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THE EFFECT OF SPECIALIZED DAIRY BREEDS ON UDDER CISTERN SIZE IN TSIGAI CROSSBREDS

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ABSTRACT

Sonographic images of the ewe left and right udder cisterns using 2 methods (1 – from side, 2 – from bottom) were taken by means of two devices: an ultrasonograph Aloka 250 (3,5 MHz linear probe) or ultrasonograph SonoVet2000 (L2-5/170 CD linear probe). Length, width and area of each udder cistern were measured during milking period in years 2002 to 2008. The ewes of 5 genotypes (purebred Tsigai, purebred Lacaune, crosses of Tsigai with Lacaune and East-Friesian with genetic portion of specialized dairy breeds 25 %, 50 % and 75 %) were evaluated. According to measured traits, 640 and 752 sonograms from 200 and 231 ewes were taken using the method 1, and 470 sonograms from 163 ewes were taken using the method 2. Data were evaluated using REML methodology and MIXED procedure (software SAS/STAT). The effect of genotype showed the highest influence ($P<0.001$) on the length and area of the left and right udder cisterns. In purebred Tsigai ewes, the average areas of the left and right udder cisterns determined using the method 1 were 1413.1 ± 78.56 mm^2 and 1400.4 ± 71.58 mm^2. These were significantly smaller in purebred Tsigai ewes than in purebred Lacaune ewes (2698.3 ± 78.62 mm^2 and 2696.2 ± 71.47 mm^2, respectively; $P<0.001$). Mostly, the udder cistern areas were significantly higher in crosses than in purebred Tsigai ewes. The effect of parity using the method 1 was significant too. The average areas of the left and right udder cisterns determined using the method 1 were 1892.0 ± 84.08 mm^2 and 1902.7 ± 77.39 mm^2 in ewes at the first parity and 2231.9 ± 97.96 mm^2 and 2315.0 ± 90.86 mm^2 in ewes at the third and further parity. Our analyses showed that crossbreeding of TS with LC and EF considerably increases ewe‘s cistern size. This fact indicates that breeding goals in dairy sheep in Slovakia are being successfully followed.

Key words: ultrasonography; udder cistern; dairy breeds; Tsigai breed

INTRODUCTION

Many scientific papers describing the cistern size of ewe's mammary gland and its impact on ewe adaptation to machine milking have been published until now. Various dairy sheep breeds have been investigated by a number of authors (Bruckmaier and Blum, 1992; Bruckmaier *et al.*, 1997; Caja *et al*., 1999; Margetín *et al*., 2002, 2003, 2010; Franz *et al*., 2003; Milerski *et al*., 2005, Castillo *et al*., 2008; Mačuhová *et al*., 2010). The udder cistern measurements taken by ultrasonography techniques have also been studied in dairy goats by Wojtowski *et al.* (2006) and in dairy cows by Ayadi *et al*. (2003). It was shown that udder scanning by ultrasonography is a suitable tool to study ewe's mammary gland throughout the whole lactation. This is a simple procedure with no special requirements. Nudda *et al*. (2000), Makovický (2009) and Margetín *et al*. (2010) made a recommendation for using sonographic measurements as a good indicator of the cistern size in ewes. Sonographic measurements may be effective criteria for selection of ewes as they enable to identify individuals with high milk yield and

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good milkability (in dependence on estimated traits that characterize cistern size of ewe's mammary gland). In Slovakia, a breeding programme aimed at improvement of milk yield and milkability in ewes of the Tsigai breed by means of crossbreeding with the Lacaune and East-Friesian dairy sheep has been ongoing since 1995 (Margetín, 2005).

The objective of this study was to investigate the udder cistern size using ultrasonography techniques in purebred Tsigai (TS) and Lacaune (LC) ewes, and TS crosses with genetic portion of LC and East Friesian (EF) - 25 %, 50 % and 75 %. The analyses of non-genetic factors that are expected to influence the udder cistern size were also done.

