UNIVERSITI PUTRA MALAYSIA

PREVALENCE, RISK FACTORS, EFFICACY OF HOOF TRIMMING, AND TREATMENT PROTOCOLS OF LAMENESS AND HOOF LESIONS IN DAIRY COWS IN MALAYSIA

SADIQ MOHAMMED BABATUNDE

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By

SADIQ MOHAMMED BABATUNDE

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, In Fulfilment of the Requirements for the Degree of Doctor of Philosophy

December 2021

DEDICATION

This thesis is dedicated to my Dad (Engr Nafiu Sadiq Olore) of blessed memory who returned to his creator on the 24th of October 2021. May Allah forgive and grant him Al Jannatul Firdaus (Ameen).

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

PREVALENCE, RISK FACTORS, EFFICACY OF HOOF TRIMMING, AND TREATMENT PROTOCOLS OF LAMENESS AND HOOF LESIONS IN DAIRY COWS IN MALAYSIA

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Chairman : Siti Zubaidah binti Ramanoon, PhD
Faculty : Veterinary Medicine

Lameness is one of the most important health issues in dairy cows. This study aimed to (1) determine the prevalence of lameness and hoof lesions and their risk factors in Malaysian dairy herds, (2) evaluate the efficacy of hoof trimming (HT) techniques for lameness management in grazing and non-grazing cows, and the short-term impact on behavioural activities, cortisol levels, and milk yield, 3) to evaluate the impact of treatment protocols for hoof horn lesions on recovery rates, behaviour and milk yield, and 4) assess dairy farmers' knowledge, attitude, and practices regarding lameness management. The first study comprised a study population of 1,051 lactating cows from 29 dairy farms in Selangor (n = 9), Perak (n = 9), Negeri Sembilan (n = 6) and Johor (n = 5). Lameness was assessed by locomotion scoring, followed by hoof examination and collection of farm and cow-level characteristics. The prevalence of lameness was 34.2% (95% Confidence Interval: 22.2-50.0%). Sole ulcers were the predominant lesion (24.9%), followed by white line disease (19.6%), sole haemorrhage (10.2%), and digital dermatitis (5.6%). Overall, these lesions were influenced by different factors at the cow and farm levels. Three studies were conducted for the second aspect that focused on preventive hoof trimming. First, 520 non-lame cows from two grazing and three non-grazing dairy farms were allocated to either hoof trimming (using the Dutch five-step method) or control groups. Second, 418 non-lame cows from one farm were randomly allocated into three groups: Dutch five-step HT (TRIM1), modified HT method (TRIM2), and a control (CON) group. Locomotion scores and other cow characteristics were assessed monthly for one lactation in all the experimental groups. Third, 20 non-lame cows without hoof lesions were randomly allocated to trimmed (n = 10) and control (n = 10) groups, blood cortisol analysis and behavioural (time spent lying down, feeding, and standing) assessment pre and post-HT, and two days later. Resultantly, lower incidence rates of lameness and significantly higher time to first lameness event were recorded in the trimmed cows in grazing (27.4 cases/100/month, mean ± S.E; 8.12 ± 0.1) and non-grazing farms (31.9 cases/100/month, 8.05 ± 0.2)

