Locomotion score and body condition shows a low relative contribution to the occurrence of foot disorders in dairy cows

Gabriela Bueno Luz[1], Antonio Amaral Barbosa[1], Ivan Ricardo Carvalho[2], Cassio Cassal Brauner[1], Eduardo Gularte Xavier[1], Eduardo Schmitt[1], Francisco Del Pino[1], Josiane de Oliveira Feijó[1], Viviane Rohrig Rabassa[1] and Marcio Nunes Corrêa[1]

Abstract – This study aims to evaluate the occurrence and distribution of foot lesion and body condition scores to define which lesions are determinant for the manifestation of locomotion scores in dairy cows. A database from 482 Holstein cows was evaluated considering information on body condition scores (BCS), locomotion scores (LS), and cows with hoof lesions. Sole hemorrhage was the hoof lesion with the greatest occurrence (74.15%), followed by nail hypoplasia (11.35%). Most cows with LS 1 showed a 3 and 4 BCS, in contrast to most animals with 2.5 and 3.5 LS, which showed a 2 and 3 LS. Linear correlations indicate that a 0 LS is inversely associated with sole hemorrhage lesions (r = -0.19), and sole hemorrhage and digital dermatitis (r = -0.26), whereas LS 1 cows are inversely related to sole hemorrhage and digital dermatitis (r = 0.14). Regardless of the categorization between healthy and lame animals, most individuals in the system showed a BCS between 3.0 and 3.5. However, we found that locomotion and body condition scores showed a low relative contribution to the occurrence of foot disorders.

Index terms: Claudication; Dairy cows; Hoof; Health.

Escore de locomoção e condição corporal apresentam baixa contribuição relativa para a ocorrência de lesões podais em vacas leiteiras

Resumo – O objetivo foi avaliar a ocorrência, distribuição de lesões podais e escore de condição corporal, para então definir quais lesões são determinantes para a manifestação do escore de locomoção em vacas leiteiras. Uma base de dados de 482 vacas da raça Holandês foi avaliado, utilizando informações de escore de condição corporal (ECC), escore de locomoção (EL) e animais com lesões podais. A lesão de maior ocorrência foi hemorragia de sola (74%), seguido por unha em saca-rolha (11%). A maior proporção de vacas com EL 1, apresentou ECC entre 3 e 4, em contraste, no EL 2 e 3, a maioria dos animais encontrava-se com escore 2.5 e 3.5. A correlação linear indicou que EL 0 é inversamente associado com lesões de hemorragia de sola (r = -0.19) e hemorragia de sola e dermatite digital (r= -0.26). Vacas com EL 1 relacionaram-se inversamente apenas com hemorragia de sola e dermatite digital (r = 0.14). Independentemente da categorização entre claudicantes e saudáveis, a maioria dos animais apresentou ECC 3.0 e 3.5. No entanto, com base nos animais avaliados neste sistema o escore de locomoção e de condição corporal apresentaram baixa contribuição relativa para a ocorrência de afecções podais.

Termos para indexação: Claudicação; Vacas leiteiras; Casco; Saúde.

Introduction

Foot affections are among the diseases commonly present in dairy herds, both in highly and lowly technological systems (LAWRENCE et al., 2011). Monitoring and controlling the occurrence of locomotor problems are vital for herds since they can directly impact the health of animals, compromising milk productivity and affecting the incidence of diseases (BARBOSA et al., 2016).

Lame cows are responsible for 33% of mastitis cases in farms with a claudication index above 10%. Moreover, these females are 3.5 times less likely to become pregnant and twice as likely to have reproduction problems (SOUZA et al., 2006). According to Martins & Melo (2012), these cows may show a decreased milk production of up to 1.5kg or from 5 to 20% of their total lactation milk production.

Disorders intrinsic to the locomotor system can be determined by multifactorial causes which are related and predisposed to failures resulting from nutritional, environmental, and sanitary management, among others. Due to the magnitude and circumstances that can affect these disorders, controlling and monitoring the herd is essential to avoid and minimize quantitative and qualitative losses for dairy production (BICALHO et al., 2009).

