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Short communication: Calf cleanliness does not predict diarrhea upon arrival at a veal calf facility

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ABSTRACT

The objective of this study was to validate the use of cleanliness scores to identify the presence of diarrhea in calves. On arrival at a milk-fed veal facility, 452 calves were scored for hide cleanliness and fecal consistency by 1 of 2 observers. Fecal consistency was scored on a scale of 0 to 3, where fecal score of 0 = normal consistency, 1 = semiformed or pasty, 2 = loose feces, and 3 = watery feces; calves with a fecal score of 2 or 3 were classified as positive for diarrhea. Hide cleanliness was also scored on a scale of 0 to 3, where 0 = clean thighs and body with little to no manure on lower legs; 1 = tail head region and back end of calf are soiled with manure; 2 = tail head region, back end of calf, and thighs or legs are soiled with manure; and 3 = tail head region, back end of calf, thighs, and legs are soiled with manure. Of the calves scored, 188 calves (42%) were identified as having diarrhea based on hide cleanliness; however, only 78 calves (17%) were identified with diarrhea based on fecal consistency. The level of agreement between the 2 scoring methods were calculated, and a weighted kappa of 0.22 indicated only fair agreement between the 2 scoring methods. However, the sensitivity and specificity, calculated using fecal consistency $\geq$2 as the classification variable, were 67 and 63%, respectively, when a cut point of $\geq$1 for cleanliness score was used. A total of 222 calves scored at arrival were scored once per day for an additional 2 d following arrival. Calves were more likely to have more days with abnormal hide cleanliness than abnormal fecal consistency; 91 calves (41%) had an abnormal cleanliness score for at least 2 d, whereas only 21 calves (9%) had an abnormal fecal score for at least 2 d. We found poor correlation between total number of days with an abnormal cleanliness score and total number of days with an abnormal fecal score, indicating that consecutive observations of hide cleanliness would not improve the validity of using hide cleanliness. Thus, hide cleanliness is not a good indicator for identifying diarrhea in calves, and scoring fecal samples for consistency should be used to more accurately identify diarrhea in calves.

Key words: hide cleanliness, diarrhea, veal calf, fecal consistency

Short Communication

Diarrhea is a common disease affecting calves (USDA, 2007; Bähler et al., 2012), causing significant morbidity and mortality (Svensson et al., 2006; Pardon et al., 2013; Windeyer et al., 2014). It can also greatly limit the genetic potential of the calf by negatively affecting ADG (Donovan et al., 1998; Windeyer et al., 2014), age at first calving (Heinrichs et al., 2005), first-lactation milk production (Heinrichs et al., 2005), as well as carcass traits in milk-fed veal calves (Pardon et al., 2013).

To reduce the short- and long-term consequences associated with diarrhea, immediate identification and rehydration of affected calves is crucial before the calves developing clinical signs of dehydration (McGuirk, 2008). An accurate method used to identify calves with diarrhea is to score feces based on consistency. This is accomplished by stimulating calves to defecate and scoring the fecal sample on a 4-point scale (McGuirk, 2008; Curtis et al., 2016; Gomez et al., 2017). Despite this method being a gold standard for identifying diarrhea, it can be time-consuming, inconvenient, and stressful to the calf. The feces can also be scored on bedding substrate; however, this is not feasible in most veal facilities, as the calves are housed on slatted flooring. As an alternative, some calf health studies have used a hide cleanliness score as an indicator of diarrhea (Jorgensen et al., 2017). Hughes (2001) proposed that the leading cause of abnormal hide cleanliness is diarrhea, although conceded that cleanliness may be influenced by many factors such as housing or bedding style, stocking density, and ventilation. Advantages to using hide cleanliness to identify diarrhea include reduced time and ease of diagnosis, improved hygienic measures, and less stress to the calf.

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The objective of our study was to validate the use of hide cleanliness against a gold standard of fecal consistency to identify diarrhea in calves upon arrival at a veal calf facility. In addition, the number of days with an abnormal cleanliness score was compared with total number of days with an abnormal fecal consistency to determine the correlation of multiple abnormal scores over a 3-d period.