compared to the controls (48.4 and 45.8 cases/100/month). Likewise, the incidence rate of lameness was 28.7, 15.8 and 42.8 cases/100 cows/months in TRIM1, TRIM2 and CON respectively during lactation, with TRIM2 demonstrating a significantly higher time to first lameness event (8.26 ± 0.16) than CON (7.32 ± 0.2). Cortisol levels increased significantly ($P < 0.05$) in both groups after treatment compared to the basal levels. Hoof-trimmed cows spent significantly more time lying down, and less time standing and at the feed bunk compared to CON on day 1. The fifth study entailed a randomised clinical trial involving five groups of moderately lame cows (n = 81): Group A (therapeutic trim + administration of ketoprofen + hoof block), Group B (therapeutic trim + hoof block), Group C (therapeutic trim + ketoprofen), Group D (therapeutic trim only), and Group E (non-lame cows receiving only maintenance trim). The enrolled cows were observed weekly until day 28 after treatment. Group A had the highest recovery rate (75%; 15/20, $P < 0.05$) compared to Group D (40%; 6/15). Groups A and E spent lesser time lying down ($P < 0.05$) compared to other treatments. Time spent at feed bunk was highest in Group E ($P < 0.05$) and lowest ($P < 0.05$) in Groups C and D. Hence, treatment protocols for hoof horn lesions affected both the lameness recovery rate and short-term behaviours in moderately lame cows. The last study was a survey conducted among dairy farmers (n = 114) in Peninsular Malaysia. Lameness was ranked as the second most important health issue in Malaysian dairies. Farmers showed satisfactory knowledge about the impact of lameness on dairy cattle welfare and production but most of them (75.8%; 22/29) underestimated lameness and rarely implemented proper management strategies in their farms. Conclusively, the present high lameness prevalence in Malaysian dairy farms requires effective control strategies. The modified HT method employed in this study demonstrated the potential of reducing lameness incidence in grazing and non-grazing cows. However, the impacts of HT and related treatment protocols on welfare indicators need to be considered. These findings add to the body of knowledge regarding the importance of lameness and hoof lesions in Malaysian dairies, and the role of HT techniques in minimising the negative impact on dairy cattle.

Keywords: Lameness, Hoof lesions, Hoof trimming, Dairy cows, Risk factors

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PREVALENS, FAKTOR RISIKO, KEBERKESANAN PERAPIAN TELAPUK DAN PROTOKOL RAWATAN TEMPANG DAN LESI TELAPUK PADA LEMBU TENUSU DI MALAYSIA

Oleh

SADIQ MOHAMMED BABATUNDE

Disember 2021

Pengerusi :Siti Zubaidah binti Ramanoon, PhD
Fakulti :Perubatan Veterinar

Tempang adalah salah satu isu masalah kesihatan yang paling penting pada lembu tenusu. Kajian ini bertujuan untuk (1) menentukan prevalens tempang dan lesi telapuk dan faktor risikonya pada gerompok lembu tenusu Malaysia, (2) menilai keberkesanan teknik perapian telapuk (HT) bagi pengurusan tempang pada lembu meragut dan tidak meragut, dan impak jangka pendek terhadap aktiviti tingkah laku, tahap kortisol, dan hasil susu, 3) menilai impak protokol rawatan lesi telapuk berdasarkan kadar pemulihan, tingkah laku, dan hasil susu, dan 4) menilai pengetahuan penternak lembu tenusu, sikap, dan amalan mengenai pengurusan tempang. Kajian pertama merangkumi populasi kajian pada 1,051 ekor lembu menyusui dari 29 ladang tenusu di Selangor (n = 9), Perak (n = 9), Negeri Sembilan (n = 6) dan Johor (n = 5). Tempang dinilai dengan skor lokomosi, diikuti dengan pemeriksaan telapuk dan pengumpulan ciri-ciri tingkat ladang dan lembu. Prevalens tempang adalah 34.2% (95% Selang Keyakinan: 22.2-50.0%). Ulser tapak adalah lesi utama (24.9%), diikuti oleh penyakit *whiteline* (19.6%), hemoraj tapak (10.2%), dan dermatitis digit (5.6%). Secara keseluruhan, lesi ini dipengaruhi oleh faktor yang berbeza di peringkat lembu dan ladang. Tiga kajian telah dijalankan bagi aspek kedua yang memfokuskan pada perapian telapuk preventif. Pertama, 520 ekor lembu tidak tempang dari dua ladang tenusu meragut dan tiga ladang tenusu tidak meragut teruntuk pada perapian telapuk (menggunakan kaedah lima langkah Belanda) atau kumpulan kawalan. Kedua, 418 lembu tidak tempang dari sebuah ladang, secara rawak, teruntuk kepada tiga kumpulan: HT lima langkah Belanda (TRIM1), kaedah HT yang diubahsuai (TRIM2), dan kumpulan kawalan (CON). Skor lokomosi dan lain-lain ciri lembu dinilai setiap bulan selama satu laktasi bagi semua kumpulan eksperimen. Ketiga, 20 ekor lembu tidak tempang tanpa lesi telapuk teruntuk secara rawak kepada kumpulan yang diperapikan (n = 10) dan kawalan (n = 10), analisis kortisol darah dan penilaian tingkah laku (masa yang dihabiskan untuk berbaring, makan, dan berdiri) sebelum dan selepas-HT, dan dua hari kemudian. Hasilnya, kadar insidens tempang yang lebih rendah

