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An objective method for assessment of foot conformation in sheep

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ABSTRACT

Assessment of foot conformation in sheep is important to study the aetiopathogenesis and impacts of diseases causing lameness. There currently exists no objective system to assess foot conformation in sheep. Based on the system of assessing conformation in the feet of dairy cattle, a set of parameters that gauged conformation in sheep are developed. They were measured in a group of sheep to assess their repeatability and reproducibility, within and between observers. Conformation parameters were compared between medial and lateral digits of the same foot. Of all parameters assessed, toe length, toe height, sole length, sole width and interdigital skin length had high repeatability and reproducibility. Most of the parameters measured were different between the medial and lateral digits, indicating anatomical or conformational differences between the two digits. A recommended approach for assessing foot conformation in sheep included manual restraint of sheep in dorsal recumbency and measurement of toe length, toe height, sole length, sole width and interdigital skin length of both digits in all four feet using digital calipers.

1. Introduction

Foot conformation is a potentially important consideration in assessing lamenessin sheep (Kaler et al., 2010) and cattle (Eddy and Scott, 1980; Russell et al., 1982). Traditionally, foot conformation has been assessed visually, but subjective visual scores are often inaccurate and inefficient at detecting important aspects of claw health and locomotion disturbances (Vermunt and Greenough, 1996). Categorisation of animals into ‘normal’ and ‘abnormal’ groups is one useful approach. For example, a dichotomous categorical scoring system was described such that a foot had normal conformation if it had an undamaged sole, heel or wall area and a perfect shape, and an abnormal conformation if it had a damaged or misshapen sole, heel or wall (Kaler et al., 2010). Objective claw measurements in cattle are used to assess conformation and many parameters have been correlated with a range of claw disorders but there may be poor relationships between visual scores and objective claw measurements in dairy cattle (Distl et al., 1984; Politiek et al., 1986). High variation in subjective evaluation of foot conformation (Morris et al., 1985) has been reported compared to low variation in objective claw measurements (Hahn et al., 1984; Ral, 1990).

Currently there is no objective method to assess foot conformation in sheep apart from categorisation into normal and abnormal groups (Kaler et al., 2010). The aim of this study was to develop a simple and reliable method to objectively assess foot conformation in sheep.

2. Materials and methods

2.1. Animal trials

The trial was conducted with approval from the Animal Ethics Committee of The University of Sydney. Forty-four Merino wethers, about two years of age, were acquired from a footrot-free property in northern NSW and managed on The University of Sydney farms at Camden, NSW. All feet were examined visually to ensure the absence of common hoof disease states such as foot abscess, toe abscess, interdigital dermatitis and footrot.

2.2. Description of parameters

Foot parameters to be measured were selected based on objective claw measurements commonly used in dairy cattle. Others were selected to define anatomical regions that play a role in diseases like ovine footrot. These parameters are described in detail (Fig. 1).

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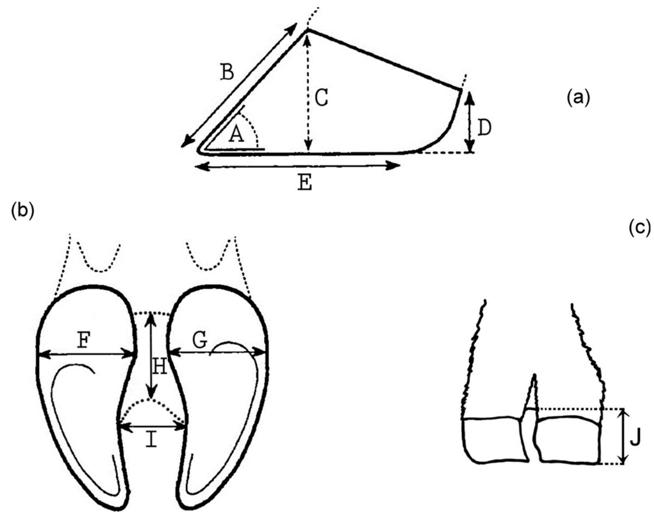

Fig. 1. Parameters to describe foot conformation in sheep.
Schematic representation of the foot depicting the (a) lateral aspect, (b) palmar or plantar aspect and the (c) caudal aspect. The following parameters are described. A - Toe angle, B - Toe length, C - Toe height, D - Heel height, E - Sole length, F - Width of lateral digit, G - Width of medial digit, H - IDS length, I - IDS width, J - IDS height. Image adapted from Vermunt and Greenough (1996).

Measurements were made with the sheep in dorsal recumbency and restrained manually. Linear measurements were made with digital calipers in millimeters. Angles were measured with a generic plastic protractor.

