# Genetic parameters of linear conformation type traits and their relationship with milk yield throughout lactation in mixed-breed dairy goats

**A. McLaren,\* S. Mucha,†[1] R. Mrode,†‡ M. Coffey,† and J. Conington†**
*Scotland's Rural College, Hill and Mountain Research Centre, Kirkton Farm, Crianlarich, FK20 8RU, United Kingdom
†Scotland's Rural College, Animal and Veterinary Sciences, Easter Bush, Midlothian, EH25 9RG, United Kingdom
‡Animal Biosciences, International Livestock Institute, PO Box 30709, Nairobi 00100, Kenya

## ABSTRACT

Conformation traits are of interest to many dairy goat breeders not only as descriptive traits in their own right, but also because of their influence on production, longevity, and profitability. If these traits are to be considered for inclusion in future dairy goat breeding programs, relationships between them and production traits such as milk yield must be considered. With the increased use of regression models to estimate genetic parameters, an opportunity now exists to investigate correlations between conformation traits and milk yield throughout lactation in more detail. The aims of this study were therefore to (1) estimate genetic parameters for conformation traits in a population of crossbred dairy goats, (2) estimate correlations between all conformation traits, and (3) assess the relationship between conformation traits and milk yield throughout lactation. No information on milk composition was available. Data were collected from goats based on 2 commercial goat farms during August and September in 2013 and 2014. Ten conformation traits, relating to udder, teat, leg, and feet characteristics, were scored on a linear scale (1–9). The overall data set comprised data available for 4,229 goats, all in their first lactation. The population of goats used in the study was created using random crossings between 3 breeds: British Alpine, Saanen, and Toggenburg. In each generation, the best performing animals were selected for breeding, leading to the formation of a synthetic breed. The pedigree file used in the analyses contained sire and dam information for a total of 30,139 individuals. The models fitted relevant fixed and random effects. Heritability estimates for the conformation traits were low to moderate, ranging from 0.02 to 0.38. A range of positive and negative phenotypic and genetic correlations between the traits were observed, with the highest correlations found between udder depth and udder attachment (0.78), teat angle and teat placement (0.70), and back legs and back feet (0.64). The genetic correlations estimated between conformation traits and milk yield across the first lactation demonstrated changes during this period. The majority of correlations estimated between milk yield and the udder and teat traits were negative. Therefore, future breeding programs would benefit from including these traits to ensure that selection for increased productivity is not accompanied by any unwanted change in functional fitness.

**Key words:** dairy goat, conformation, milk yield, random regression

## INTRODUCTION

Conformation traits are of interest to many animal breeders, not only as descriptive traits in their own right but also because of their influence on production, longevity, and profitability (Brotherstone 1994). In dairy cattle, linear type traits were first recorded in the early 1980s (Meyer et al., 1987; Short and Lawlor, 1992; Brotherstone, 1994). In terms of small ruminants, one of the earliest scales was developed by the American Dairy Goat Association (ADGA), which has been used to score goats across a range of different breeds since 1988 (Luo et al., 1997). The linear traits included in this scale are scored from 1 to 50, with an additional score, based on overall appearance according to several weighted criteria, of between 50 and 99. However, several other scales, which have also been used to assess conformation traits, have been developed based on 9-point linear type scoring systems. One of the earliest proposed for dairy sheep was by de la Fuente et al. (1996) during an evaluation of Churra ewes, from which several other scales, adapted for different breeds, have emerged (Carta et al., 2009). In terms of dairy goats, a 9-point scale has been developed and is currently used by French dairy goat breeders, as described by Manfredi et al. (2001).

Initially, the most commonly recorded traits were udder and teat type traits, mainly due to their influence on milking ability, udder health, and longevity of animals. More recently, several studies have considered additional traits, such as those relating to the legs and feet of the animals (Manfredi et al., 2001; de la Fuente et al., 2011). By improving aspects such as animal mobility and structural correctness, it is possible that productivity and profitability of dairy goat herds could further improve, particularly when coincidentally exposed to intense selection pressure for yield traits.