dan masa menjadi tempang kali pertama yang lebih lama dicatatkan secara signifikan pada lembu meragut yang diperapikan (27.4 kes/100/bulan, purata ± ralat piawai, SE; 8.12 ± 0.1) dan ladang bukan meragut (31.9 kes/100/bulan, 8.05 ± 0.2) berbanding kawalan (48.4 and 45.8 kes/100/bulan). Begitu juga, kadar insidens tempang adalah masing-masing 28.7, 15.8 dan 42.8 kes/100 ekor lembu/bulan bagi TRIM1, TRIM2 dan CON semasa laktasi, dengan TRIM2 menunjukkan masa kepada kejadian tempang kali pertama yang signifikan lebih panjang (8.26 ± 0.16) daripada CON (7.32 ± 0.2). Tahap kortisol meningkat dengan ketara ($P < 0.05$) bagi kedua-dua kumpulan selepas rawatan berbanding tahap basal. Lembu yang telapuknya telah diperapikan menghabiskan lebih banyak masa berbaring, dan lebih sedikit masa berdiri dan berada di tempat makan berbanding CON pada hari pertama. Kajian kelima berupa percubaan klinikal secara rawak melibatkan lima kumpulan lembu yang tempang sederhana (n = 81): Kumpulan A (perapian terapeutik + ketoprofen + blok telapuk), B (perapian terapeutik + blok kuku), C (perapian terapeutik + ketoprofen), D (perapian terapeutik sahaja) dan E (lembu tidak tempang yang menerima perapian senggara sahaja). Lembu yang didaftarkan diperhatikan setiap minggu hingga hari ke-28 selepas rawatan. Kumpulan A mempunyai kadar pemulihan tertinggi (75%; 15/20, $P < 0.05$) berbanding Kumpulan D (40%; 6/15). Kumpulan A dan E menghabiskan lebih sedikit masa untuk berbaring ($P < 0.05$) berbanding rawatan lain. Masa yang dihabiskan di tempat makan adalah paling panjang bagi Kumpulan E ($P < 0.05$) dan paling pendek ($P < 0.05$) bagi Kumpulan C dan D. Oleh yang demikian, protokol rawatan untuk lesi telapuk mempengaruhi kedua-dua kadar pemulihan tempang dan tingkah laku jangka pendek pada lembu tempang sederhana. Kajian terakhir adalah survei yang dijalankan di kalangan penternak lembu tenusu (n = 114) di Semenanjung Malaysia. Tempang digolongkan sebagai isu kesihatan kedua terpenting di ladang tenusu Malaysia. Penternak menunjukkan pengetahuan yang memuaskan mengenai impak tempang terhadap kesejahteraan dan pengeluaran lembu tenusu tetapi kebanyakan mereka (75.8%; 22/29) memandang rendah tempang dan jarang menerapkan strategi pengurusan yang betul di ladang mereka. Secara konklusif, prevalens tempang yang tinggi di ladang tenusu Malaysia memerlukan strategi kawalan yang berkesan. Kaedah HT yang diubah suai yang digunakan dalam kajian ini menunjukkan potensi mengurangkan insidens tempang pada lembu tenusu meragut dan bukan meragut. Walau bagaimanapun, impak HT dan protokol rawatan yang berkaitan pada petunjuk kesejahteraan perlu dipertimbangkan. Penemuan ini menambah pengetahuan mengenai kepentingan tempang dan lesi telapuk pada lembu tenusu Malaysia, dan peranan teknik HT dalam meminimumkan impak negatif terhadap lembu tenusu.

