



Relationships between morphological udder characteristics in Improved Valachian, Tsigai and Lacaune dairy sheep breeds

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The anatomy and morphology of the sheep udder is well known and some examples of curious selection on udder morphology have been assayed (i.e. increasing prolificacy and number of teats). The interest in the dairy sheep udder has increased in the last few years in which anatomy has been explored in depth (Caja *et al.* 1999, Carretero *et al.* 1999). Linear evaluation of udder traits has been proposed (Carta *et al.* 1999) and the genetic parameters evaluated (Gootwine *et al.* 1980, Fernández *et al.* 1995). Moreover, given the negative effects observed in udder morphology as a result of the increase in milk yield, main udder traits of breeds of different production level (Rovai *et al.* 1999, Makovický *et al.* 2013) or of genetically isolated lines of the same breed (Marie *et al.* 1999) are under comparison. The improvement of udder conformation might be beneficial to milking ability and animal health, but present selection on dairy production traits does not warrant a favourable trend in udder morphology. Milking characteristics and udder morphology are some of the factors determining milkability in dairy ewes. Knowledge of milk yield, milking time and udder conformation is necessary for optimal adaptation of the milking environment to the needs of the ewe (Makovický *et al.* 2015a). Udders are strongly attached to the abdominal wall and with vertical teats placed on the lowest part of the cistern are less subjected to teat-cup falls and need fewer manual interventions for stripping (Casu *et al.* 2000). By contrast, when teats are horizontal and implanted far from the udder floor, a certain amount of milk may be retained in the cistern (Bruckmaier *et al.* 1997). Horizontal teats are also more susceptible to distortion during machine milking. This

inhibits the ejection reflex and thus increases alveolar milk retention (Labussière 1988). Deep udders also retain part of the milk in the cistern during the machine milking; thus, manual intervention is needed to complete the milk extraction. Several authors have also highlighted the strong relationship between udder depth and milk yield (Labussière 1988, Casu *et al.* 2000). Udder conformation may be linked to functional longevity because grazing ewes with deep udders are more exposed to injury, and consequently may be more liable to be culled. A linear method for the morphological appraisal of sheep udders have been proposed for 5 traits scored on a nine-point linear scale (De la Fuente *et al.* 1996). Score distributions, objectivity of classifiers, and the effects of environmental factors on linear udder traits have been studied elsewhere (Fernández *et al.* 1995; Makovický *et al.* 2014, 2015b). Traits related to udder size (depth, width, and circumference) were significantly influenced by lactation month, flock, and milk yield; traits related to cistern morphology (cistern height, teat position, and teat angle) were significantly affected by flock and parity.

Investigations were performed in 5 flocks of dairy sheep in the Slovak Republic. Total 266 pure bred Tsigai (T), Improved Valchian (IV) and Lacaune (LC) ewes were included in the experiment. Measurements were recorded repeatedly within and between lactations, therefore 772 sets of measurements and linear scores were collected in total. Udder morphology measurements and subjective linear appraisals were made on the ewes approximately 12 h after previous milking. External udder measurements of 6 traits were performed by one technician and included udder length measured by tape (UL), udder width (UW), rear udder depth (RUD), cistern depth (CD), teat length (TL), teat angle from the vertical (TA). Additionally the measurements of udder cistern cross-section areas were carried out by the ultrasound technique from the side (SCA) according to the methodology of Ruberte *et al.* (1994) and from below in a water bath (BCA) as described by Bruckmaier and Blum (1992). The linear assessments were done subjectively by one experienced assessor using 9 point scale. Linear assessment scheme contained 7 characteristics of udder and

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Table 1. Correlation coefficients between subjectively assessed linear scores and measurements of characteristics of udder morphology in Tsigai dairy ewes

Linear score	Udder measurement							
	UL	UW	RUD	CD	TL	TA	BCA	SCA
Udder depth	0.69	0.76	0.78	0.25	ns	ns	0.49	0.52
Cistern depth	0.33	ns	0.24	0.76	-0.205	0.61	0.28	ns
Teat position	0.19	ns	ns	0.67	-0.27	0.69	0.26	ns
Teat size	ns	ns	ns	ns	0.75	-0.17	ns	ns
Udder cleft	ns	ns	ns	-0.24	ns	-0.23	ns	ns
Udder attachment	0.47	0.71	0.57	ns	ns	ns	0.29	0.44
Udder shape	0.58	0.73	0.67	ns	ns	-0.18	0.37	0.48

UL, udder length; UW, udder width; RUD, rear udder depth; CD, cistern depth; TL, teat length; TA, teat angle; BCA, cistern cross-section area measured from bottom; SCA, cistern cross-section area measured from side.

