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Association of body condition with lameness in dairy cattle: a single-farm longitudinal study

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Abstract

This research communication describes the relationship between the occurrence of lameness and body condition score (BCS) in a sample of 288 cows from a single farm that were repeatedly scored in the course of 9 months while controlling for confounding variables. The relationship between BCS and lameness was evaluated using generalised linear mixed-effects models. It was found that the proportion of lame cows was higher with decreasing but also with increasing BCS, increased with lactation number and decreased with time since the last claw trimming. This is likely to reflect the importance of sufficient body condition in the prevention of lameness but also raises the question of the impact of overcondition on lameness and the influence of claw trimming events on the assessment of lameness. A stronger focus on BCS might allow improved management of lameness that is still one of the major problems in housed cows.

Lameness is still one of the greatest challenges in the husbandry of dairy cows (Oehm *et al*., 2019). It is highly relevant in respect to welfare due to the associated pain but also in respect to production (Oehm *et al*., 2019). Previous studies found a relationship between an increased risk of lameness and low body condition score (BCS; Green *et al*., 2014, Westin *et al*., 2016, Randall *et al*., 2015, 2018, Oehm *et al*., 2019). There are also some indications that a very high BCS also coincides with lameness (Ristevski *et al*., 2017). On the whole, the aetiology of bovine lameness is poorly understood. As one contributing factor, cows may suffer from nutritional deficits due to the high energy demand in early lactation. This deficit may result in a reduction in thickness of the digital cushion, which can then no longer absorb the weight of the cow (Bicalho *et al*., 2009; Green *et al*., 2014).

Other aspects of individual cows are also known to influence the risk of lameness, such as lactation stage or age (reflected by lactation number: Oehm *et al*., 2019). A medical treatment for a cause other than lameness may additionally indicate a challenged immune system and, therefore, an increased risk for lameness (similar to heifers with a high first-calving age: Randall *et al*., 2015). In addition, the housing system or management factors can increase the risk of lameness. Uncomfortable lying areas (Dippel *et al*., 2009), season (heat stress: Cook *et al*., 2007) or low social rank can increase standing time and accordingly the risk of lameness. However, it is unclear to what extent hard surfaces and pasturing increase and decrease the risk of lameness (Haufe *et al*., 2012). Finally, improper claw trimming can also lead to lameness (Chapinal *et al*., 2010).

Here, we analysed the relationship between lameness and body condition score while controlling for lactation stage, lactation number, additional medical treatment, season, and time since last claw trimming in a one-farm longitudinal study.

Materials and methods

In this project, 288 German Holstein dairy cows from a single farm were followed from February to October 2019 when they were in milk. They were housed in free-stall pens when observed but spent some time on pasture when dry (non-seasonal calving). At the end of each month (except for March), all cows were scored by the first author for whether they were lame (lameness score >2 *vs*. score 1 and 2), and for their body condition (scale of 1 to 5 in quarter steps). These scorings were complemented with information on lactation stage (0 to 80, 81 to 160, $\geq$ 161 d), lactation number (low: 1, intermediate: 2–3, high: $\geq$ 4), medical treatment (yes-no), season (winter-spring, summer, fall), and time since the last claw trimming event (continuous in days). A total of 1544 observations, (mean ± SD) 5.36 ± 1.89 observations/cow, were included in the statistical analysis. We evaluated the data using a Bayesian generalised linear mixed-effects model. We considered lameness as the dichotomous outcome variable and used the other variables as fixed predictors, including their two-way interactions. The relationship with body condition score showed some non-linearity and was

Table 1. Statistical information on the overall *P*-value of the full model (compared with an intercept only model) and the *P*-values from the single term deletions

Term, dropped	df	χ^2_{df}	*P*-value
All (full model *vs.* intercept only model)	51	224.98	<0.0001
Body condition score (BCS, continuous)	1	4.41	**0.036**
BCS squared (continuous)	1	10.51	**0.001**
Lactation stage (0–80, 81–160, ≥ 161, dry)	2	2.90	0.23
Lactation number (low: 1–2, middle: 3–4, high: >4)	2	22.45	**<0.0001**
Medical treatment (yes-no)	1	1.84	0.17
Season (Winter/spring, summer, fall)	2	6.06	0.048
Time since the last claw trimming (continuous)	1	12.89	**0.0003**
BCS × lactation stage	2	2.16	0.34
BCS^2 × lactation stage	2	2.73	0.26
BCS × lactation number	2	0.84	0.66
BCS^2 × lactation number	2	2.61	0.27
BCS × medical treatment	1	0.80	0.37
BCS^2 × medical treatment	1	0.62	0.43
BCS × season	2	1.62	0.44
BCS^2 × season	2	0.45	0.80
BCS × time since the last claw trimming	1	0.36	0.55
BCS^2 × time since the last claw trimming	1	0.73	0.39
Lactation stage × lactation number	4	1.70	0.79
Lactation stage × medical treatment	2	0.54	0.76
Lactation stage × season	4	2.24	0.69
Lactation stage × time since the last claw trimming	2	0.11	0.95
Lactation number × medical treatment	2	2.92	0.23
Lactation number × season	4	7.67	0.10
Lactation number × time since the last claw trimming	2	6.18	0.045
Medical treatment × season	2	5.79	0.06
Medical treatment × time since the last claw trimming	1	0.26	0.61
Season × time since the last claw trimming	2	3.53	0.17