Kata kunci: Tempang, Lesi telapuk, Perapian telapuk, Lembu tenusu, Faktor risiko

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Thesis submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the supervisory committee were as follows:

Siti Zubaidah binti Ramanoon, PhD
Senior Lecturer
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Chairman)

Rozaihan binti Mansor, PhD
Associate Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

Wan Mastura binti Shaik Mohamed Mossadeq, PhD
Senior Lecturer
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

Sharifah Salmah binti Syed-Hussain, PhD
Senior Lecturer
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

_____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 9 March 2022

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Signature: _____
Name of Chairman of Supervisory Committee: Dr Siti Zubaidah binti Ramanoon

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr Rozaihan Mansor

Signature: _____
Name of Member of Supervisory Committee: Dr Wan Mastura binti Shaik Mohamed Mossadeq

Signature: _____
Name of Member of Supervisory Committee: Dr Sharifah Salmah Syed-Hussain

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LIST OF ABBREVIATIONS

BCS	Body condition score
CSC	Corkscrew claw
CI	Confidence interval
CON	Control or non-trimmed cows
CON-GR	Control cows in grazing herds
CON-NGR	Control cows in non-grazing herds
DC	Digital cushion
DD	Digital dermatitis
DIM	Days in milk
DVS	Department of Veterinary Services
FAO	Food and Agricultural Organization
GR	Grazing herds
ICAR	International Committee for Health Recording
ICC	Intraclass correlation coefficient
NGR	Non-grazing herds
HCS	Hock condition score
HHDL	Hoof horn disruptive lesions
HHE	Heel horn erosion
HR	Hazard ratio
HT-GR	Hoof-trimmed cows in grazing herds
HT-NGR	Hoof-trimmed cows in non-grazing herds
HYP	Interdigital hyperplasia
IF	Infectious hoof lesions
KAP	Knowledge, Attitudes, and Practices

LS	Locomotion score
LSS	Lesion severity score
LW	Limb withdrawal
NSAID	Non-steroidal and anti-inflammatory drug
NIF	Non-infectious hoof lesions
OR	Odds ratio
PNT	Pressure nociceptive threshold
RR	Relative risk
RM	Rubber mats
SC	Swelling of coronet area
SH	Sole haemorrhage
SU	Sole ulcer
STP	Standard treatment protocol
TU	Toe ulcers
TRIM	Trimmed cows
TS	Thin soles
WF	Wall fissures
WLD	White line disease

CHAPTER 1

INTRODUCTION

1.1 Study Background

Lameness is any condition characterised by alteration of gait resulting from pain caused by injury to the hoof or limb (Olechnowicz and Jaśkowski, 2011). Amongst the common diseases or conditions affecting dairy cows worldwide, lameness is one of the most important in terms of economic loss and welfare (Whay and Shearer, 2017; Dolecheck and Bewley, 2018). Hoof lesions are the leading cause of lameness in dairy cows (Solano *et al*., 2016) and they are broadly categorised into non-infectious (hoof horn lesions) and infectious types (Potterton *et al*., 2012). Nevertheless, irrespective of the actual causes or severity, lameness is commonly associated with a painful sensation and subsequent changes in cattle behaviour (Weigele *et al*., 2018).

