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Short communication

A comparison of claw conformation and claw horn structure of two sheep breeds, and their relationship to footrot incidence

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ABSTRACT

This study compared claw conformation (length of dorsal border (DB), diagonal length (DL), dorsal angle (DA), heel height (HH), hardness) and claw horn structure (number of horn tubules, diameter of tubules medullary cavity (TC), thickness of tubules cortex (TX) and average and total horn tubules zone) of two sheep breeds. Heritabilities for these parameters were estimated and the relationship to the incidence of footrot investigated. In total, front and hind claws of 240 sheep of the two breeds Merinoland (ML; $n = 142$) and Rhoen sheep (RH; $n = 98$) were examined four times in monthly intervals. Animals were screened for footrot every second week during the study period. DL and DB, were greater in ML than in RH ($P < 0.05$) and greater in front than in hind claws ($P < 0.05$). Front claws had greater HH and DA than hind claws ($P < 0.05$) with the values being superior in ML compared to RH ($P < 0.05$). Only in ML front and hind claws differed in their hardness ($P < 0.05$). Only 14% of ML animals were footrot-positive. These animals showed higher values in DA ($P < 0.01$) and HH ($P < 0.05$) and shorter DL than footrot-negative ones. Heritability estimates were on a moderate level for DL (0.29–0.53) and HH (0.15–0.25), whereas lower values were estimated for DB (0.04–0.15) and DA (0.08–0.19). Hardness was not found as a possible selection trait. Regarding the claw horn structure, TC, TX and average and total tubules zone were lower in ML than in RH ($P < 0.05$). In RH hind claws had larger average ($P < 0.05$) as well as total ($P < 0.05$) tubules zone than front claws. Parameters of claw horn structure showed moderate heritabilities (0.36–0.57). In conclusion, the results indicated the possibility to select sheep on the basis of morphological parameters of claw conformation and claw horn structure for an improved claw quality. However, the low incidence of footrot-positive animals did not allow drawing conclusions on the relationship between the observed parameters and the incidence of footrot.

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1. Introduction

Footrot, a bacterial and highly infective disease, is one of the major diseases in sheep production and causes lameness, pain and production losses (Nieuwhof and Bishop, 2005; Kaler and Green, 2008). The multifactorial disease is primarily caused by the pathogen *Dichelobacter nodosus* (Buller et al., 2010). An infection might lead to undermining of claw horn (Egerton et al., 1969). Kaler et al. (2010) described a dynamic interaction between lameness, claw conformation and footrot. The variance of claw conformation and claw horn structure between sheep breeds (Kindler, 1990; Erlewein, 2002) results in differing susceptibilities to infectious claw diseases (Thoms, 2006).

Heritability for resistance to footrot ranges between 0.1 and 0.2 varying between populations as well as phenotypes (Nieuwhof et al., 2008). These values indicate the potential

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for selecting footrot-resistant animals. Furthermore, functional candidate genes associated with footrot were recently found and might be used in the future to identify sheep at lower risk of infection (Smith et al., 2012). Nevertheless, footrot is not recorded under practical conditions and other parameters are needed to select less-susceptible animals. A promising alternative is the use of parameters of claw conformation and claw horn quality. In cattle, several claw conformation parameters were suggested as suitable for genetic improvements (Distl et al., 1990), but heritability estimates for parameters of claw conformation and particularly claw horn structure in sheep breeds were not studied in detail, yet. Thus, it is not clarified how foot conformation and claw horn structure might influence footrot in sheep.

Therefore, the aims of the study were firstly, to compare claw conformation and claw horn structure in Merinoland and Rhoen sheep; secondly, to estimate the heritabilities of claw conformation and claw horn structure in these breeds; and thirdly, to investigate the relationship between claw conformation and claw horn structure with the incidence of footrot.

2. Materials and methods

2.1. Animals and measurements

Claws of 240 sheep of the two breeds Merinoland (ML; $n = 142$) and Rhoen sheep (RH; $n = 98$) kept at the research station 'Oberer Hardthof' of the University of Giessen, Germany were examined. The purebred ewes aged from 1 to 8 years and descended from 5 sires. During assessment of parameters the flocks were kept in herds on pasture. The claws of ML and RH were trimmed by the same person in the week before they were moved to the pasture. Both breeds were grazed on the same pasture.