This study was conducted in cooperation with a milk-fed veal producer and in accordance with the University of Guelph Animal Care Committee requirements (Animal Use Protocol: #3453). A total of 452 calves were evaluated for hide cleanliness and fecal consistency immediately upon arrival at a milk-fed veal calf facility, and 222 of those calves were monitored for a total of 3 consecutive days after arrival. The calves scored arrived from different sources and were not all housed in the same location. A total of 12 rooms were used to house the scored calves. The age of these calves at arrival was unknown but would likely be a week of age or less. Due to logistic reasons, all calves could not be followed for all 3 d. Calves were housed individually on slatted stalls and were rectally stimulated to encourage defecation; fecal samples were scored for fecal consistency. Fecal consistency was scored on a scale of 0 to 3, where fecal score 0 = normal consistency, 1 = semi-formed or pasty, 2 = loose feces, and 3 = watery feces; calves with a fecal score of 2 or 3 were classified as positive for diarrhea (McGuirk, 2008). Hide cleanliness [adapted from Panivivat et al. (2004) and Sutherland et al. (2014)] was also scored on a scale of 0 to 3, where 0 = clean thighs and body with little to no manure on lower legs; 1 = tail head region and back end of calf are soiled with manure; 2 = tail head region, back end of calf, and thighs or legs are soiled with manure; and 3 = tail head region, back end of calf, thighs, and legs are soiled with manure. All calves were scored by 1 of 2 observers, both trained for consistency by a veterinarian. If an observer was evaluating a calf, both the fecal consistency and hide cleanliness score were completed by that observer. However, different observers may have evaluated the calves when observed for more than 1 d.

For the purposes of sample size calculations a priori, the prevalence of diarrhea (fecal consistency $\geq$2) at arrival was expected to be 15% (Renaud et al., 2018), and the sensitivity and specificity of the cleanliness scoring as a test in identifying calves with diarrhea were predicted to be 80 and 85%, respectively. Utilizing the method described by Buderer (1996) and assuming the clinically acceptable width of the 95% confidence intervals for sensitivity and specificity was to be no larger than 10%, the sample size required was determined to be 410 calves.

All statistical analyses were completed using Stata 13 (StataCorp LP, College Station, TX). Data were imported from Microsoft Excel (Microsoft Corp., Redmond, WA) into Stata 13 and checked for completeness. A weighted kappa was used to determine the agreement between the 2 scales on the day of arrival, accounting for the agreement that could occur due to chance (Dohoo et al., 2009). The kappa used ratings weighted by 1.00, 0.67, 0.33, and 0 and allowed partial agreement to be considered, which is important for the continuous scales used in our study. A nonparametric receiver operating characteristic (**ROC**) curve was generated to compare cleanliness and fecal scores and to determine the sensitivity and specificity of hide cleanliness to classify cases of diarrhea identified using fecal scoring (Dohoo et al., 2009). Fecal score was the classification variable, and was dichotomized to represent diarrhea (score of $\geq$2) and nondiarrhea (score of $<$2; McGuirk, 2008). The cut-point for cleanliness score was selected to optimize sensitivity and specificity to limit the effect of both false-positive and -negative diagnoses (Florkowski, 2008). To evaluate the correlation over multiple days with abnormal scores, simple linear regression analysis was conducted with total days with abnormal cleanliness score ($\geq$1 cleanliness score) as the predictor and total days with abnormal fecal score ($\geq$2 fecal score) as the outcome of interest. The assumptions of normality and homoscedasticity of the residuals were tested using a Shapiro-Wilks test and Cook Weisberg test.

The weighted kappa (k) calculated on 452 calves at arrival resulted in a k value of 0.22, indicating fair agreement; a k value of 0 would indicate no agreement above what is expected by chance and a k value of 1 would indicate perfect agreement (Landis and Koch, 1977; Dohoo et al., 2009). The ROC curve for these data had an area of 0.66 under the curve, which indicates the probability that a randomly selected positive individual has a greater score than a randomly selected negative individual (Dohoo et al., 2009). Assuming the optimal cut-point is the point where sensitivity and specificity are at a maximum, the cut-point for cleanliness score was determined to be a score of $\geq$1, which correctly classified 64% of calves (Dohoo et al., 2009). This cut-point generated a sensitivity of 67%, which is the true positive rate, and indicates the proportion of calves with diarrhea that were given an abnormal cleanliness score on arrival. The cut-point of $\geq$1 had a specificity of 63%, which is the true negative rate, and indicates the proportion of calves that did not have diarrhea and were given a normal cleanliness score at arrival (Florkowski, 2008).

Using this cut-point of $\geq$1 on the cleanliness scale, 188 of 452 calves (42%) at arrival would be diagnosed