Various studies have focused on identifying the risk factors for lameness and specific hoof lesions (Solano *et al*., 2015; Sadiq *et al*., 2017a). Several studies have reported the prevalence of lameness in dairy herds and various management such as free-stall (Somers and O'Grady, 2015; Solano *et al.,* 2015; 2016; Westin *et al.*, 2016) and tie-stall (Adams *et al.*, 2017; Bouffard *et al.*, 2017), pasture-based (Richert *et al.*, 2013; Bran *et al.*, 2018), and compost-bedded systems (Costa *et al.*, 2018). Overall, the prevalence of lameness was higher in freestalls and tie-stalls compared to grazing herds (Solano *et al.*, 2015; Ranjbar *et al.*, 2016). One of the consistent factors for the increasing lameness prevalence on dairies is intensive management and confinement (Cook *et al.*, 2016). Under such management, cows are deprived of their natural environments including pasture access, which is appropriate for healthy feet and comfort (Ranjbar *et al.*, 2016; Armbrecht *et al.*, 2017). Hoof health was improved following the exposure of dairy cows to outdoor grazing either in tie-stall or free-stall barns (Haskell *et al.*, 2006; Olmos *et al.*, 2009). These benefits were attributed to the provisions of softer bedding for optimal locomotion, lying behaviour and maintenance of good leg hygiene (Charlton and Rutter, 2017).

The vital role of hoof trimming (HT) in lameness management and hoof care has been demonstrated in earlier and recent studies (Manske *et al.*, 2002a; Thomas *et al.*, 2015; Armbrecht *et al.*, 2017). Farms that conducted HT twice annually had lower odds of lameness and hoof lesions compared with those practising single HT (Manske *et al.*, 2002a). A few studies have reported the therapeutic effects of HT on hoof health in herds with (Armbrecht *et al.*, 2017) and without pasture access (Manske *et al.*, 2002a; Ouweltjes *et al.*, 2009). HT aims to improve the welfare of the dairy cow by prompting recovery, ameliorating the pain, and behavioural changes caused by existing hoof injury (Stoddard and Cramer, 2017). Nevertheless, there are limited data on the preventive efficacy of HT for lameness in dairy cows under different management systems.

Therapeutic HT is also a vital procedure for the management of hoof horn lesions in dairy cows. The removal of necrosed tissues and debriding the underlying lesion is necessary to facilitate the healing process (Thomas *et al.*, 2015). Given the limited evidence-based data to support various treatment protocols for hoof horn lesions, most clinicians rely on experience gained in the field when applying the HT procedure (Potterton *et al.*, 2012; Thomas *et al.*, 2015). Moreover, the impact of various treatment options (i.e., involving therapeutic HT) on welfare variables such as behavioural parameters, stress levels, and production remain unclear.

Overall, understanding farmers' perception of lameness and their current practices are equally important for effective lameness management. The significance of elucidating farmers' knowledge of lameness and their participation in research to develop practical solutions to hoof health challenges have been demonstrated in numerous studies (Leach *et al.*, 2010; Bran *et al.*, 2017; Olmos *et al.*, 2018). Examples include the factors influencing farmers' practices and management of lame cows (Bran *et al.*, 2017; Olmos *et al.*, 2018), their expertise in detecting lame cows, knowledge of lameness risk factors (Horseman *et al.*, 2014; Cutler *et al.*, 2017), and ways to motivate them in taking appropriate actions (Leach *et al.*, 2010). Besides the farmers' perspective, such information will assist policymakers in identifying areas to focus on to improve hoof health and implement lameness control strategies.

1.2 Problem Statement

Lameness is a multifactorial condition, thus identifying the associated risk factors is essential to install specific on-farm preventive measures and reduce the prevalence in dairy herds (Bran *et al.*, 2018; Costa *et al.*, 2018). Hoof lesions are the major causes of lameness in dairy cows and they may elicit pain (Passos *et al.*, 2017), stress response (Janßen *et al.*, 2016), and behavioural changes (Proudfoot *et al.*, 2010).

