



# Short term repeatability of body fat thickness measurement and body condition scoring in sheep as assessed by a relatively small number of assessors



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## ABSTRACT

This study evaluated the intra-observer repeatability of the rump fat thickness (RFT) measurements by ultrasound and body condition scoring (BCS) in sheep, and the reproducibility of RFT and BCS determined i) by six investigators, ii) at different sites (left and right, lumbar and sternal) and iii) in unshorn and shorn sheep. Six investigators with different experience in estimating body condition score in sheep determined BCS and RFT repeatedly at the different sites in 65 ewes before and after shearing. Intra-observer repeatability was greater for repeated measurement of RFT left ( $r=0.83$  and  $r=0.84$ , in unshorn and shorn sheep) than RFT right ( $r=0.64$  and  $r=0.77$ , resp.). A lower repeatability for measuring the sternal fat thickness (SFT) in unshorn sheep ( $r=0.31$ ) indicates that this method is not feasible to score ewes. The correlation between fat thicknesses determined at different sites (RFT left, RFT right, SFT) and in unshorn and shorn sheep revealed a generally higher reproducibility of RFT measurements left and right ( $r=0.63$ – $0.76$ ) compared with the reproducibility of RFT and SFT ( $r=0.37$ – $0.79$ ). Repeatability and reproducibility varied between investigators and in unshorn and shorn sheep. The repeatability for measuring BCS lumbar in unshorn and shorn sheep was greater ( $\kappa=0.73$  and  $\kappa=0.67$ , resp.) than for determining BCS sternal ( $\kappa=0.01$  and  $\kappa=0.44$ , resp.) and varied between investigators and in unshorn and shorn ewes. Reproducibility of lumbar and sternal BCS determined by the six investigators was poor to fair in unshorn and poor to moderate in shorn ewes. In summary, measuring RFT or BCS at a sternal site cannot be recommended. Furthermore, taking measurement on shorn sheep improved reproducibility. Based on these results, the assessment of RFT or BCS in sheep has the greatest repeatability in the lumbar region. It has to be noted that this study analyzed the repeatability but not the accuracy of the described methods.

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## 1. Introduction

The assessment of the body condition in ewes is an important tool for a good flock management (Hocking Edwards et al., 2011). With continuous monitoring of the body condition, increasing risks for metabolic diseases, e.g. pregnancy toxæmia, can be identified in individual sheep and on herd level (Rook, 2000). Nutrition can be optimized by adjusting the feeding according to the body condition of the animals, particularly during early lactation and in late pregnant ewes (Brozos et al., 2011; Rook, 2000). Managing flocks

according to recommendations for body condition, for example guidelines developed in the Lifetimewool project in Australia (Dart et al., 2011), also increases wool production of ewes (Ferguson et al., 2011) and wool quality of their progeny (Hocking Edwards et al., 2011). Determining BCS or measuring RFT are also common methods to determine meat quality in sheep (Frutos et al., 1997; van Burgel et al., 2011). The merit of condition scoring for managing the nutrition of sheep and as an alternative to liveweight measuring has been shown by van Burgel et al. (2011).

In general, there are two methods for determining the body condition of ruminants, the estimation of the body condition score (BCS) by visual and by palpation, and the measurement of rump fat tissue thickness (RFT) by ultrasound. Several authors have described techniques for body condition scoring in sheep as

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reviewed by Russel (1984) and recently by Kenyon et al. (2014). Jefferies (1961) first described a useful body condition scoring system on a scale from 1 (very thin) to 5 (very fat). Later, the scoring system was modified by using 0.25-point increments (Russel et al., 1969). Russel (1984) suggested assessing the BCS by palpation of the lumbar region, on and around the backbone in the loin area behind the last rib and above the kidney. BSC can also be performed also by sternal palpation (Leeb et al., 2007).

Silva et al. (2006) and Teixeira et al. (2008) used the ultrasonographic measurement of RFT and sternal fat thickness (SFT) in sheep and goat to estimate the carcass composition. The measuring points were between the third and fourth lumbar vertebra and over the third sternebra of the sternum. The depth of tissue (fat and muscle), 11 cm from the backbone over the last long rib (GR site and GR tissue depth), can be used to estimate the body fat reserves (Shands et al., 2009; van Burgel et al., 2011).

In Austria, where this study was performed, body condition scoring is common to adjust the feeding of the flock with the aim to prevent diseases, but to a lesser extent to estimate the carcass quality. The scoring should be aligned with physiological changes of the animal, e.g., gestation, and the environmental conditions, e.g., food on offer and can be performed by farmers (Dart et al., 2011; van Burgel et al., 2011) or by infrequent and impartial observers, for example the local veterinarian (Rook, 2000).