MATERIAL AND METHODS

The recorded ewes originated from the experimental farm Trenčianska Teplá of the Animal Production Research Centre Nitra. The experiment was performed during the 7-year period from 2002 to 2008. Each year the ewes were kept within the same flock and were milked twice a day. Machine milking was carried out in a 1x24 low-line, side by side milking parlour. Milking machine was set to provide 140-160 pulsations per min (1:1 ratio with a vacuum level of 38 kPa). Purebred Tsigai (TS) and purebred Lacaune (LC) ewes, and TS crosses with 25 %, 50 % and 75 % genetic portion of specialized dairy breeds (SDB) Lacaune and East-Friesian (EF) were included in the experiment (TSxSDB 25 %, TSxSDB 50 % and TSxSDB 75 %). TSxLC crosses occurred most frequently. Each year the ewes at first, second, third and further parity were tested. Sonographic measurements of the left and right udder cistern (length, width and area) were taken. Two apparatuses were used: an ultrasonograph ALOKA 250 with a linear probe with the frequency 3.5 MHz (early years of the experiment) and ultrasonograph SonoVet2000 with a 170 mm linear probe with the frequency 2 to 5 MHz (late years of the experiment).

When the method 1 (from side) was used, each udder half was scanned separately. The probe was applied into inguinal abdominal fold (according to Nudda *et al.*, 2000 and Margetín *et al*., 2002). When the method 2 (from bottom) was used, both udder halves were scanned simultaneously. The udder was immersed into water and the probe was applied in its bottom (according to Nudda *et al*., 2000 and Margetín *et al*., 2002). Each scanning provided a sonographic image which enabled measuring the length and width of the udder cistern (mm) following a procedure (figure 1) proposed by Nudda *et al*. (2000). Also, the areas of the left and right cistern were determined (mm^2). The scanning was done 12 hours following machine milking.

Each year two (at minimum) or four (at maximum) scannings were performed. Sonographic measurements were carried out mostly in May, June or July. Occasionally, the ewes were included in the experiment for two or more successive years (up to 8 scans per individual ewe). During the period from 2002 to 2005 and year 2007 the method 1 was used to measure the length and width of the left and right udder cisterns (traits LLC1, WLC1, LRC1, WRC1). During the period from 2002 to 2008 the method 1 was used to determine the area of the left and right udder cisterns (traits ALC1, ARC1) and the total cistern area was expressed as a sum of the left and right udder cistern areas (trait SLRC1). There were taken 640 sonograms (length and width of the left and right udder cistern) in 200 ewes and 752 sonograms (area of the left and right udder cistern) in 231 ewes using the method 1 (at average of 3.20 and 3.26 measurements per individual ewe, respectively). During the period from 2002 to 2005 the method 2 was used to determine the length and width of the left and right udder cisterns (traits LLC2, WLC2, LRC2, WRC2), the area of the left and right udder cisterns (traits ALC2, ARC2) and the total cistern area (trait SLRC2). There were taken 470 sonograms in 163 ewes using the method 2 (at average of 2.80 measurements per individual ewe).

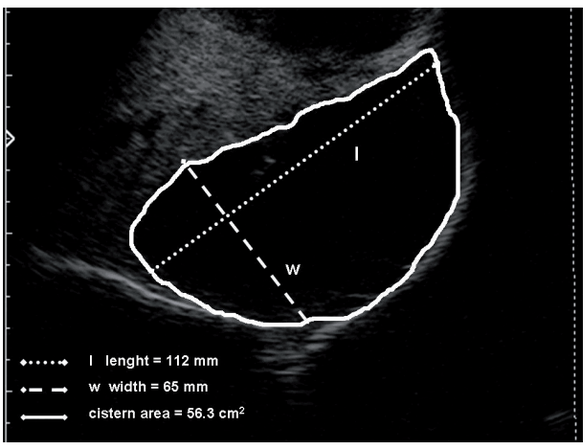

Fig. 1: Sonogram of udder using the method 1 - from side

Statistical analysis was done using the REML methodology (MIXED procedure as implemented in SAS/STAT v.9.2, 2002-2008). The following model with fixed and random effects was applied:

$y_{ijklm} = \mu + Y_i + LS_j + G_k + P_l + a_m + b*DIM_{ijklm} + e_{ijklm}$

kde:

y_{ijklm} = individual observations of studied traits (length, width and area measurements; see above for details),

Yi = year (fixed effect with 4 to 7 levels; in dependence on method used),

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

G_k = genotype (breed group, fixed effect with 5 levels; see above for characterization),

P_j = parity (fixed effect with 3 levels; first, second, third and further parity),

a_m = animal (random effect),

DIM_{ijklm} = days in milk (covariate; 40 to 210 days in milk),

e_{ijklm} = residual.

Least squares means of traits as estimated for individual levels of the fixed effects included in the model were compared by Scheffe's multiple range test. The differences were statistically significant at $\alpha<0.05$, $\alpha<0.01$ and $\alpha<0.001$.

RESULTS AND DICUSSION

Tables 1 and 2 show the influence of investigated fixed effects (covariance analysis) on sonographic measurements of the left and right udder cisterns taken using the method 1 (from side) and method 2 (from bottom). The effect of genotype highly significantly influenced all studied traits (regardless of method used). The influence of remaining effects was less expressed. A highly significant effect of genotype on udder cistern volume was also reported by Margetín *et al*. (2002, 2010) and Milerski *et al*. (2005). The effect of parity highly significantly ($P<0.01$ or $P<0.001$) influenced all sonographic measurements taken using the method 1. The effect of parity was less important when the method 2 was used. Mostly, non-significant differences between ewes at different parities were found (Table 2). The effect of lactation stage was non-significant ($P>0.05$) in most of traits taken either using the metod 1 or 2. In contrast, the effect of days in milk treated as a covariate significantly influenced most of traits (regardless of method used). The impact of this effect was highly significant for the total cistern area ($P<0.001$). Margetín *et al*. (2010) reported similar findings in purebred Improved Valachian ewes and crosses of Improved Valachian with specialized dairy breeds. According to Makovický (2009), the total cistern area determined either from side or from bottom was highly significantly influenced by genotype, parity and days in milk (regardless of method used).

Table 1: Covariance analysis of traits describing udder cistern size of ewes diagnosed by the method „from side"

Source of variation	df	Trait													
		LLC1*[2]		WLC1		ALC1		LRC1		WRC1		ARC1		SLRC1	
		F value	P>F	F value	P>F	F value	P>F	F value	P>F	F value	P>F	F value	P>F	F value	P>F
Genotype	4	28.94	<0.0001	34.13	<0.0001	35.51	<0.0001	30.27	<0.0001	40.47	<0.0001	43.60	<0.0001	43.16	<0.0001
Year	4 (6)*[1]	7.40	<0.0001	9.95	<0.0001	3.30	0.0034	2.41	0.0482	3.10	0.0156	0.59	0.7404	1.70	0.1182
Lactation stage	3	0.36	0.7848	2.32	0.0749	2.56	0.0546	1.49	0.2178	0.49	0.6871	0.95	0.4150	2.10	0.0991
Parity	2	4.68	0.0097	7.41	0.0007	8.39	0.0003	7.33	0.0007	11.52	<0.0001	13.41	<0.0001	12.87	<0.0001
Days in milk - DIM	1	2.11	0.1468	9.37	0.0023	12.18	0.0005	1.81	0.1789	4.17	0.0416	6.23	0.0129	11.86	0.0006

LLC1 - length of left cistern diagnosed by the method „from side"(1), WLC1 - width of left cistern, ALC1 - area of left cistern, LRC1 - length of right cistern, WRC1 - width of right cistern, ARC1 - area of right cistern, SLRC1 - sums of both cross-section areas.