If conformation traits are to be considered for inclusion in future dairy goat breeding programs, relationships between the conformation traits themselves, as well as with production traits such as milk yield, must be considered. Fernandez et al. (1997) and Legarra and Ugarte (2005), while estimating genetic correlations between conformation traits and milk yield in Churra and Laxta sheep, respectively, calculated correlations that indicated that selection for improved milk yield could have implications on udder morphology. Depth of the udder and placement of the teats were particularly affected, leading to a possible decline in the milking ability of animals in machine-milking environments. Similar findings were observed by Manfredi et al. (2001), indicating that to reduce the decline of milking ability while attempting to improve milk yield, it would be valuable to include conformation traits in breeding programs.

However, while examining the links between conformation traits and milk yield, many of these studies have used cumulated milk yields produced during lactations of different lengths; for example, 120-d milk yield in sheep (Fernandez et al., 1997; Legarra and Ugarte, 2005) or 250-d milk yield in goats (Manfredi et al., 2001; Rupp et al., 2011). With the increased use of random regression models to estimate genetic parameters in goats (Menéndez-Buxadera et al., 2010; Mucha et al., 2014), the opportunity now exists to investigate correlations between conformation traits and milk yield throughout lactation in more detail.

The aims of this study were therefore to (1) estimate genetic parameters for conformation traits in a population of crossbred dairy goats, (2) estimate correlations between all conformation traits, and (3) assess the relationship between conformation traits and milk yield throughout lactation.

## MATERIALS AND METHODS

### Conformation Traits

Conformation trait data were collected from goats based on 2 farms, owned by the same farming business and consisting of related animals, during August and September in 2013 and 2014. The data set comprised data available for 4,220 goats in their first lactation. The traits recorded for each animal, scored by the same recorder, were linear in form and scored using a 9-point scale that was similar to that developed by the French dairy goat breeders' association CAPGENES and used by Manfredi et al. (2001) and Rupp et al. (2011). The data contained information for 3 udder traits, 3 teat traits, and 4 traits relating to legs and feet.

The udder traits, as shown in Figure 1, were as follows: Udder furrow (**UF**), viewed from the rear of the udder, indicates the prominence of the medial suspensory ligament. A score of 1 indicates that the ligament is highly prominent, with an extreme cleft in the base of the udder, whereas a score of 9 indicates that the ligament is not prominent and there is little or no cleft visible. Udder depth (**UD**) is the depth of the udder measured compared with the hocks of the animal. Udders scored 1 are close to the ground, whereas those scored 9 are well above the hocks. A score of 5 indicates that the cleft of the udder is at the hock level. Udder attachment (**UA**) represents the strength of attachment based on the perimeter of the insertion to the abdominal wall. A score of 1 represents udders with a weak and narrow level of attachment, whereas those scored 9 are udders with a large and strong perimeter of attachment.

The teat traits, also shown in Figure 1, were as follows: Teat shape (**TS**), indicating the diameter and shape of the teat, ranges from wide and conical for score 1 to small and cylindrical for score 9. Teat angle (**TA**) describes whether the teat, when looking from the side of the animal, is pointing forward (score 1) or toward the rear (score 9); a score of 5 represents teats pointing straight downwards. Teat placement (TP) is scored using a rear view of the udder and gives an indication as to placement of the teats in relation to the medial ligament. Teats pointing outward, away from each other, are scored as 1, whereas those pointing inward, toward each other, are scored 9; a score of 5 would be given for teats pointing straight down.

The leg and feet traits are shown in Figure 2. The scoring for the front legs is similar to that shown for the back legs. A score of 5 for both the front legs (**FL**) and back legs (**BL**) represented legs that were completely straight. Animals with legs that pointed inward at a severe angle, resulting in the hocks (**BL**) or knees (**FL**) nearly touching, would be given a score of 1, whereas the opposite, with the hocks or knees a large distance apart and forming bowed legs, would be scored as a 9. The front feet (**FF**) and back feet (**BF**) scores describe the direction that the hooves are facing when the animal is standing (Figure 2). A score of 1, considered the