Note: The continuous variables were normalised for this analysis and sum-contrasts were used for the factor variables.

accordingly included as an additional squared term. Cow identity was used as the random effect. For a more detailed description of the housing system, the data collection, and the statistical evaluation see the Supplementary Material & Methods.

Results

In the current sample, the average prevalence of lameness at each monthly scoring was 19.1% (± 5.7SD; range 10.3–29.1%). Of all the 1544 observations used in the sample, 1249 (80.9%) were scored as 1–2 (618 and 631 cases with score 1 and 2, respectively) and considered lame for the current evaluation. In addition, 162 (10.5%) observations scored as 3, 113 (7.3%) as 4 and 20 (1.3%) as 5–6 in respect to lameness.

A higher proportion of cows with a low and somewhat less clearly with a high BCS were lame (Table 1; Fig. 1, top). The occurrence of lameness also increased with lactation number (Table 1; Fig. 1, middle). Finally, more cows were lame a short time after claw trimming (Table 1; Fig. 1, bottom).

Effects of season and the interaction of lactation number and the time since the last claw trimming did not seem well supported visually and are, therefore, not interpreted even with a *P*-value slightly below 0.05. We consider these low *P*-values as chance occurrences due to the relatively large number of *P*-values that were calculated (Table 1). In any case, they were indicating relationships that were much weaker compared to those described above (and shown in Fig. 1).

Discussion

In respect to our central question on the relationship of lameness and body condition score, we found that a low BCS was associated

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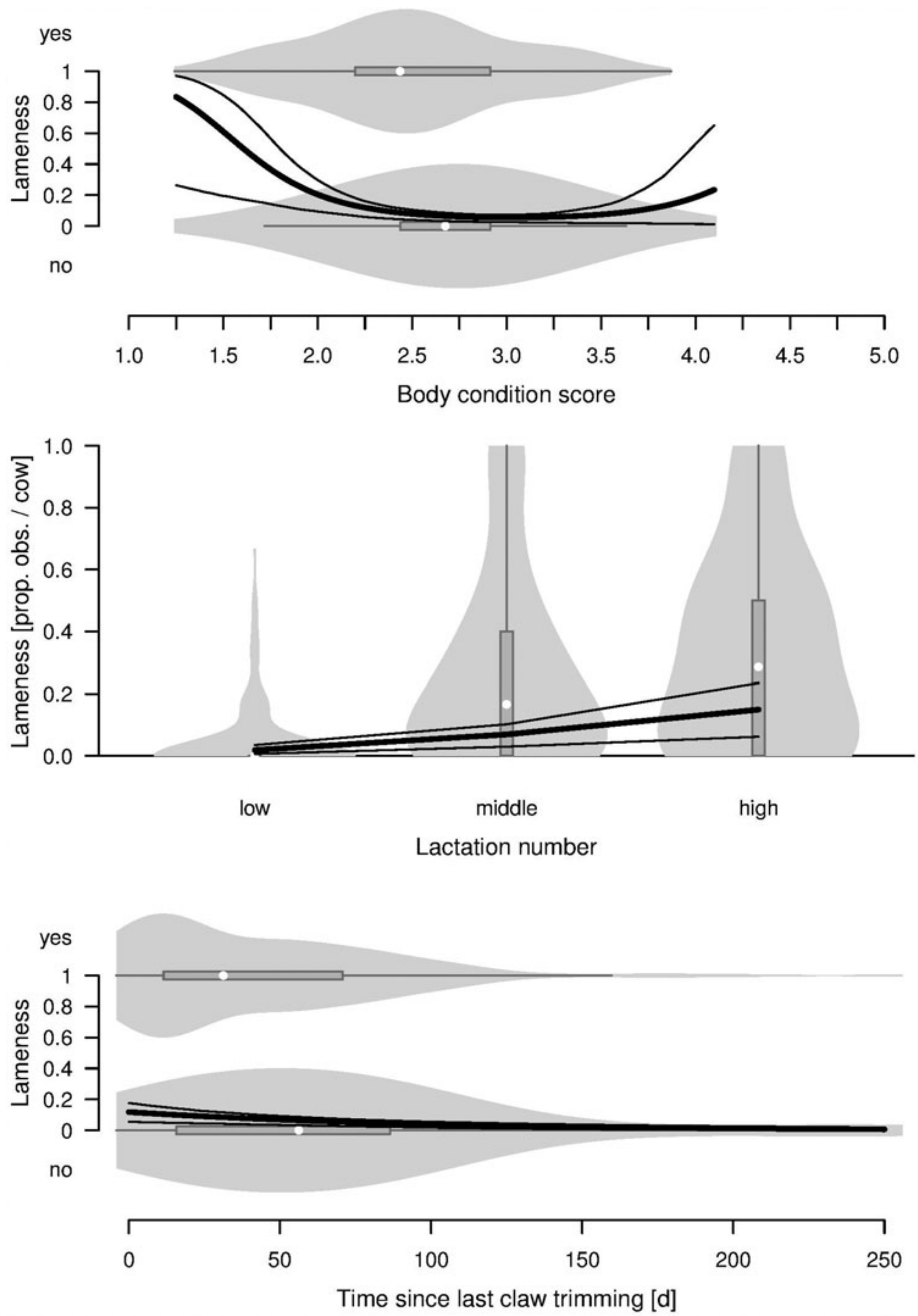