The literature shows the difficulty of standardizing forms to monitor, quantify,

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[1] Núcleo de Pesquisa, Ensino e Extensão em Pecuária (NUPEEC), Universidade Federal de Pelotas (UFPel), CEP 96160-000, Capão do Leão, RS, e-mail: gabrielabluz.veterinaria@gmail.com; nupeec@gmail.com

[2]Departamento de Estudos Agrários (DEAG), Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUÍ), CEP 98700-000, Ijuí, RS, e-mail: ivan.carvalho@unijui.com.br

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and diagnose the real situation of each farm. Thus, several methodologies were developed, based on observational aspects, which are easily applicable during the routine of dairy farms (CHAPINAL et al., 2013). Among these, we highlight the evaluation of body condition and locomotion scores. These evaluations, if faithfully associated, may suggest the conditions of each farm. However, the literature still lacks detailed information on what lesion types determine the manifestation of these scores.

In this context, this study aimed to evaluate the occurrence and distribution of foot lesions and body condition scores to define which lesions determine the manifestation of locomotion scores in dairy cows maintained in compost barn systems.

Material and methods

The data for this study were retrospectively obtained from a database of 482 Holstein cows with high milk yields (35 ± 4.9kg day^{-1}) which were fed according to the NRC 2001 and maintained in a compost barn system in a dairy farm localized in Rio Grande – RS (Brazil). Our study protocol was approved by the University of Pelotas Animal Care and Use Committee (CEEA 0105185/2017).

The animals in this farm were evaluated every three months, and the data analyzed for this study was collected in one evaluation performed in 2019. Assessment of body condition scores (BCS) in cows was performed by two technicians via a discrete ordinal scale ranging from 1 to 5 (1 represents a cachectic cow; 5, an obese one) (RENNÓ et al., 2011). To evaluate locomotion scores, the considered methodology followed Wells' (1993) score and ranged from 0 (healthy, without abnormalities) to 4 (severely lame). Cows were considered lame if they showed an LS score between 1 and 4.

Hoof lesions were classified via specific clinical examination of the locomotor system of all animals (n = 482). Only 88 showed visible lesions, which were then subjected to therapeutic trimming, whereas the others were subjected to corrective trimming. The lesions identified in lame cows were categorized as sole hemorrhage, nail hypoplasia, digital dermatitis, white line disease, white line lesion, axial fissure, phlegmon interdigital dermatitis, sole ulcers, and others according to Nicoletti (2004).

The data obtained are based on discrete random variables which are fragmented into ordinal (LS and BCS) and dichotomous categories (0 and 1) to assess the injuries. The dichotomous categorical variables were obtained by producing dummy variables which enabled us to obtain parameters and the applicability of biometric models. First, descriptive statistics were carried out to properly position the proportions and classes of animals after the fragmented frequency was established by the score effects (BCS and LS) so we could correctly implement the association between discrete variables using the Spearman linear correlation, aiming to understand the association degree and tendency of each locomotor score. In possession of all variables, an average Euclidean algorithm was used to construct a distance matrix, which was used in Singh's relative contribution method to determine which variables are more informative to distinguish animals in the herd. Then, a dendrogram was constructed using the hierarchical grouping method based on the average distance between groups (UPGMA) to show which scores and lesions are similar or dissimilar. To establish which injuries determined locomotion scores, a multiple logistic regression model, with significance based on maximum likelihood, was used. The Stepwise variable selection methodology was used with a significance based on the non-parametric chi-square test (x^2). Statistical analyses were performed using the SAS, R, and Genes software.

Results and discussion

The results obtained in the evaluation and classification of podal lesions in lame cows showed that the most common hoof lesion were sole hemorrhage (74% of the total sample), followed by nail hypoplasia (11%), and digital dermatitis (7%) (Figure 1).

Other studies corroborate these findings. Serra (2017) found foot lesions in crossbred cows and postulated the predominance of horn diseases, highlighting the prominence of white line disease (95%), followed by sole hemorrhage (85%), white line hemorrhage (41.25%), and nail hypoplasia (13.75%). It is known that the pathophysiology and factors of foot affections show specific risks, commoly categorized by an etiology denoting infectious and non-infectious lesions (POOTERTON et al., 2012). In this scenario, most lesions found in this study are classified as non-infectious and were diagnosed in 18% of the animals evaluated (88/482), suggesting that these changes were intrinsic to a fraction of the herd rather than to the system of the farm.