*1 - Number 6 is valid for traits ALC1, ARC1 and SLRC1; *2 Abbreviations LLC1, WLC1, etc. valid also for tables 3 and 5.

Table 2: Covariance analysis of traits describing udder cistern size of ewes diagnosed by the method „from bottom"

Source of variation	df	Trait													
		LLC2*[1]		WLC2		ALC2		LRC2		WRC2		ARC2		SLRC2	
		F value	P>F	F value	P>F	F value	P>F	F value	P>F	F value	P>F	F value	P>F	F value	P>F
Genotype	4	42.23	<0.0001	26.84	<0.0001	36.96	<0.0001	47.73	<0.0001	28.74	<0.0001	39.62	<0.0001	43.36	<0.0001
Year	3	4.41	0.0047	7.28	<0.0001	5.65	0.0009	5.36	0.0013	7.93	<0.0001	3.56	0.0147	3.77	0.0111
Lactation stage	3	1.24	0.2945	1.21	0.3070	3.65	0.0131	0.35	0.7885	0.83	0.4764	0.99	0.3977	3.01	0.0306
Parity	2	5.14	0.0064	2.03	0.1330	2.23	0.1095	1.47	0.2308	0.89	0.4110	4.61	0.0107	2.67	0.0707
Days in milk - DIM	1	5.51	0.0195	2.37	0.1251	3.41	0.0660	4.98	0.0264	6.86	0.0093	12.21	0.0005	11.16	0.0009

LLC2 - length of left cistern diagnosed by the method „from bottom" (2), WLC2 - width of left cistern, ALC2- area of left cistern, LRC2 - length of right cistern, WRC2 - width of right cistern, ARC2 - area of right cistern, SLRC2 - sums of both cross-section areas
*1 - Abbreviations LLC2, WLC2, etc. valid also for tables 4 and 6.

Least squares means estimated for all traits taken using the method 1 were the highest in purebred LC ewes. In contrast, the smallest least square means were mostly found in purebred TS ewes. Least square means estimated for cistern areas that were determined using the method 1, were 2698.3 mm^2 (left cistern) and 2696.2 mm^2 (right cistern) in purebred LC ewes. When the method 1 was used, purebred TS ewes had the lowest length of the left (60.23 mm) and right cistern (60.86 mm). Similarly, the lowest width and area of the left (30.76 mm and 1413.1 mm^2, respectively) and right cistern (31.38 mm and 1400.4 mm^2, respectively) were found in purebred TS ewes. The differences in all sonographic measurements taken using the method 1 were highly significant (P<0.001) between purebred TS and LC ewes. According to Margetín *et al.* (2010), sonographic measurements (for instance traits ALC1 = 1563.5 mm^2 and ARC1 = 1613.2 mm^2) in purebred Improved Valachian ewes were similar to sonographic measurements in purebred TS ewes (present study). Milerski *et al*. (2006) also found the largest cistern areas in purebred LC ewes (sum of both cisterns were 6029 mm^2 – from side and 5814 mm^2 – from bottom). The average area of cisterns in Sarda sheep: 19 cm^2 (one of the best known dairy breeds) was reported by Nudda *et al*. (2000).

Crosses with genetic portion of LC and EF 25 %, 50 % and 75 % had udders with both the dimensions and the areas higher than purebred TS ewes (Table 3). The differences were highly significant (P<0.001), regardless of genetic portion of specialized dairy breeds. When the method 1 was used, least square means estimated for ALC1 and SLRC1 were the highest in crosses with genetic portion of SDB 75 % (2262.1±193.53 mm^2 and 4476.4 ± 352.88 mm^2, respectively). The analyses showed that large cisterns in TS crosses were formed probably as a consequence of the fact that these ewes shared genetic portion of dairy breeds with large udder cistern volume (LC and EF).

