctance to move, or an altered gait.

3.8 Data analysis

Statistical analyses were meticulously conducted using IBM SPSS version 26.0 to for a comprehensive examination of the dataset. Descriptive statistics, including mean, standard deviation, minimum, and maximum, were employed to scrutinize the characteristics of the outcome variable, as well as goat-level and herd-level explanatory variables. The determination of lameness prevalence at the goat level was based on the calculation of cows with a locomotion score (LS) greater than or equal to 2, relative to the total number of observed animals. Hoof length and lameness predictor variables were analyzed using the higher score of the limbs. Binary logistic regression models were systematically constructed to assess the association between lameness prevalence and predictor variables. To ensure the integrity of the model, continuous variables such as staff number, herd size, body condition score (BCS), hoof length, and age were precedingly examined for collinearity. Nonlinear relationships prompted the categorization of variables in accordance with industry recommendations, followed by preliminary testing for associations with the outcome. The tests run was used to evaluate the potential risk for associated factors with p-value less than 0.5 indicating a statistical significance

4.0 RESULTS

A total of 100 goats were examined from the 5 farms and upon observation of the goats, it was found that the mean distribution of the age of the goats is 2.35 ± 0.575 and the mean distribution for BCS of the goats is 2.73 ± 0.504 depicted in Table 1.

Variable	Value (Mean; Standard deviation)
Age	2.35 ; 0.575
Body Condition Score (BCS)	2.73 ; 0.504