To list the possible causes or aspects that may be linked to the occurrence of hoof disorders, frequencies were stratified for each body condition score, which may indicate the predisposition of animals to disorders of the locomotor system (Table 1).

We categorized most cows, both health and lame, into 3.0 (59%) and 3.5 (53%) BCS, respectively, showing that most animals in the farm have adequate body condition scores for dairy cows (FERNANDES et al., 2016).

In view of the response profile of the evaluated animals (Fig. 2A), we stratified the frequency distribution by BCS and specific locomotion score (LS); the latter divided into LS 1 (Fig. 2B), LS 2 (Fig. 2C), and LS 3 (Fig. 3D). Thus, we found that in LS 1, most animals show a BCS between 3 and 4, whereas, for those with 2 and 3 LS scores, most animals showed a BCS between 2.5 and 3.5.

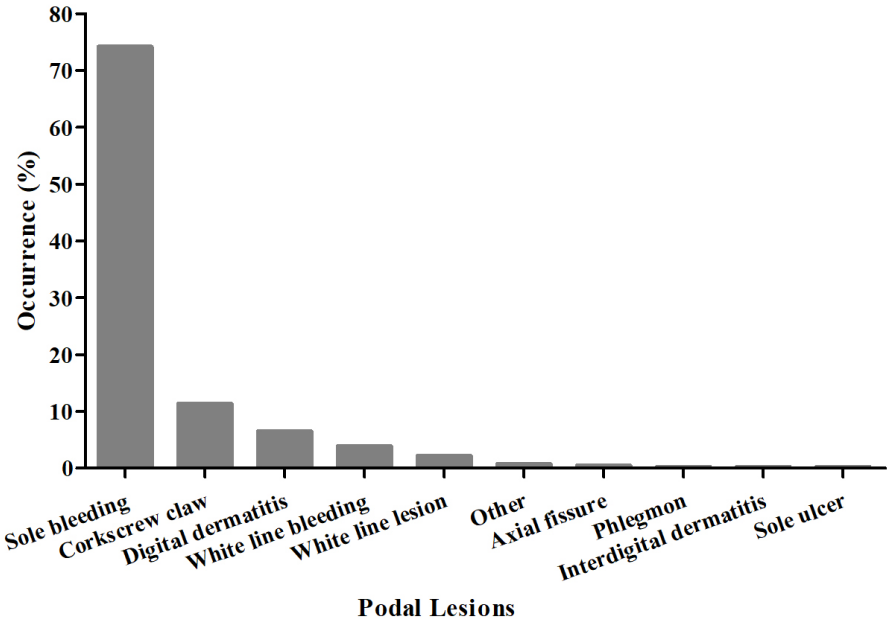

Figure 1. Occurrence (%) of hoof lesions in lame cows.
Source: The authors
Figura 1. Ocorrência (%) de lesões podais em vacas claudicantes.
Fonte: autoria própria

Table 1. Frequency (%) of healthy and lame dairy cows in a compost barn system, stratified for the effects of the body condition score
Tabela 1. Frequência (%) de vacas saudáveis e claudicantes em sistema compost barn *estratificada para os efeitos do escore de condição corporal*

Group	Body condition score						
	2	2.5	3	3.5	4	4.5	5
Healthy cows (%)	0.71	12.85	35.72	27.85	15.71	4.3	2.86
Lame cows (%)	1.8	23.49	22.89	25.6	12.35	8.45	5.42

The literature shows that nutritional condition reflects the health of animals. Therefore, cows with lower body condition scores are more vulnerable to metabolic and orthopedic disorders (BUCKLEY et al., 2003). Studies aiming to evaluate possible nutritional interferences in the dynamics of locomotion in dairy cows have shown possible causes for this relation. According to Barbosa et al. (2018), who evaluated the relation between body condition and locomotion scores in dairy cows in a semi-extensive system, the assigned scores showed an inverse relation. Bicalho et al. (2009) reported a direct relation between body condition scores and the thickness of the digital cushion (since this structure can dampen concussions of the digit to the ground), stating that the higher the BCS, the greater the damping and the lower the chances of claudication.

