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ESTIMATION OF GENETIC AND PHENOTYPIC PARAMETERS FOR UDDER MORPHOLOGY TRAITS IN DIFFERENT DAIRY SHEEP GENOTYPES

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Abstract

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Knowledge of genetic parameters is the basis of sound livestock improvement programmes. Genetic parameters have been estimated for linear udder traits: Udder depth (UD), Cistern depth (CD), Teat position (TP), Teat size (TS) and external udder measurements: Rear udder depth (RUD), Cistern depth (CDe), Teat length (TL) and Teat angle (TA) – 1275 linear assessments (381 ewes) and 1185 external udder measurements (355 ewes) were included in the analysis for each character of 9 genotypes. Nine breeds and genotypes were included in these experiments: purebred Improved Valachian (IV), Tsigai (T), Lacaune (LC) ewes, and IV and T crosses with genetic portion of Lacaune and East Friesian (EF) – 25 %, 50 % and 75 %. Primary data were processed using restricted maximum likelihood (REML) methodology and the multiple-trait animal model, using programs REMLF90 and VCE 4.0. High genetic correlations were found between UD and RUD (0.86), CD and CD(e) (0.93), TP and TA (0.90), TS and TL (0.94). The highest heritabilities were estimated for exact measurements of TL and CD (0.35–0.39) and subjectively assessed TA and TS (0.32–0.33).

Keywords: ewes, genetic and phenotypic correlations, heritability, udder

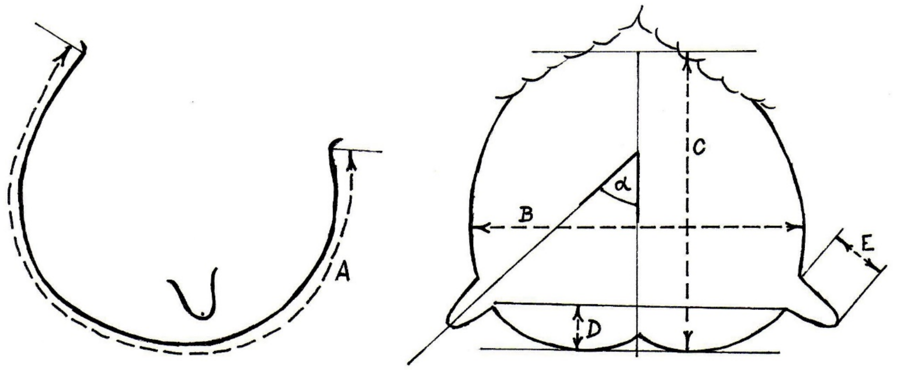
INTRODUCTION

In the last decades machine milking has been introduced more widely into dairy sheep husbandry. This evokes attention of breeders and scientists for morphological and functional characteristics of udder traits in order to enable an easy and uniform milking routine. Estimates of heritabilities and genetic correlations are essential population parameters required in animal breeding research and in design and application of practical animal breeding programmes. Several dairy sheep breeds have been studied in regards to their udder morphology traits. Therefore, the relationship of udder traits with milk yield and their usefulness for genetic improvement in sheep (Kukovics *et al.*, 2006; Džidić *et al.*, 2009; Kominakis *et al.*, 2009; Casu *et al.*, 2006; 2010; Legaz *et al.*, 2011; Gelasakis *et al.*, 2012; Huntley *et al.*, 2012; Makovický *et al.*, 2013; 2014; 2015a,b; Perez-Cabal *et al.*, 2013; Prpić *et al.*, 2016; Ayadi *et al.*, 2011; 2014; Sari *et al.*, 2015; Sezenler *et al.*, 2016), camels (Atigui *et al.*, 2016; Ayadi *et al.*, 2013; 2016a,b; Dioli, 2016; Nagy and Juhasz, 2016; Marnet *et al.*, 2016), sows (Balzani *et al.*, 2015; 2016a,b,c; Ocepek *et al.*, 2016), cows (Khan and Khan, 2015; 2016a,b) and goats (Pajor *et al.*, 2014) have been focused. Morphology of the mammary gland is a key factor for the optimization of machine milking parameters of small ruminants (Rovai *et al.*, 2008). Linear measurements of udder (circumference, width, and length) as well as of teat (circumference and length) characterize the morphology of mammary (Pourlis, 2011). Understanding of udder characteristics and design of mechanical milking systems for dairy sheep was investigated during the 1970–1988s (Labussière *et al.*, 1981; Labussière, 1988). Evaluation of udder morphology can be performed by direct measurements of the udder (Džidić *et al.*, 2004; Labussière, 1988) or by subjective assessment of udder traits using linear scales (De la Fuente *et al.*, 1996). Udder depth, udder attachment, teat placement, teat size and udder shape are commonly used traits for the selection programmes. In dairy ewes, the most important functional traits are those related to udder morphology, because they determine the machine milking efficiency of the animal and have a substantial effect on its functional lifetime (Gutiérrez *et al.*, 2008). The relationship between udder traits are known for dairy cattle (Seykora and McDaniel, 1986; Rogers and Spencer, 1991). Results from those studies have contributed to improvements in mammary morphology and aptitude for machine milking through adequate selection programs. The goal of this work was to determine the relationships between measurements of chosen udder dimensions or angles and subjective assessment of udder characteristics based on linear score in different sheep breeds in Slovakia. The knowledge of the relationships between individual characteristics of udder morphology is important also for their including into total selection indexes or for construction of partial selection indexes for udder morphology and enables to predict future correlated responses in milk-oriented selection schemes.