Table 1 : Age and BCS

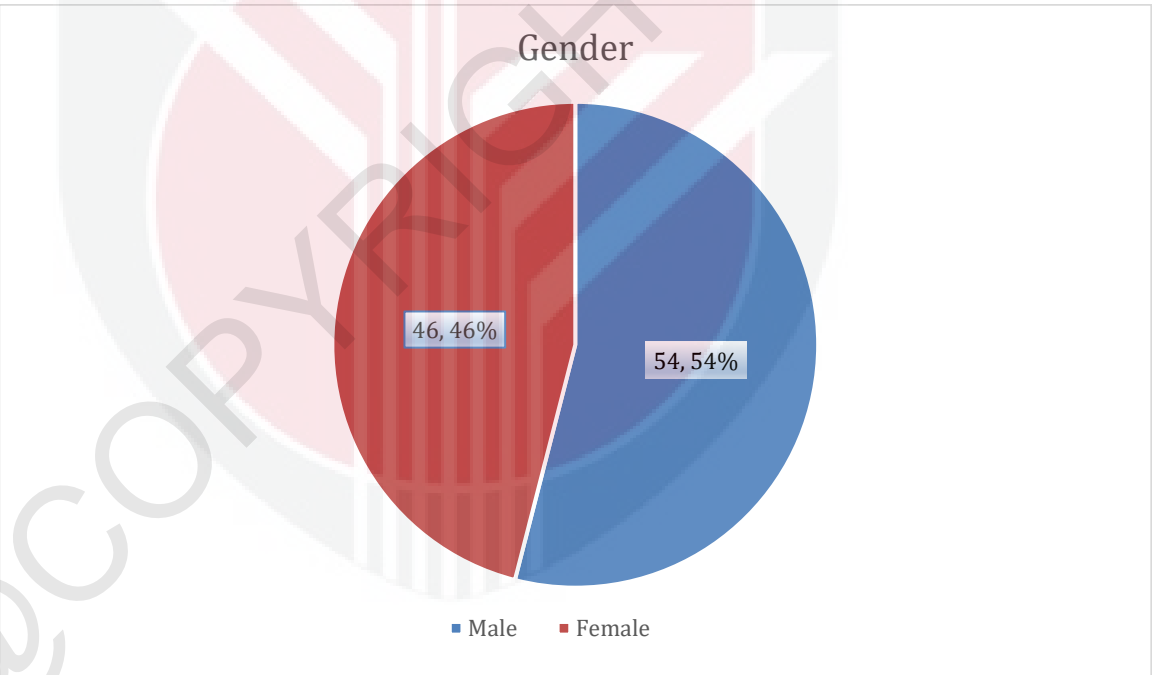

Figure 1 : Gender distribution of goats

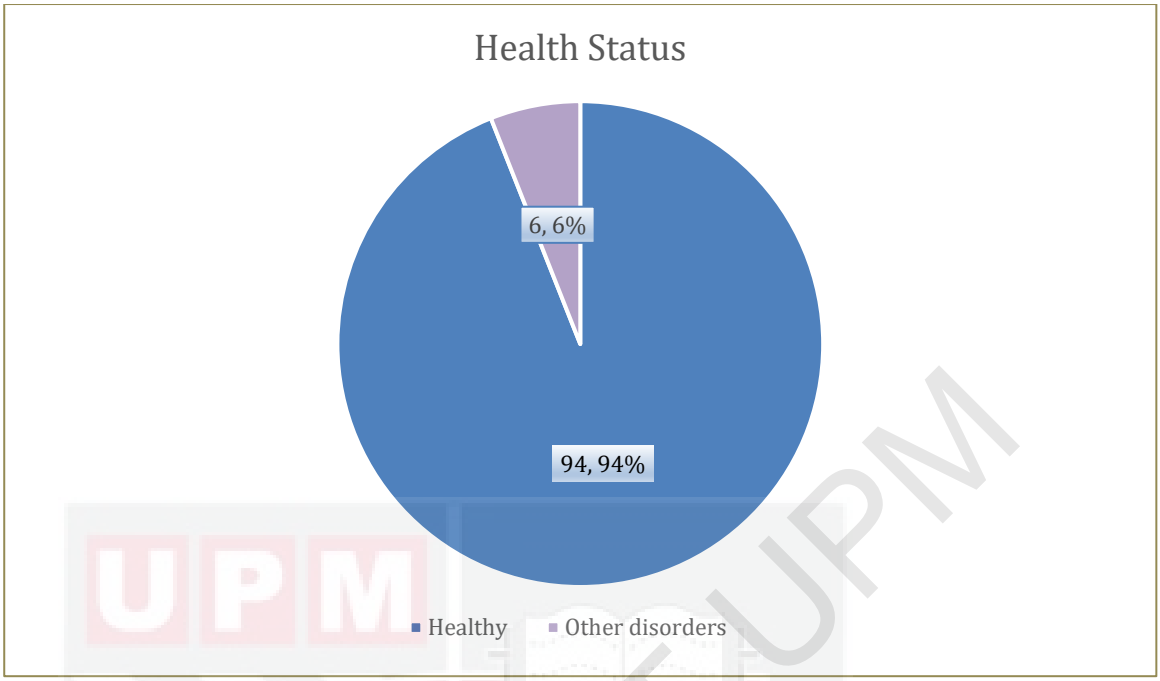

Figure 2 : Health status of goats

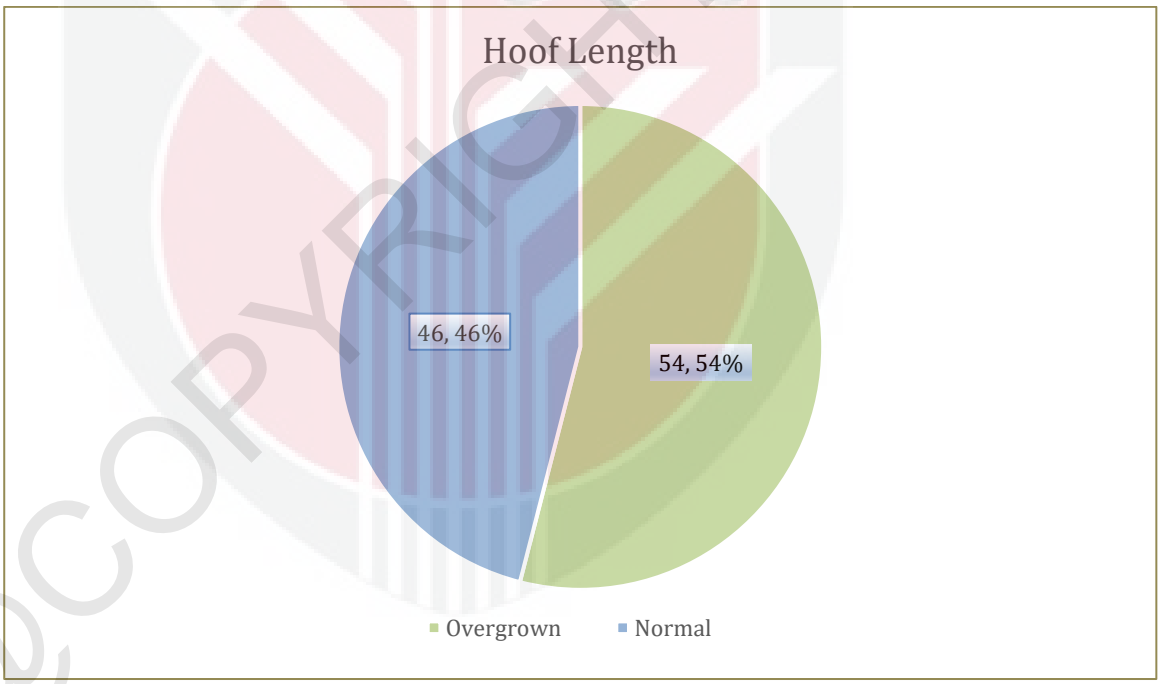

Figure 3 : Hoof length of goats

Figure 1 depicts the distribution of the gender of the goats in the farm with 46 males and 54 females showing a relatively balanced distribution of gender among the samples chosen. Figure 2 depicts the health status of the goats where 94 of the goats did not exhibit any signs of illness and the remaining 6 showed clinical signs such as discharge from the eyes and nasal region. Figure 3 depicts the condition of the hoofs upon examination of the hooves it was found that there were 54 of the 100 goats were observed to have overgrown hooves. Figure 3 also shows the prevalence of hoof disorders in the farms is at 54% (95% CI : 16.7-69.2%).

	Management system	Herd size	Feeding	Housing and flooring	Deworming routine	Vaccination routine	Hoof care practices
Farm 1	Intensive	>50	Forage	Wooden Raised	No	None	None
Farm 2	Semi-intensive	<50	Soy , pellet , palm leaves	Wooden Raised	No	None	None
Farm 3	Intensive	>50	Napier , pallet	Wooden Raised	Yes	None	None
Farm 4	Intensive	<50	Forage	Wooden Raised	No	None	None
Farm 5	Semi-intensive	>50	Forage , Pellet , Silage , PKC	Wooden Raised	Yes	None	None

Table 2 : Farm characteristics of the study population.

Table 2 shows the management systems practiced in the individual farms practiced in which 3 of the 5 farms practiced intensive farming where the animals were not allowed to graze on open pastures but kept in confined stalls. The herd size for 3 of the 5 farms were considered to be medium scale farming and the other 2 were small scale farming. All the 5 farms had raised wooden goat pens with no bedding. Deworming was only practiced in 2 of the 5 farms and none of the farms practiced any form of vaccination or hoof care practices.