Least square means estimated for sonographic measurements taken using the method 2 (Table 4) were similar to those estimated for sonographic measurements taken using the method 1. The largest areas of the left and right udder cisterns (3008.2 ± 89.49 mm^2 and 3068.9 ± 88.71mm^2, respectively) were also found in purebred LC ewes. The lowest areas were found in purebred TS ewes (highly significant differences in comparison to purebred LC ewes, P <0.001). The total cistern area determined using the method 2 was significantly lower in purebred TS ewes (3153.2 ± 151.45 mm^2) than in purebred LC ewes (6076.0 ± 166.67 mm^2). The total cistern area in crosses with a genetic portion of SDB 25 %, 50 % and 75 % was lower than in purebred LC ewes, however, higher than in purebred TS ewes. The differences between purebred TS ewes and crosses with genetic portion of SDB 50 % (one of the most numerous groups) were highly significant (P<0.001). Values given in Tables 3 and 4 indicate that areas of the left and right udder cisterns determined using the method 1 – from side were higher than areas determined using the method 2 – from bottom (regardless of genotype). Both methods, however, gave similar results. As a general pattern, the cistern size increased with increasing portion of specialized dairy breeds.

Although the differences between ewes at the first, second, third and further parity were not significant in all studied traits taken either using the method 1 (Table 5) or method 2 (Table 6), the cistern size increased with an increasing age of ewes. Highly significant differences between the ewes at the first parity and ewes at the third and further parities were found when the method 1 was used. For instance, ALC1 and ARC1 were 1892.0 ± 84.08

Table 3: Effect of genotype on traits describing udder cistern size of ewes diagnosed by the method „from side"

Source of variation		n1	n2	Trait													
				LLC1 (mm)		WLC1 (mm)		ALC1 (mm²)		LRC1 (mm)		WRC1 (mm)		ARC1 (mm²)		SLRC1 (mm²)	
				LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE	
Tsigai	(1)	245	271	60.23	1.263	30.76	0.960	1413.1	78.56	60.86	1.240	31.38	0.887	1400.4	71.58	2813.5	143.02
TsxSDB (25 %)	(2)	11	17	69.46	5.549	36.26	4.219	1895.1	304.53	75.71	5.444	42.01	3.900	2275.5	275.59	4154.7	554.93
TsxSDB (50 %)	(3)	125	157	72.13	1.683	36.98	1.283	1975.7	96.40	71.94	1.651	37.31	1.186	1975.5	87.83	3947.3	175.47
TsxSDB (75 %)	(4)	36	46	72.86	3.253	40.28	2.534	2262.1	193.53	74.24	3.190	39.73	2.333	2211.3	174.47	4476.4	352.88
Lacaune	(5)	223	261	79.17	1.300	46.65	1.316	2698.3	78.62	79.96	1.757	47.37	0.920	2696.2	71.47	5403.29	143.17
Significant differences				1:3,4,5+++; 3:5+++;		1:3,4,5+++; 3:5+++; 2:5+4:5+		1:3,4,5+++; 3:5+++; 2:5+4:5+		1:3,4,5+++; 3:5+++; 1:2++		1:3,4,5+++; 3:5+++; 1:2++; 4:5++		1:3,4,5+++; 3:5+++; 1:2++; 4:5++		1:3,4,5+++, 3:5+++; 1:2++; 4:5+; 2:5+	

+++ P<0.001; ++P<0.01; +P<0.05; n1 – number of measurements valid for traits LLC1, WLC1, LRC1 and WRC1; n2 - number of measurements valid for traits ALC1, ARC1 and SLRC1.
(2) - crossbreds of Tsigai breed with 25 % genetic portion of specialized dairy breeds Lacaune and East Friesian, (3) - crossbreds of Tsigai breed with 50 % genetic portion of specialized dairy breeds Lacaune and East Friesian, (4) - crossbreds of Tsigai breed with 75 % genetic portion of specialized dairy breeds Lacaune and East Friesian