Presently, little is known about the hoof health status and risk factors for lameness in Malaysian dairy herds. To date, only two lameness-related studies in dairy cows have been reported in Malaysia (Sadiq *et al.*, 2017a; Ramanoon *et al.*, 2018). Cow-level prevalence of lameness and hoof lesions in intensively managed dairy farms in Selangor was reported as 19% and 33%, respectively, (Sadiq *et al.*, 2017a), whereas the other study was a retrospective analysis of lameness cases in cattle reported to an institutional veterinary hospital (Ramanoon *et al.,* 2018). However, both studies lacked data on specific hoof lesions and potential risk factors were not investigated. Epidemiology data on these areas are important, not only for the identification of hoof lesions but monitoring their trends and dynamics in dairy facilities.

Hoof trimming (HT) is a common management practice for the prevention of lameness and treatment of hoof horn lesions (Mahendran and Bell, 2017; Stoddard and Cramer, 2017). A few studies have reported the therapeutic effects of HT on hoof health in pasture-based herds (Armbrecht *et al.*, 2017) and housed dairy cattle (Manske *et al.*, 2002a; Ouweltjes *et al.*, 2009). Nevertheless, there is limited data on the application of HT as a preventive measure for lameness in dairy cows. Most of the existing studies lack a detailed description of the HT technique, hoof health of animals while the benefits of HT in grazing and non-grazing cows have not been investigated. With recent findings indicating that dairy farms in Selangor rarely practice preventive HT (Sadiq *et al.*, 2017a), an evaluation of such knowledge gaps is pertinent in the Malaysian dairy context.

Another important aspect is the availability of various HT methods in the literature. The functional or Dutch five-step method remains the widely applied technique, however, other modified methods such as White line (Blowey, 2015), White Line Atlas (Daniel, 2014), and Kansas methods (Siebert, 2005) have been reported. These modified methods were designed to ensure that the anatomy of the medial and lateral digit is considered during HT while maintaining even weight distribution between and within the claws (Manning *et al.*, 2016). Cows kept in confined housing or intensively managed are exposed to environmental and management factors that increase the risk of lameness (Cook *et al.*, 2016). Currently, there is data paucity to compare the efficacy of various HT methods in housed dairy cows. The knowledge gap in the literature is to identify the most appropriate HT technique for reducing lameness and hoof lesions incidence during lactation in completely housed cows. Besides, since the aim of preventive HT is to improve hoof health and well-being, the behavioural changes associated with lameness should be minimal after the procedure. A few studies have highlighted the short-term negative impact of preventive HT on dairy cattle welfare and production (Korkmaz *et al.*, 2014; Erol *et al.*, 2019) but it is unclear if these alterations result from cow restraint or actual horn removal.

Given the increasing emphasis on animal welfare, there is a paradigm shift in lameness-related research towards prompt detection of lame cows (van Nuffel *et al.*, 2015; van Hertem et al., 2014; Alsaaod *et al.*, 2017) and the development of effective preventive (Solano *et al.*, 2017; Moreira *et al.*, 2019) and treatment protocols (Thomas *et al.*, 2015; 2016). Prompt detection and administration of appropriate treatment are essential in reducing lameness progression from mild to severe cases (Miguel-Pacheco *et al.*, 2016; Thomas *et al.*, 2016). Although hoof horn disruptive lesions are highly prevalent in dairy cows, there are information deficits in the most appropriate treatment protocol (Shearer *et al.*, 2015). Most adopted treatments are based on experience from field practitioners, rather than evidence-based data from well-designed clinical trials (Shearer *et al.*, 2015). Moreover, there is data paucity on the impact of available treatment protocols on welfare and production variables in dairy cows.