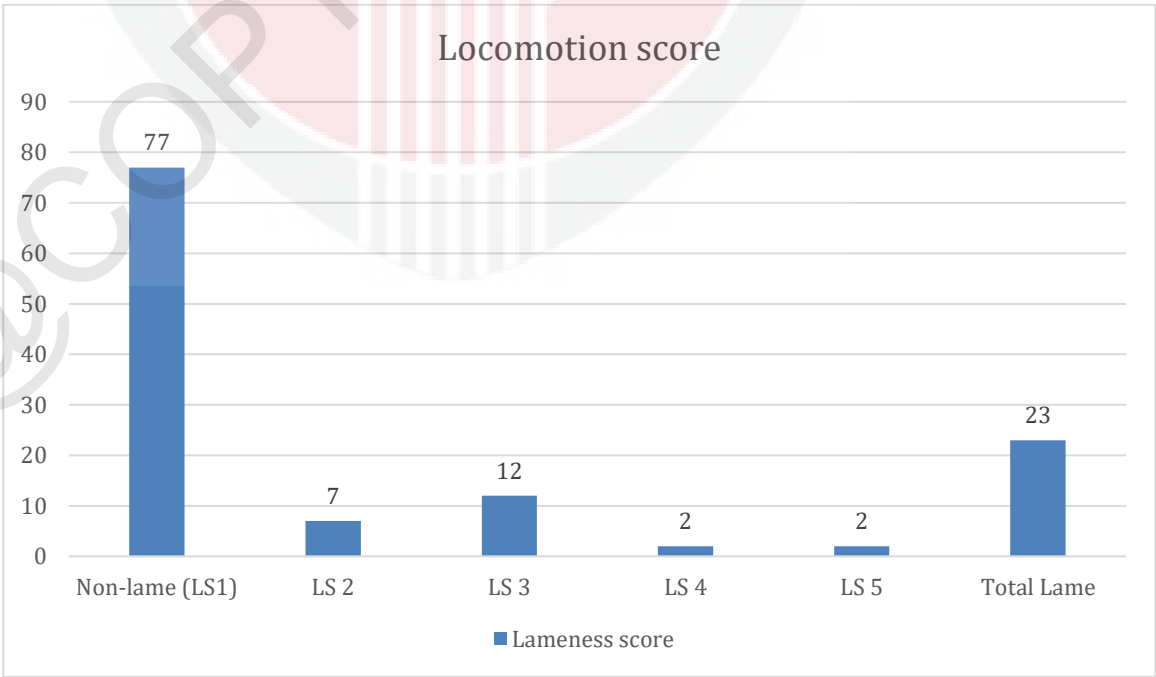

Figure 4 : Locomotion score distribution of goats

Figure 4 depicts the total number of lame and non-lame goats. During the examination it was found that 23 of the 100 goats were found to be considered lame (LS ≥ 2). The majority of the goats (77%) had a locomotion score of 1 which indicated that the goats were not lame. The further breakdown of the distribution of the scores is 7(LS 2) , 12 (LS 3) , 2 (LS 4) and 2 (LS5) respectively. From Figure 4 , it is shown that the prevalence for lameness in the farm is at 23% (95% CI : 4.2 – 30.8%)

Affected limb	Lame goats	Percentage (%)
Left Forelimb	2	8.7
Left Hindlimb	11	47.8
Right Forelimb	3	13.0
Right Hindlimb	7	30.4
Total	**23**	**100**

Table 3 : Distribution of foot affected.

Table 3 depicts the breakdown of the limbs that were observed to be the issue causing lameness. The main limbs affected are the left hindlimb with 47.8% followed by right hindlimb at 30.4%. The forelimbs are less affected with the left forelimb at 8.7% and right forelimb at 13%.