Table 4: Effect of genotype on traits describing udder cistern size of ewes diagnosed by the method „from bottom"

Source of variation		n	Trait													
			LLC2 (mm)		WLC2 (mm)		ALC2 (mm²)		LRC2 (mm)		WRC2 (mm)		ARC2 (mm²)		SLRC2 (mm²)	
			LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE	
Tsigai	(1)	194	68.48	1.283	29.77	0.877	1570.5	81.67	66.42	1.241	30.08	0.917	1577.1	81.01	3153.2	151.45
TsxSDB (25 %)	(2)	3	60.83	7.931	29.34	5.539	1446.9	504.67	72.11	7.658	33.56	5.761	2061.6	501.83	3455.1	921.91
TsxSDB (50 %)	(3)	88	80.96	1.822	35.48	1.241	2132.3	116.02	80.11	1.763	34.88	1.299	2179.9	115.03	4317.1	215.67
TsxSDB (75 %)	(4)	23	83.27	3.799	39.56	2.554	2375.4	242.10	83.92	3.681	36.46	2.682	2345.2	239.67	4717.9	454.34
Lacaune	(5)	162	92.33	1.405	42.79	0.995	3008.2	89.49	91.35	1.360	44.29	1.000	3068.9	88.71	6076.0	166.67
Significant differences			1:3,4,5+++; 2,3:5+++; 2:3,4+; 4:5+		1:3,4,5+++; 3:5+++; 2:5+		1:3,5+++; 3:5+++; 1:4++; 2:5++; 4:5+		1:3:4:5+++; 3:5+++; 2:5+		1,3:5+++; 1:3++; 4:5++; 1:4+		1:3,5+++; 3:5+++; 1:4++; 4:5++; 2:5+		1:3,5+++; 3:5+++; 1,5:4++; 2:5++	

+++ P<0.001; ++P<0.01; +P<0.05

Table 5: Effect of parity and stage of lactation on traits describing udder cistern size of ewes diagnosed by the method „from side"

Source of variation		n1	n2	Trait													
				LLC1 (mm)		WLC1 (mm)		ALC1 (mm²)		LRC1 (mm)		WRC1 (mm)		ARC1 (mm²)		SLRC1 (mm²)	
				LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE	
Parity																	
1.	(1)	236	268	68.53	1.474	36.70	1.102	1892.0	84.08	69.54	1.447	37.02	1.022	1902.7	77.39	3788.9	152.81
2.	(2)	202	232	70.53	1.659	37.37	1.206	2022.7	88.41	72.77	1.629	39.93	1.124	2117.6	82.18	4137.7	160.39
3+	(3)	202	252	73.25	1.789	40.49	1.316	2231.9	97.96	75.30	1.757	41.73	1.224	2315.0	90.86	4550.6	177.74
Significant differences				1:3++;		1:3+++; 2:3++		1:3+++; 2:3++		1:3+++; 1:2+		1:2,3+++; 2:3+		1:3+++; 1,3:2++		1:3+++; 1,3:2++	
Stage of lactation																	
40th-99th day	(1)	170	174	71.57	2.918	37.27	1.897	2028.5	150.12	73.41	2.874	39.62	1.807	2156.6	148.48	4174.2	269.33
100th-129th day	(2)	191	221	70.43	1.707	37.15	1.222	1987.2	94.3	71.20	1.677	39.01	1.141	2062.6	88.89	4045.3	170.59
130th-159th day	(3)	165	202	70.03	2.026	37.83	1.391	1986.6	98.96	73.61	1.993	39.49	1.310	2077.9	94.09	4061.9	178.84
160th-210th day	(4)	114	155	71.04	3.151	40.50	2.023	2193.1	149.43	71.94	3.104	40.13	1.932	2148.0	147.98	4354.7	268.03
Significant differences				ns		3:4+		ns		ns		ns		ns		ns	