Table 2. Correlation coefficients between subjectively assessed linear scores and measurements of characteristics of udder morphology in Improved Valachian dairy ewes

Linear score	Udder measurement							
	UL	UW	RUD	CD	TL	TA	BCA	SCA
Udder depth	0.76	0.72	0.80	0.58	ns	0.32	0.58	0.57
Cistern depth	0.43	0.28	0.41	0.80	-0.27	0.69	0.38	0.25
Teat position	0.32	ns	0.30	0.56	-0.36	0.76	0.24	ns
Teat size	ns	ns	ns	ns	0.65	0.29	ns	ns
Udder cleft	ns	ns	ns	ns	ns	ns	0.21	0.27
Udder attachment	0.32	0.66	0.44	0.25	ns	ns	0.25	0.37
Udder shape	0.59	0.75	0.72	0.42	ns	ns	0.46	0.48

UL, udder length; UW, udder width; RUD, rear udder depth; CD, cistern depth; TL, teat length; TA, teat angle; BCA, cistern cross-section area measured from bottom; SCA, cistern cross-section area measured from side.

Table 3. Correlation coefficients between subjectively assessed linear scores and measurements of characteristics of udder morphology in Lacaune dairy ewes

Linear score	Udder measurement							
	UL	UW	RUD	CD	TL	TA	BCA	SCA
Udder depth	0.80	0.53	0.76	0.29	ns	ns	0.56	0.58
Cistern depth	0.40	ns	ns	0.76	ns	0.75	0.32	ns
Teat position	0.39	ns	ns	0.69	ns	0.73	0.31	ns
Teat size	0.36	ns	0.32	ns	0.69	ns	0.30	ns
Udder cleft	ns	ns	ns	-0.28	ns	ns	ns	ns
Udder attachment	ns	0.41	ns	ns	ns	-0.38	ns	ns
Udder shape	ns	0.57	ns	ns	ns	-0.31	ns	0.32

UL, udder length; UW, udder width; RUD, rear udder depth; CD, cistern depth; TL, teat length; TA, teat angle; BCA, cistern cross-section area measured from bottom; SCA, cistern cross-section area measured from side.

teats namely udder depth (1-low, 9-high) cistern depth below the teat level (1-none, 9-high), teat placement (1-vertical, 9 horizontal), teat length (1-short, 9-long), udder attachment (1-narrow, 9-wide), udder cleft (1-not detectable, 9-expressive), udder shape from the point of view of machine milking (1-bad, 9-ideal).

Data were processed by MIXED procedure from the SAS statistical package (SAS Institute, 2000). Following statistical model was used for all investigated traits:

$$Y_{ijkl} = \text{Edi} + \text{PAR}_j + \text{ank} + a * \text{dimijkl} + b * \text{dimijkl}^2 + \text{eijkl}$$

where Y_{ijkl} , measured or assessed trait; Edi, experimental

day (fixed effect – 12 levels for T and IV, 8 levels for LC); PAR_j , parity (fixed effect: 3 levels—1st, 2nd, 3rd, and further lactations); ank, animal (random effect); dimijkl, days in milk (covariable: min. 42 days, max. 191 days); eijkl, residual error.

Estimated random animal effects (ank) included in addition to genetic effects of individuals also lifewide and within lactation permanent environmental effects. Pearson correlation coefficients between estimates of random animal effect (ank) for udder measurements and for the traits of linear assessment scheme were computed by the CORR procedure from the SAS statistical package.

Subjectively assessed linear scores for udder depth, cistern depth, teat angle and teat size showed high correlations with actual measurements of appropriate traits on udder in all 3 examined breeds ($r_p=0.65-0.80$). It would appear that the used linear scoring system is appropriate for evaluating in dairy ewes of Tsigai, Improved Valachian and Lacaune in the Slovak Republic. Nevertheless for final designing of linear scoring scheme in Slovakia also, knowledge about relationships between udder traits assessments and milk yield, resp. machine milk flow characteristics is needed. Interbreed differences in relationships between linear scores for udder shape and some other udder morphology characteristics suggested that udder shape assessment is more influenced by those characteristics which are far from the ideal udder shape. The knowledge about relationships between morphological udder traits would permit to predict future correlated responses in milk-oriented selection schemes.

SUMMARY

Udder morphology traits were measured and subjectively assessed by the use of linear scores and cistern cross-section areas were scanned by ultrasound machine, and were examined in 266 dairy ewes of Tsigai (TS), Improved Valachian (IV) and Lacaune (LC) dairy ewes. Measurements were recorded repeatedly within and between lactations, therefore 772 sets of measurements were collected in total. Analysis of variance was conducted with the mixed procedure of SAS statistical package. The model included effects of experimental day, parity, day in milk, random effect of animal and residual error. Subsequently correlations between random animal effects for udder measurements and linear scores were computed. Subjectively assessed linear scores for udder depth, cistern depth, teat angle and teat size showed high correlations with actual measurements of appropriate traits on udder in all examined breeds ($r_p=0.65-0.80$).

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