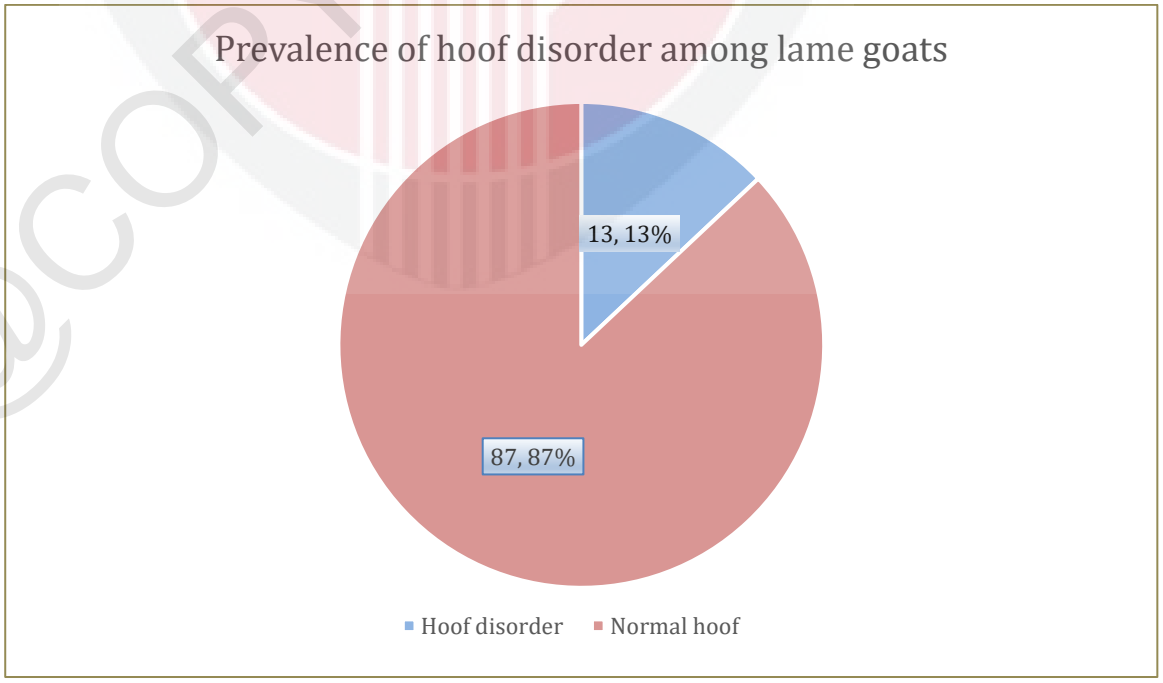

Figure 5 : Prevalence of hoof disorders in lame goats

Figure 5 depicts the prevalence of hoof disorder among the goats that are found to exhibit lameness (LS ≥ 2). The prevalence of hoof disorders when looking at only the lame goats increases from the previous overall prevalence rate of 54% to 87% showing that most of the lame goats also had hoof disorders (overgrown hooves).

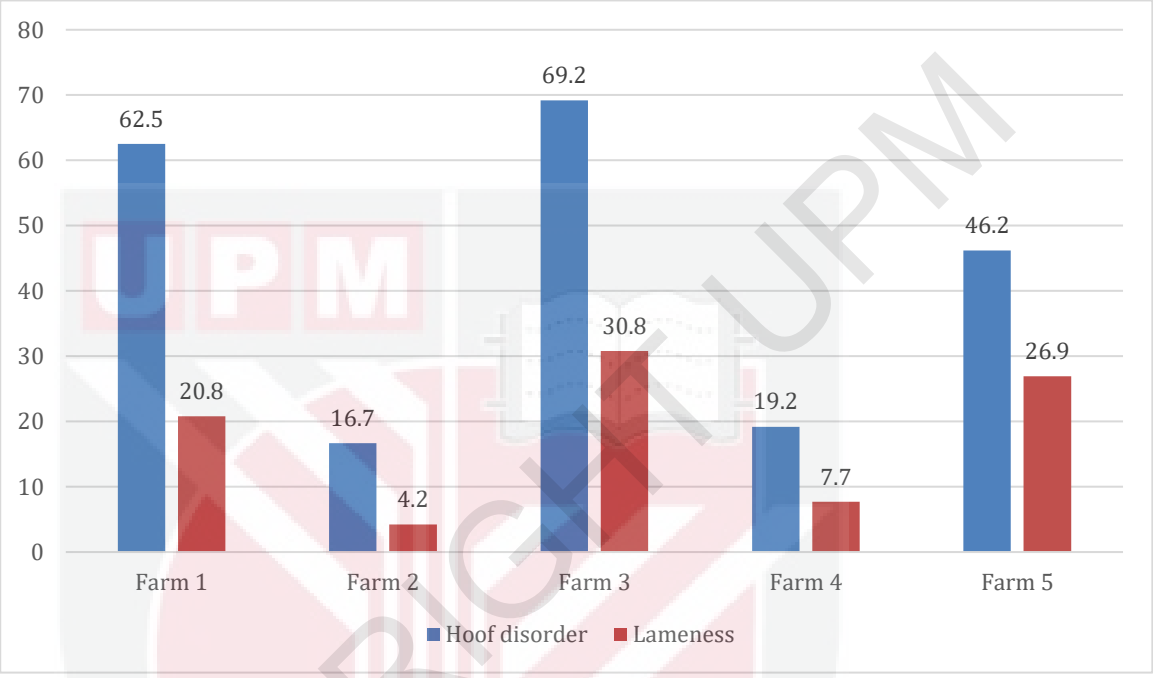

Figure 6 : Distribution of lameness and hoof disorder in each farm

Figure 6 shows the percentage of hoof disorders and lameness among the 5 farms that were observed. The prevalence of lameness in Farms 1 , 2 , 3 , 4 and 5 were as follow, 20.8% , 4.2% , 30.8% , 7.7% and 26.9% respectively. The prevalence of hoof disorders in Farms 1 , 2 , 3 , 4 and 5 were as follow, 62.5% , 16.7% , 69.2% , 19.2% and 46.2% respectively.