The parameters measured were:

Toe angle (dorsal angle) – Slope of the dorsal border of the foot with respect to the sole (Fig. 1a: A).

Toe length (length of the dorsal border) – Distance between the dorsal skin-horn junction and the apex of the digit (Fig. 1a: B).

Toe height – Vertical distance from the dorsal skin-horn junction to the sole (Fig. 1a: C).

Heel height (heel depth) – Vertical distance from the sole to the skin-horn junction at the extreme plantar or palmar margin of the bulb of the foot (Fig. 1a: D).

Sole length – Length of the abaxial wall and bulb that are in contact with the floor surface (Fig. 1a: E).

Sole width (lateral digit and medial digit) – Subjectively selected largest distance between the abaxial and axial wall at the sole-bulb junction of each digit (Fig. 1b: F and G).

Interdigital skin (IDS) length – Length of the interdigital skin measured along the cranial-caudal axis. This parameter was measured when the foot was held with its palmar/plantar surface exposed to the observer (Fig. 1b: H).

IDS width – Width of the IDS when taut and stretched maximally (Fig. 1b: I).

IDS height – The vertical distance between the IDS at its caudal most point and the sole (Fig. 1c: J).

2.3. Intra-observer variation

Single conformation parameters were measured on the lateral digits of the left hind and right front limbs of ten sheep selected randomly from a group of 44 sheep. Following measurement, the sheep were released into their pens and rounded up again in order to measure the parameters a second time. Measurements were recorded by the same person on separate sheets with completed sheets placed out of sight to enable 'blind' measurements each time. For each parameter, variation between the two readings was assessed in three ways.

2.3.1. Coefficient of variation (CV)

The CV, a dimensionless quantity used to compare relative amounts of variation, was calculated as the ratio of the standard deviation of the two readings to the mean of the readings and expressed as a percentage.

$$\text{Coefficient of Variation} = \frac{\text{Standard deviation of Reading 1 and Reading 2}}{\text{Mean of Reading 1 and Reading 2}} \times 100$$

A mean CV of less than 15% was considered to be acceptable for intra-observer variation based on other studies (Patel et al., 2001; Reed et al., 2002).

2.3.2. Intraclass correlation coefficient (ICC)

The ICC represents the proportion of the total variability in the observations which is due to the differences *between* the pairs of observations as opposed to *within* the pairs of observations (Petrie and Watson, 2006). The ICC was calculated by Restricted Maximum Likelihood (REML) analysis in a linear mixed model (Genstat, 11th edition, VSN International Ltd, UK). Individual sheep were categorised as a random effect while the two observations were fixed effects for the conformation parameter measured.

$$\text{ICC} = \frac{\text{Variance of random component}}{\text{Variance of random component+residual variance}} \times 100$$

An ICC of greater than 70% was considered acceptable for repeatability (Nunnally and Bernstein, 1994) as this indicated that less than 30% of the variation could be attributed to the different observations.

2.3.3. Limits of agreement

The 95% limits of agreement define the limits within which most of the differences between the two sets of observations lie (Altman and Bland, 1983). Specifically, the 95% limits of agreement define the upper and lower limits of the majority of the differences and are calculated as the bias ± 1.96 times the standard deviation (Altman and Bland, 1983). In the absence of a gold standard, agreement between the two sets of observations is analysed by calculating the bias (the mean difference between the readings), and plotting it against the mean of the readings. As there are no set guidelines defining acceptable magnitudes in differences between the two readings it was arbitrarily decided whether the measurement of the parameter was acceptable or not, based on the limits of agreement in the context of the size of the data points. In this study, the limits were considered acceptable if 1.96 × SD was less than a quarter of the highest observation (mean of the two readings).

If the data were not normal and the difference between the two readings changed with the size of the readings, the limits of agreement were defined differently. First the data were transformed into the logarithmic scale and then the standard deviation of the transformed differences was calculated (Euser et al., 2008). The limits of agreement were then defined as:

$$\text{Limit of agreement} = \frac{\text{mean of readings} \times 2 \times (10^{1.96 \times \text{SD of transformed differences}} - 1)}{(10^{1.96 \times \text{SD of transformed differences}} + 1)}$$

2.4. Inter-observer variation

The day after intra-observer variation in measurements was assessed, the same ten sheep were used to assess inter-observer variation. The conformation parameters for the ten sheep were measured by the first observer in the absence of the second. The sheep were released and rounded up again for the second observer to measure. Measurements were made on separate sheets and the two observers were unaware of the other's measurements. All conformation parameters were measured on the lateral digits of the left hind and right front limbs of all ten