Claws were measured once a month between July and October 2008 for ML and June and September 2009 for RH. Measurements recorded were length of dorsal border (DB, mm), diagonal length (DL, mm), heel height (HH, mm), dorsal angle (DA, degree) and hardness (according to Baumgartner et al., 1990; Vermunt and Greenough, 1995). The hardness was determined with a Shore durometer (ASTM D2240, Zwick, Ulm, Germany) and is given as Shore D units (0–100) as described by Baggott et al. (1988). DA and hardness were measured on the lateral and DL, DB and HH on the medial and lateral claws of the front and rear feet. The sheep were screened for footrot every second week during the study periods according to the criteria described by Stewart et al. (1982). The animals were classified into footrot-negative and -positive with each animal showing any clinical sign of footrot being categorized as footrot-infected.

At the end of the study periods a claw horn sample of each individual was taken by cutting horn perpendicular to the dorsal claw wall (Danscher et al., 2010). Horn samples were taken medial and lateral in ML and lateral in RH from the front and rear leg, respectively. Fixed in 10% formalin solution, sections (12 μm) were made by using a freezing microtome (Cryostat Mikrom HM500 OM, Heidelberg, Germany) and colored with instant hematoxylin. The samples were amplified in the white line area (*Zona alba*) with a light optical microscope (Nikon ECLIPSE E600, Tokyo, Japan). Two sections each with 1 mm^2 per sample were recorded by using the software *Lucia G* (Version 4.60, Laboratory Imaging Limited, Prague, Czech Republic) and the number of horn tubules per mm^2 was counted. Furthermore, the in- and outside diameters of 10 horn tubules were measured to determine the diameter of the tubules medullary cavity (TC, μm) and the thickness of tubules cortex (TX, μm). The average (μm^2) and total horn tubules zone ($\mu m^2/mm^2$) was calculated accordingly.

2.2. Statistical analysis

The data were analyzed with the SAS program software (SAS, Inc., Cary, NC, USA) using the mixed procedure. Results are presented as least square mean values ± standard error. Pairwise differences were examined using the Tukey test ($P < 0.05$). The statistical model for claw conformation parameters included breed, footrot status (only ML), age, date and claw (front, hind) as fixed effects, the interactions between breed and date and breed and claw and animal as random effect. For claw horn structure parameters the model included breed, footrot status, age, claw (front, hind) and section as fixed effects, the interaction between breed and claw and animal as random effect. The values of TC and TX were log-transformed prior to the analysis, whereas results are presented as untransformed values.

Heritabilities were estimated with an animal model by using VCE, version 6.0.2 (Neumaier and Groeneveld, 1998). The animal model of claw conformation measurements included age and breed as fixed effects, animal as additive effect, the permanent environment as effect for repeated measurements and the residual effect. Because horn samples for claw horn structure of front and rear claw of ML were compounded, heritabilities were estimated only in RH using the above described animal model without the breed effect.

3. Results

DL and DB were greater in ML than in RH sheep ($P < 0.05$; Table 1). Additionally, front claws had greater measures of these parameters than hind claws in both breeds ($P < 0.05$). This was observed for medial as well as for lateral measurements. Similarly, HH and DA values were higher in front than in hind claws ($P < 0.05$) and superior in ML compared to RH ($P < 0.05$). Only in ML front claws were harder than hind claws ($P < 0.05$).

The estimated phenotypic correlations between parameters of front and rear claw were on a high level for DL, DB and DA (0.63–0.84; $P < 0.001$) in both breeds. The accordant correlations for the hardness and HH were moderate (0.27–0.54; $P < 0.001$). Heritability estimates (±SE) of the investigated claw conformation measurements are presented in Table 2. Estimates were greatest for DL. In DA values were at similar levels as for DB, whereas the hardness of the claw horns was found with very low values.

Footrot was present in 14.1% of the ML sheep, but did not occur in the RH flock during the study period.

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