Association between animal-level factors and lameness prevalence

Univariable analysis revealed no significant association (P< 0.05) between BCS and lameness prevalence among the sampled goats from the five farms. Likewise, factors such as age, gender, health status and hoof length did not depict any significant relationship (P > 0.05) with the prevalence of lameness. However, goats with overgrown hoof length were 8 times more likely to be lame (OR = 8.43; 95% CI 2.31-30.75) compared to goats with normal hoof length.

Table 4 : Univariable model for the association between animal-level factors and prevalence of lameness among goats in Ladang Angkat farms

Factors	B	S.E.	Wald	P-value	Odds ratio	95% CI	
						Lower	Upper
Body condition score							
Good	-0.416	0.484	0.737	0.390	0.660	0.255	1.704
Poor					Reference		
Age	-0.336	0.416	0.652	0.420	0.715	0.316	1.616
Gender							
Male	-0.560	0.636	0.774	0.379	0.571	0.164	1.988
Female					Reference		
Health status							
Healthy	0.553	0.901	0.377	0.539	1.738	0.297	10.157
Not healthy					Reference		
Hoof length							
Overgrown	2.132	0.660	10.425	0.001	**8.431**	2.311	30.757
Normal					Reference		

5.0 DISCUSSION

This study presents the investigation on the factors associated with lameness in goat farms in Selangor, with specific focus to Ladang Angkat farms. A random sample of 100 goats were used for this study from 5 farms to assess farm-level factors and animal-level factors. During hoof examination conducted by a group of observers trained in animal-based welfare assessment, overgrown hoof was the predominant condition observed, followed by some mild discharges from the nasal region and the ocular region.

Locomotion scoring, coupled evaluation of hoof health for all sampled goats, was undertaken to identify potential causes of locomotion disturbance. It is imperative to note that the selection of farms was influenced by convenience and the willingness of farmers to actively participate in the study. The criteria for farm selection included proximity to UPM and the presence of a substantial goat population, with the intention of ensuring a sufficiently large sample size to facilitate the implementation of on-farm assessment protocols for herd-level factors. While acknowledging the potential for selection bias, the criteria were strategically applied to enroll farms conducive to rigorous evaluation.

All farms recorded cases of overgrown hooves in all the five farms, although Farm 3 showed the highest percentage. The reason for the considerable difference in the prevalence of hoof disorder may be due to the inability to achieve an even number of target sample sizes from each farm of 20 goats per farm. Hence some farms had a target sample size of less than the intended 20 target samples. This can be attributed to the reason that some of the farms did not have sufficient number of goats to be sampled as most of the production at these farms were centered around sheep production and cattle production. This resulted in the inability to obtain the necessary samples from some farms which leads to the compensation of obtaining more samples from other farms. As a result these goats were not evenly distributed in the study in order to fulfill the criteria of 100 goats.

It was noted that most of the and overgrown hoof and affected limb were recorded at the hindlimbs (78.2%) compared to forelimbs (21.7%) in the farms. Mahla (2010) made similar observation while Murray et al. (1996) had reported in U.K. hoof lesions were recorded in the hind limbs (92%). The established association between lameness and the presence of hoof disorders aligns with expectations, as hoof disorders persist as the primary contributors to lameness in goats according to Groenevelt et al. (2015c).

The high prevalence of hoof overgrowth in the farms (54%) could be due to confinement in pens with hard surfaces (slated wood) which reduce horn wear. It was reported by Sherer and Van Amstel (2003) that the hard flooring amplifies the physical impact of severe load bearing on feet and tends to irritate the corium and promote hoof growth, which causes overgrowth and overloading of the affected claws. Moreover it was noted that, in Farm 3 , it was also notable that the prevalence of lameness is also the highest recorded among these five farms.

Most goat-level and herd-level factors were assessed through subjective methods derived from previously published studies, necessitating a cautious approach when comparing the present findings with existing works. Given the cross-sectional nature of the study, caution must be exercised in drawing inferences regarding the directionality of associated factors or their causal effects on lameness prevalence. The study revealed a lameness prevalence of 23% in the investigated population, with a predominant occurrence of hoof disorders among lame goats. Several risks factors (Age , BCS , gender, frequency of trimming, housing condition, deworming and vaccination) were identified to determine whether there was an association between these variables and occurrence of hoof disorders in each farm and overall.