The importance of these characteristics allowed us to identify which aspects can help differentiate the animals of the herd, based on all score aspects and injuries intrinsic to the study scenario (Table 2). Note that locomotion and body condition scores show a low relative contribution toward this aim. This indicated a low variability throughout the herd. However, we could detect possible foot lesions with a greater contribution to the total variation of the lesions in the herd. In this context, nail hypoplasia (6%); nail hypoplasia, sole hemorrhage, and phlegmon (6%); and nail hypoplasia, axial fissure, and sole ulcers (6%) were the most polymorphic illnesses in the herd, i.e., they are the most important to distinguish lame from healthy cows.

These results, which aim to evaluate the importance of these characters and their contribution to the lesions found, corroborate Häggman & Juga (2013), who evaluated the genetic correlation between horn disorders and conformation characters, and obtained low heritability estimates. Therefore, the importance of monitoring and evaluating the occurrence of these diseases in farms is evident since a wide range of factors and effects are involved in the health of the locomotor system (VAN DER WAAIJ, 2005).

Our dendrogram expresses the similarity and dissimilarity of the lesions identified in the 482 dairy cows evaluated (Fig. 3). In this context, we observed a similar profile comprising nail hypoplasia; nail hypoplasia, axial fissure, and ulcers; nail hypoplasia, hemorrhage sole, and phlegmon; sole hemorrhage, nail hypoplasia, and others; sole hemorrhage, digital dermatitis, and interdigital dermatitis; and white line lesion and digital dermatitis. The studied lesions show a high dissimilarity between BCS and LS estimates. We obtained a great stratification among the animals showing sole hemorrhage; sole hemorrhage and digital dermatitis; and digital dermatitis. We considered these lesions as the most variable in the studied herd. Among horn disorders, these are usually associated with primary causes, such as mechanical trauma (ALGERS, 2009).

Linear correlations indicate that an LS 0 is inversely associated with sole hemorrhage lesions (r = -0.19*), and sole hemorrhage and digital dermatitis (r = -0.26*). In constrast, cows with an LS 1 are inversely related to sole hemorrhage and digital dermatitis (r = 0.14*). Under these conditions, it is evident that the occurrence of sole hemorrhage and digital dermatitis was insufficient to determine locomotion