Based on the scarcity of lameness-related research in Malaysia, there is also the need to understand farmers' understanding of the problem since they are primarily responsible for their animals' welfare. To date, knowledge, attitude, and practices regarding dairy cattle lameness among Malaysian dairy farmers remain unknown. In other words, data to evaluate the subject from the farmers' perspective are currently lacking in Malaysia. On that note, it is pertinent to assess the importance of lameness to dairy farmers, current practices related to hoof health and factors mitigating against the adoption of preventive measures.

1.3 Significance of the Study

This study will be the first attempt to investigate lameness and the associated risk factors in dairy farms in Johor, Perak and Negeri Sembilan state, thereby expanding lameness related research in Malaysia. Determining the prevalence of lameness and hoof lesion provides basic information about the extent of the problem in dairy herds, whereas data on associated factors are vital for implementing effective lameness control strategies. Likewise, the epidemiological data will assist in the identification of hoof lesions and monitoring their trends and dynamics in dairy facilities. The expected research findings are timely to assist relevant authorities and policymakers in the dairy industry when strategising on how to address lameness issues and enhance dairy cattle welfare in Malaysia.

The novelty in this research is to elucidate the benefits of preventive hoof trimming (HT) in cows managed under grazing and non-grazing conditions, comparing the efficacies of functional HT and a modified technique that focuses on the weight-bearing claw on the fore and hind feet, and evidence-based clinical data on effective treatment protocols for hoof horn disruptive lesions. By enrolling cows with reliable information on lameness history and monitoring of animal-based welfare measures, the actual role of preventive HT in lameness management can be elucidated. Notably, this study will be the first research on lameness prevention in Malaysia and among the prior attempts to determine the effectiveness of the Dutch five-step HT method in reducing lameness incidence under various management systems.

Before the presentation of dairy cows for preventive or therapeutic HT, the expected short-term changes concerning welfare variables such as lying down activity, associated stress, and milk yield need to be ascertained. Such data will improve our knowledge on stress responses that are due to actual HT procedures or restrain of animals. Furthermore, the findings will assist researchers and other related personnel to make informed decisions on the need for pain management during preventive HT. Besides, more clinical trials are required to investigate the effects of available treatment options for hoof horn disruptive lesions. By considering the potential welfare impact of various treatment protocols, there will be available data to further justify the importance of prompt detection and treatment of lame cows.

1.4 Research Objectives

The research objectives of this study were:

1. to determine the prevalence of lameness, hoof lesions, and the associated risk factors in dairy farms in Peninsular Malaysia.

2. to determine the impact of preventive HT and animal-based welfare measures on time to lameness and hoof lesion prevalence in grazing and non-grazing cows.

3. to evaluate the impact of two HT methods on time to first lameness event and hoof lesion prevalence in housed dairy cattle.

4. to determine the short-term impact of preventive HT on behavioural activities, cortisol levels, and milk yield in dairy cows.

5. to evaluate various treatment options for hoof horn lesions and the impact on behavioural variables and milk yield in first parity dairy cows.

6. to investigate Malaysian dairy cattle farmers' knowledge, attitudes, and practices regarding lameness management.

1.5 Research Hypothesis

Objective 1:

H_0: there is no association between lameness prevalence and cow and herd-level factors in dairy farms in Peninsular Malaysia.

H_0: there is no association between prevalence of hoof lesions and cow and herd-level factors in dairy farms in Peninsular Malaysia.

Objective 2:

H_0: time to first lameness event and hoof lesion prevalence are not significantly different between grazing and non-grazing cows after preventive HT.

Objective 3:

H_0: time to first lameness event and hoof lesion prevalence are not significantly different between cows trimmed using functional and an adaptation method.

Objective 4:

H_0: there is no significant difference in the mean lying down duration, lying bouts frequency, time spent at the feed bunk, cortisol levels, and milk yield between cows undergoing preventive HT and untrimmed groups.

Objective 5:

H_0: there is no significant difference in the recovery rate, mean lying down duration, time spent at the feed bunk, and milk yield between dairy cows treated for hoof horn disruptive lesions using various treatment protocols.

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