Fig. 1. The probability of observing lameness in relation to the body condition score (top), lactation number (middle), and time since the last claw trimming (bottom). Middle: the violin-and boxplot indicates the proportion of observations with lameness for each cow. Otherwise, the violin- and boxplots represent the raw data from the single observations. Model estimates with 95% confidence intervals are shown by the thick and thin lines, respectively.

with a higher prevalence of lameness compared to moderate BCS score, supporting earlier studies (Schöpke *et al*., 2013; Green *et al*., 2014; Westin *et al*., 2016; Randall *et al*., 2015, 2018; Oehm *et al*., 2019). Whether thinness is a risk factor for lameness (Bicalho *et al*., 2009) or whether lame cows cannot keep up their body condition (Norring *et al*., 2014) could not be differentiated in this study and would need a more frequent assessment of lameness and BCS in order to follow the temporal sequence of changes in BCS and lameness more closely. It has been hypothesised that a low BCS in early lactation may pose a specific risk factor for lameness (Bicalho *et al*., 2009; Schöpke *et al*., 2013). This could not be supported in our sample because we did not find an interaction between BCS and lactation stage. Moreover, we could support that a moderately high BCS may also be associated with a higher prevalence of lameness (Schöpke *et al*., 2013; Ristevski *et al*., 2017). All in all, the association of lameness and BCS emphasised the usefulness of a regular BCS assessment as a management tool for potential prevention of lameness.

In addition, we found an increased prevalence of lameness with increasing lactation number, supporting previous studies (Dippel *et al*., 2009; Schöpke *et al*., 2013; Oehm *et al*., 2019). Yet, in comparison to earlier studies, the prevalence in our sample was rather low (Bicalho *et al*., 2009). The effect of season with a low lameness prevalence in winter and a high prevalence in

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summer was only weakly supported statistically, but followed previous results (Cook *et al.*, 2007). The increased prevalence of lameness shortly after claw trimming could be associated to an incorrect claw trimming process (Chapinal *et al.*, 2010). This contrasts with the finding of a positive effect of claw trimming on lameness (Manske *et al.*, 2002). An alternative explanation for this temporal effect is that lame cows were treated more often and that, therefore, cows that had been treated due to lameness still showed some indications for lameness shortly after treatment. Finally, we did not find clear support for an effect of lactation stage, additional medical treatment nor season on the occurrence of lameness in our sample.

In conclusion and given the current analysis, the following aspects seem promising for follow up and testing: Apart from a low BCS, a high BCS also seems a risk factor for lameness. If indeed the load on the digital cushion caused the lameness, the higher weight at a high BCS would be a risk factor. Therefore, cows with a BCS even higher than observed in the current study could be investigated to understand the relevance of this risk. Moreover, cows may walk unevenly shortly after claw trimming, which may be perceived as weak to moderate lameness during scoring. This poses the question of whether cows just need to habituate to a new (and trimmed) claw conformation or whether this is associated with pain as with other causes of lameness.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022029921000297

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