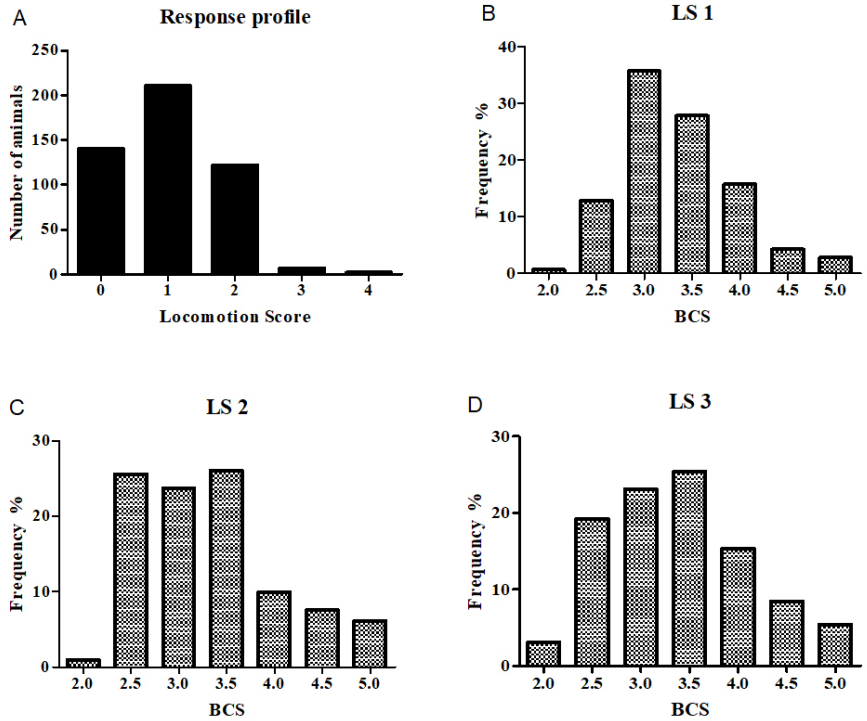

Figure 2. A - Response profile of animals evaluated for locomotion score; B - Frequency distribution of body condition scores specific to lame cows with a locomotion score 1; C - Frequency distribution of body condition score specific to lame cows with a locomotion score 2; D - Frequency distribution of body condition score specific to lame cows with a locomotion score 3.
Source: The authors
Figura 2. A - Perfil de resposta dos animais avaliados para escore de locomoção; B - Distribuição de frequência de escore de condição corporal específica de vacas com escore de locomoção 1; C - Distribuição de frequência de escore de condição corporal específica de vacas com escore de locomoção 2; D – Distribuição de frequência de escore de condição corporal específica de vacas com escore de locomoção 3.
Fonte: autoria própria

conditions regardless of the score attributed to the animal.

The information obtained was subjected to an Euclidean algorithm to obtain genetic distances. It suggested a high cophenetic correlation between observed and estimated fractions (ccc = 0.96), which indicates the reliability and adjustment of the multivariate model used. Moreover, we obtained a low matrix distortion percentage (3.86%) and minimal evidence of a matrix stress index of distances (19.66%).

To identify which possible lesions determine locomotion scores, we used a multiple logistic regression model, jointly selecting independent determinants variables. First, locomotion scores (Y1 = 0, Y2 = 1, Y3 = 2, Y4 = 3, and Y5 = 4) were assigned as a dependent character. We found an accumulated frequency of 140, 211, 122, 7, and 2 for each dependent class, respectively. Global tests were use to test the significance of the multiple model (Table 3). These were based on the maximum likelihood rate and score and Wald tests, all of which are significant by the chi-square test (x^2), establishing that the intercepts (Y1, Y2, Y3, Y4) are probabilistically reliable.

Estimating the model parameters

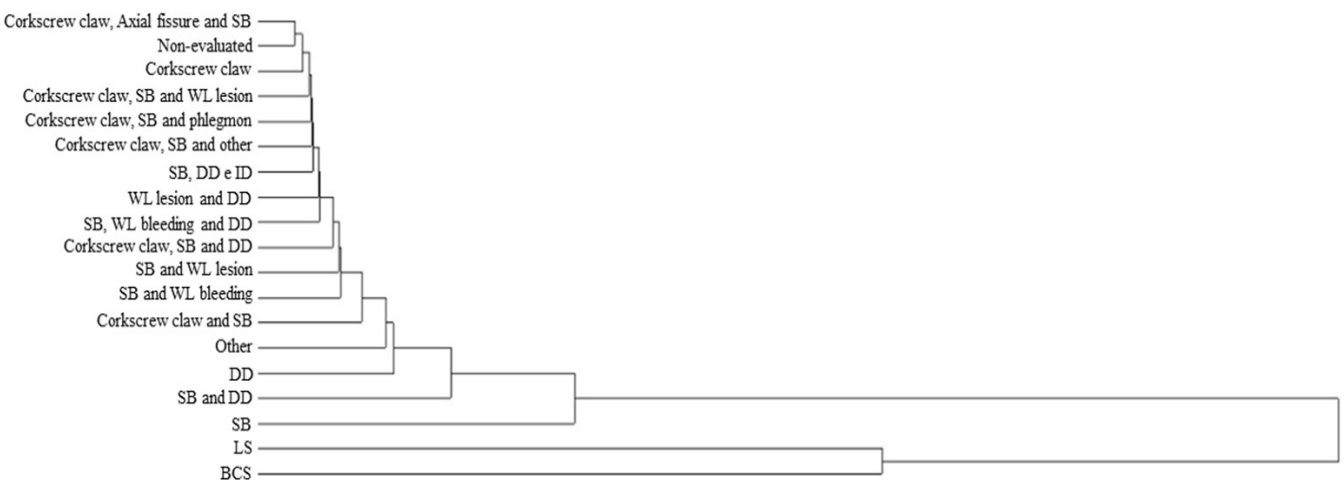

Figure 3. Dendrogram of hoof lesion profiles evidenced together. (SB – sole hemorrhage; WL – White line disease; DD – digital dermatitis; ID – interdigital dermatitis; LS – locomotion score; BCS – body condition score).
Source: The authors
Figura 3. Dendrograma do perfil de lesões podais evidenciadas conjuntamente. (SB – hemorragia de sola; WL – linha branca; DD – dermatite digital; ID – dermatite interdigital; LS – escore de locomoção; BCS – escore de condição corporal).
Fonte: autoria própria