MATERIALS AND METHODS

East Friesian (EF) sheep is ranked among one of the most important dairy sheep breed in the world. Lacaune (LC) breed is also ranked among most important dairy sheep breed, however this breed originated from France and its milk is there above all used for making a cheese called Roquefort. Both above mentioned breeds are already several years reared in Slovak Republic either as purebreds, or as a sire breed crossed with domestic dairy breeds in order to improve the milk yield and quality of milk. However, East Friesian sheep are rather sensitive to unfavourable climatic conditions. On the other hand the Lacaune sheep can adapt relatively well to these conditions. Taking into account the above stated facts on some slovak farms in mountainous and sub-mountainous regions have started to cross East Friesian ewes or ewes East Friesian crossbreds with domestic breeds (Improved Valachian, Tsigai breed) with Lacaune sires in order to improve resistance of sheep against unfavourable climatic conditions and even also, to some measure, improved milk quality. Nine different sheep genotypes were included in this experiment to determine traits of subjective assessments and the external udder traits of the ewes belonging to the following populations: Improved Valachian (IV); Improved Valachian x East Friesian (25 %); Improved Valachian x East Friesian (50 %); Improved Valachian x East Friesian (75 %); Tsigai (T); Tsigai x East Friesian (25 %); Tsigai x East Friesian (50 %); Tsigai x East Friesian (75 %); Lacaune (LC).

This experiment was performed during the 7-year period and took place in one experimental flock of dairy sheep. Subjective assessments and exact measurements of udder morphology traits were carried out about twelve hours after milking. Linear scores for seven traits were assigned by one experienced technician using a nine-point scale: udder depth (1 – low, 9 – high), cistern depth below the teat level (1 – none, 9 – high), teat placement (1 – vertical, 9 – horizontal), teat size (1 – short teats, 9 – long teats), udder cleft (1 – nondetectable, 9 – expressive), udder attachment (1 – narrow, 9 – wide) and udder shape with respect to machine milking (1 – bad, 9 – ideal). Moreover, exact measurements of six traits were taken (Fig. 1). The methodology used for measuring udder traits was that described by Milerski *et al.* (2006). These included the following traits: udder length (measured with a tape, mm), udder width (mm),



1: *Udder measurements. A – udder length (UL), B – udder width (UW), C – rear udder depth (RUD), D – cistern depth (CD), E – teat length (TL), α – teat angle from the vertical (TA).*

(rear) udder depth (mm), cistern depth (mm), teat length (mm) and teat angle (°).

Three-breeding crosses with 25 %, 50 % and 75 % of the genetic proportion of both specialized dairy breeds: Lacaune and East-Friesian (SBD) formed during the entire period were significantly less from the assessed population (about 5%). Genetic parameters have been estimated for linear udder traits (UD, CD, TP, TS) and external udder measurements (RUD, CDe, TL, TA), 1275 linear assessments (381 ewes) and 1185 external udder measurements (355 ewes) were included in the analysis for each character of 9 genotypes. The estimation of covariance was based on a multiple trait animal model including 8 traits performed. Genetic parameters and combination of both sets of traits were estimated using restricted maximum likelihood (REML) methodology and the multi-trait animal model, using the REMLF90 and VCE 4.0 programs (Groeneveld and García Cortés, 1998). In addition to genetic correlations, the value was set using the Pearson phenotype correlations, for the calculation of the same data sets were used as the calculation for genetic correlations. Phenotypic correlations were calculated using CORR procedure in mathematical-statistical program package SAS/STAT (2002–2008). For estimation of covariance components and genetic parameters for all of the above parameters, the following model was used:

$$y_{ijklmno} = \mu + Y_i + LS_j + GEN_k + P_l + b^{*}DIM_{ijklm} + a_m + tp_n + e_{ijklmno},$$

where:

$y_{ijklmno}$ ..... is the vector of observations for the investigated characteristics (see above for details);

Y_i .... year (fixed effect with 5 to 7 levels; depending on the analysed indicator);

LS_j........... lactation stage (fixed effect with 4 levels; from 40th to 99th lactation day, from 100th to 129th lactation day, from 130th to 159th lactation day and from 160th to 210th lactation day);

GEN_k.... genotype (breed group, fixed effect with 9 levels; see above for characterization);

P_l .... parity (fixed effect with 3 levels; first, second, third and further parity);

a_m........... is the additive genetic effect of ewes;

DIM_{ijklm}. days in milk (covariate; 40 to 210 days in milk); tp_n is the permanent environmental effect of ewes;

$e_{ijklmno}$...... is the random error.

RESULTS AND DISCUSSION

Tab. I shows the coefficients of heritability (on diagonal), genetic correlations (above diagonal) and phenotypic correlations (below diagonal) between traits of subjective assessments and external measurements of udder traits. High genetic correlations were found between Udder depth and Rear udder depth (0.86), Cistern depth and Cistern depth(e) (0.93), Teat position and Teat angle (0.90), Teat size and Teat length (0.94). The highest heritabilities were estimated for exact measurements of Teat length and Cistern depth (0.35–0.39) and subjectively assessed Teat angle and Teat size (0.32–0.33). These results agree with practical observations and those obtained previously on Mediterranean dairy sheep. Moreover, the heritability estimates in this study were in agreement with the estimates for the other sheep breeds. Fernández *et al.* (1995) observed that stage of lactation produced significant effects on all udder traits while breed effects on udder length and distance between teats were non significant. Also, differences in teat dimensions (width and length) and udder height (depth and cistern height) were significant for breed and parity. It was further reported by Fernández *et al.* (1995) that as udder width increased, cistern height and teat angle and position decreased and as udder height increased, cistern height and teat angle and position also increased. The most significant and repeatable udder traits agreed by different authors (De la Fuente *et al.*, 1996; Fernández *et al.*, 1997; Gootwine *et al.*, 1980) for a wide sample of dairy sheep breeds are: teat dimensions (length) and position (angle), udder height (also called depth), width and cisterns height. In dairy ewes, relationships between udder characteristics and milk yield had since been established (Sagi and Morag, 1974; Jatsch and Sagi, 1979) as part of effort to manufacture and adapt ewes to machine milking. The four udder traits considered by De la Fuente *et al.* (1996) to be significant for machine milking were: udder depth or height (from the perineal insertion to the bottom of the udder cistern), udder attachment (insertion perimeter to the abdominal wall), teat angle (teat insertion angle with the vertical), and teat length (from the gland insertion to the tip). Although, the use of these four linear udder traits will be sufficient to improve programs of udder morphology, however phenotypic and genetic correlations showed that selection for milk yield may produce worse udder morphology most especially when much selection pressure is imposed on them as it may result in baggy udders which are inadequate for machine milking (De la Fuente *et al.*, 1996).

I: *Heritability coefficients (on diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations between traits of subjective assessments and external measurements of udder traits*

Traits	Linear udder assessment scores				External udder measurements			
	UD,*[1]	CD,*[1]	TP,*[1]	TS,*[1]	RUD,*[2]	CDe,*[2]	TL,*[2]	TA,*[2]
Udder depth,*[1]	0.20	0.36	0.31	–0.05	0.86	0.22	0.14	0.19
Cistern depth,*[1]	0.47	0.32	0.95	–0.43	0.33	0.93	–0.38	0.95
Teat position,*[1]	0.36	0.85	0.26	–0.54	0.42	0.87	–0.55	0.90
Teat size,*[1]	0.18	–0.07	–0.08	0.33	0.02	–0.22	0.94	–0.49
Rear udder depth,*[2] (mm)	0.74	0.42	0.33	0.10	0.24	0.29	0.09	0.19
Cistern depth,*[2] (mm)	0.55	0.71	0.60	–0.02	0.55	0.39	–0.19	0.95
Teat length,*[2] (mm)	0.008	–0.18	–0.21	0.55	0.013	–0.08	0.35	–0.42
Teat angle (°),*[2]	0.30	0.59	0.58	–0.090	0.31	0.58	–0.19	0.32

*[1] Linear udder assessment scores (9 points scale, from 1 to 9).
*[2] External udder measurements (mm; Teat angle °).

CONCLUSION

The knowledge of the relationships between morphological udder traits would permit to predict future correlated responses in milk-oriented selection schemes. Moreover, further researches with larger numbers of different sheep breeds in Slovakia are required to confirm these results.

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