To evaluate a measuring system, it is important to analyze the intra-observer repeatability as well as inter-observer reproducibility or correlation (Bartlett and Frost, 2008). Several systematic reasons may influence the observers' measurements, for example experience of the investigator, method, heterogeneity of population, and site of measurement (Bartlett and Frost, 2008). Repeatability and reproducibility of BCS and RFT have been calculated in dairy cows (Ferguson et al., 1994; Kristensen et al., 2006; Pothmann et al., 2015; Vasseur et al., 2013; Veerkamp et al., 2002) as well as in sheep (Shands et al., 2009; van Burgel et al., 2011). van Burgel et al. (2011) compared results of ultrasonographic measures of fat depth over the eye muscle of sheep and reported a good reproducibility between different investigators. Calavas et al. (1998) assessed body condition scoring in ewes under field condition. They reported good intra-observer repeatability ranging from 52.1% to 100%, but found a poor inter-observer reproducibility with significant differences between individuals and groups of observers with different experience in body condition scoring.

The present study was conducted to evaluate the intra-observer repeatability of RFT, SFT and BCS and the reproducibility of results obtained i) by six investigators, ii) at different sites (left and right, lumbar and sternal), and iii) in unshorn and shorn sheep. The study was not designed to evaluate the accuracy of the described methods; this would have required euthanasia of animals and carcass evaluation.

## 2. Materials and methods

### 2.1. Animals

The study was conducted at the Teaching and Research Farm Kremesberg, University of Veterinary Medicine Vienna, Austria. In total, 65 ewes from three different breeds (42 Merino, 19 Tyrol mountain sheep, 4 Tyrol Steinschaf) and at different reproductive status (50 pregnant at different stages of gestation, 9 non-pregnant and lactating, 6 non-pregnant and non-lactating) were included in this trial. All ewes were kept in groups on deep litter and were fed ad libitum with hay, silage of alfalfa, and concentrate obtained from squeezed oat. During summer, the sheep had access to pasture during the day. The mean body weight in unshorn sheep was

**Table 1**  
BCS-system lumbar and sternal (according to Leeb et al., 2007).

Score	Lumbar	Sternal
1 very thin	Muscles cover the transverse processes only two thirds; the bone is distinct palpable.	Link between rib cartilage and sternum palpable; central recess of the sternum palpable due to missing fat.
2 thin	Transverse and spinous processes are distinct palpable; the skin between forms a concave line.	Link hardly palpable, as covered with some fat; central recess of sternum is filled with fat thus a straight line is palpable.
3 good	The space among transverse and spinous processes is filled with muscles; the skin forms a straight line.	Due to increased fat on the sternum are distinct recesses on both sides of the sternum palpable.
4 very good	The bones are hard to palpate; the skin forms a convex line.	Sternum and ribs are hard to palpate; recess on both sides of the sternum disappears.
5 obese	Along the dorsal line there is a distinct recess visible; due to protrusion of muscles and fat on both sides.	No recess palpable; the skin forms a convex line.

100 kg (maximum 157 kg, minimum 71 kg), with a mean thoracic circumference of 112 cm (maximum 135 cm, minimum 94 cm).

The study was discussed and approved by the institutional ethics committee in accordance with national legislation, and was not classified as an animal experiment.

### 2.2. Determination of body condition and fat thickness

The body condition was estimated by palpation of the lumbar and sternal site of the sheep and scored on a 5-point scale, described in detail in Table 1.

RFT and SFT were determined by ultrasound (Easi Scan bovine scanner, Technology Ltd, Livingston, Scotland), with a 5 MHz linear array and ultrasonic gel as contact medium. RFT was measured between *tuber ischiadicum* and *trochanter major*. SFT was measured at the lowest point of the *sternum*, approximately 3 cm caudal from the cranial end of the *manubrium sterni*.

### 2.3. Design of the study

The study started in April 2013 and lasted two weeks. Six investigators with different experiences with RFT, SFT and BCS conducted the measurements: one student of veterinarian medicine (I1), one veterinarian with no experience in BCS/RFT in sheep but in cows (I2), one multi-media art student with no experience in sheep (I3), one employee of the research farm (I4), one farmer (I5) and one veterinarian with experience in BCS/RFT in sheep (I6). Prior to the start, all investigators were introduced to the methods and trained on the same sheep (n = 5) for one day. During the training and the entire study period, all investigators were equipped with a guideline for RFT, SFT and BCS with images. All sheep were kept in one stable in group pens according their reproductive status with no access to pasture. For measuring RFT, SFT and BCS, sheep were brought one by one to an examination pen within the same stable.

The scoring and ultrasound examinations were performed in pairs of two investigators at the same time in the stable, but with some distance between the investigators and with no access to the results of the respective other investigator. The results were recorded on a paper sheet by each investigator. The investigators determined the lumbar body condition score (BCSlu), sternal body condition score (BCSst), rump fat thickness left (RFTl), rump fat thickness right (RFTr) and sternal fat thickness (SFT) in all 65 unshorn sheep. This procedure was repeated the next day, before the next two investigators started on the third day, and so on. After

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