Table 2. Singh's relative contribution method responsible for defining characters and evaluating which characters contribute to the total variation of the animals in the dairy herd

Tabela 2. Método da contribuição relativa de Singh responsável pela definição e quais caracteres são mais contribuintes para a variação total dos animais no rebanho leiteiro

Variable	S.j.	Contribution %
Locomotion score	19.59	4.75
Body condition score	22.77	5.52
Digital dermatitis	20.54	4.98
Sole hemorrhage	14.03	3.40
Nail hypoplasia	23.15	5.62
Other	20.55	4.98
Sole hemorrhage and digital dermatitis	18.69	4.53
Sole hemorrhage and white line hemorrhage	22.25	5.40
Sole hemorrhage and white line lesion	22.21	5.40
Sole hemorrhage, digital dermatitis, and interdigital dermatitis	23.04	5.59
Sole hemorrhage, white line hemorrhage, and digital dermatitis	22.87	5.55
Sole hemorrhage, nail hypoplasia, and other	22.98	5.57
White line lesion and digital dermatitis	22.79	5.53
Nail hypoplasia and sole hemorrhage	21.47	5.21
Nail hypoplasia, sole hemorrhage, and digital dermatitis	22.37	5.42
Nail hypoplasia, sole hemorrhage, and phlegmon	23.01	5.58
Nail hypoplasia, axial fissure, and sole hemorrhage	23.13	5.61
Nail hypoplasia, sole hemorrhage, and white line disease	22.98	5.57
Non-evaluated	23.55	5.71

*S.j: variance attributed to the effects of the variable relative to contribution (%).

Table 3. Global hypothesis tests for the probabilistic multiple regression model

Tabela 3. Teste global de hipóteses para o modelo de regressão múltipla probabilística

Tests	Chi-square (x^2)	Probability
Likelihood ratio (LRT)	32.89	< 0.0001*
Score	23.66	0.0003*
Wald	34.74	< 0.0001*

*significant probability of 5%.

Table 4. Analysis of maximum likelihood estimates

Tabela 4. Análise das estimativas de máxima verossimilhança

Parameter	Estimate	Standard error	Wald Chi-square	Punctual effect	95% Wald test		*P*
Sole hemorrhage	0.53	0.3034	3.0748	1.702	0.939	3.09	0.007
Other	-3.54	0.8692	16.5965	0.029	0.005	0.16	< 0.001
Sole hemorrhage and digital dermatitis	1.63	0.6366	6.5756	5.117	1.469	17.8	0.001
Sole hemorrhage, nail hypoplasia, and other	-5.12	1.9128	7.167	0.006	< 0.001	0.25	0.007
Sole hemorrhage and nail hypoplasia	-1.57	0.8837	3.1757	0.207	0.037	1.17	0.07

obtained by maximum likelihood (Table 4) showed significant and increasing intercepts as locomotion scores quantitatively increased. We found that greater residual variances are obtained in LS 2 and 3 because they contain a smaller number of animals. The Stepwise variable selection method allowed us to identify which lesions can determine LS. In this scenario, we found that the concomitant occurrence of sole hemorrhage, digital dermatitis, nail hypoplasia, and other lesions define the locomotion score. Distinction (LS =1, LS = 2, LS = 3, and LS = 4) depends on how many lesions and their rate of occurrence. All selected variables are within the 95% confidence interval, showing that the selected lesions are reliable for the observed herd.

Several factors may be associated with the occurrence of orthopedic diseases in dairy cattle, such as type of farm system, nutrition, genetics, and many others that have not been listed and analyzed separately in this study. Thus, with greater control of the system and the animal database, it is possible to detail the factors involved in the injuries found in each farm and reality.

Conclusions

We found that the most prevalent hoof lesion was sole hemorrhage, followed by nail hypoplasia.

Most animals in the system showed a BCS between 3.0 and 3.5, regardless of their categorization into healthy or lame.

Locomotion and body condition scores showed a low relative contribution to the occurrence of foot disorders.

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