However, the analytical test results show that there were no association between the risk factors and hoof disorders, with all them showing $p>0.05$. Although, a higher percentage of males (54%) showed hoof condition in at least one foot

compared to females (46%), gender was statistically not significant, which could be explained by the higher ratio of males to females in the study sample.

Moreover, even though more goats had hoof condition at farms with no hoof care routine, no association was found between this variable and development of hoof disorders because of unevenness in the sample size in each farm as the result contradicts the study finding whereby significance of predisposing factors, and the value of the early implementation of appropriate preventive and control, in farms where foot related lameness is high (Lewis. 2006).

A substantial percentage of the farms surveyed in this study exhibited high stocking densities, revealing that those with elevated stocking density experienced greater odds of lameness compared to those with ample space. This aligns with research reporting lower lameness prevalence and healthier hooves in goats housed in low stocking densities, in contrast to those in high stocking densities prone to traumatic hoof lesions (Chesterson, 2015). Notably, farms practicing routine hoof trimming demonstrated lower lameness prevalence, emphasizing the reported benefits of this practice in reducing lameness occurrence. Regular on-farm hoof trimming facilitated prompt lameness detection, correction of hoof deformities, and decreased recovery time after treatment, in accordance with findings by Winter (2011).

Additionally, farms conducting preventive hoof trimming only when goats exhibited overgrown claws experienced higher lameness prevalence, possibly due to delayed intervention, as suggested by Deeming et al. (2023). The prolonged intervals between hoof trimmings may provide little benefit in reducing lameness, as posited by Sadiq et al. (2020).

The observed average lameness prevalence of 23% in this study surpasses that reported in intensive dairy farms in other Southeast Asian countries (Sadiq et al., 2017b). This discrepancy may stem from the broader scope of the present study, involving more states, a larger study population, variations in associated factors, management systems, and the definition of lameness Deeming et al. (2023).

Furthermore, the prevalence reported here exceeds estimates from previous observations on dairy goat farms in the UK, where lameness prevalence ranged between 9.1% and 19.2% Groenevelt et al. (2015b). Groenevelt et al. (2015) emphasize the multifactorial nature of lameness and suggest that certain management practices could be more effective in mitigating lameness issues in goats. The prevalence of lameness in this study, ranging from 20% to 60%, is considered high based on benchmarks and classifications from previous studies. However, the low variability in lameness prevalence between intensive and semi-intensive farms suggests that factors associated with lameness may be similar under these management systems.

6.0 CONCLUSION

In conclusion, this study reveals insights into the factors associated with lameness in goat farms, particularly in Ladang Angkat farms in Selangor. The prevalence of overgrown hooves, hindlimb prevalence, and the impact of stocking densities on lameness are highlighted. The selection of farms, though convenient, may introduce bias, and caution is advised in interpreting cross-sectional findings.

While the study identifies risk factors, statistical tests show no significant associations, emphasizing the complex nature of lameness in goats. The importance of routine hoof trimming in reducing lameness is reiterated, contrasting with higher prevalence in farms with irregular preventive trimming.

The observed high lameness prevalence, exceeding benchmarks from other studies, prompts consideration of multifactorial influences. The study contributes valuable information on goat lameness, but further research is warranted to explore management practices that effectively mitigate lameness in different farming systems.

7.0 RECOMMENDATIONS

Based on the high prevalence of hoof overgrowth in each farm, it is imperative to educate farmers on the importance of hoof trimming and to provide training on appropriate claw trimming to reduce the number of goats being affected by the condition, hence allowing a more comfortable gait. There are some limitations in this research that could have affected the findings such as not meeting the targeted sample population in each farm individually and pregnant animals were not sampled because it might cause unnecessary stress and it was not feasible to confirm pregnancies within the goats without proper diagnostic tools. However, for future similar study, a larger sample size would be more convenient. The study should cover more farms and from a wider geographical region for more accuracy. Also, other risk factors such as age, body condition score, nutrition, genetics, breeds and parity should be included for better control and prevention of hoof disorders on the farms.

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