+++ P<0.001; ++P<0.01; +P<0.05; ns – nonsignificant effect

Table 6: Effect of parity and stage of lactation on traits describing udder cistern size of ewes diagnosed by the method „from bottom"

Source of variation		n	Trait													
			LLC2 (mm)		WLC2 (mm)		ALC2 (mm²)		LRC2 (mm)		WRC2 (mm)		ARC2 (mm²)		SLRC2 (mm²)	
			LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE	
Parity																
1.	(1)	181	77.69	1.882	34.64	1.313	2046.4	119.74	77.69	1.817	35.15	1.366	2102.8	119.05	4140.0	218.88
2.	(2)	151	75.06	1.993	34.89	1.401	2054.9	126.76	78.53	1.923	36.37	1.455	2329.6	126.17	4374.9	229.94
3+	(3)	138	78.76	2.147	36.62	1.498	2218.7	136.60	80.13	2.073	36.07	1.559	2307.2	135.84	4516.6	249.30
Significant differences			2:3++; 1:2+		ns		2:3+		ns		ns		1:2++; 1:3+		1:3+	
Stage of lactation																
40th-99th day	(1)	120	75.92	2.952	36.37	2.185	2193.3	187.33	78.87	2.832	35.01	2.244	2081.1	187.76	4259.2	323.67
100th-129th day	(2)	147	75.53	2.057	34.88	1.456	2000.0	130.78	78.42	1.983	34.81	1.510	2142.8	130.28	4121.0	236.01
130th-159th day	(3)	122	77.43	2.271	34.47	1.636	2018.8	144.31	78.26	2.186	36.01	1.690	2300.0	144.10	4307.8	256.28
160th-210th day	(4)	81	79.81	3.088	35.83	2.301	2214.7	195.89	79.59	2.961	37.61	2.359	2462.3	196.52	4687.4	336.33
Significant differences			ns		ns		ns		ns		ns		ns		3:4+	

+++ P<0.001; ++P<0.01; +P<0.05; ns – nonsignificant effect

mm^2 and 1902.7 ± 77.39 mm^2 in ewes at the first parity, and 2231.9 ± 97.96 mm^2 and 2315.0 ± 90.86 mm^2 in ewes at the third and further parities (P<0.001, Table 5). These findings correspond with the findings of Margetín (2005) and Margetín *et al.* (2010), who reported that older ewes had larger cistern volumes. They are also in concert with findings of Marie *et al.* (1999) and Casu *et al.* (2000), who reported that older ewes had teats placed more horizontally (consequence of the increasing udder cistern size along with an increasing age).

Tables 5 and 6 indicate that non-significant differences were mostly found between lactation stages. Unexpectedly, some traits, for instance SLRC1 (Table 5) and SLRC2 (Table 6) tended to increase as lactation proceeded. Least square means estimated for SLRC1 were 4259.2 ± 323.67 mm^2 in ewes on the 40th to 99th lactation day and 4687.4 ± 336.33 mm^2 in ewes on the 160th to 210th lactation day (P>0.05). This is probably due to differences in lactation length that may be observed between ewes of various genotypes. In the group 4 (160th to 210th lactation day), mainly purebred LC ewes and crosses with higher genetic portion of SDB (i.e. individuals with high milk yield, whose milking period was longer) occurred. When no effect of genotype was taken into consideration, the cistern area tended to decrease as lactation proceeded.

CONCLUSION

According to findings in this study and ongoing trends in countries with developed sheep industry, ultrasonographic techniques may be used to assess the cistern size of the ewe's mammary gland. Selection of ewes based on sonographic measurements may be an effective tool to identify individuals with high milk yield and good milkability. We therefore recommend the ewe udder cisterns to be scanned during milking period on a routine basis. As a selection criterion, we recommend the area of the left udder cistern (ALC1) to be scanned using the method 1 – from side. In addition, our analyses showed that crossbreeding of TS with LC and EF considerably increases ewe's cistern size (regardless of genetic portion of specialized dairy breeds). This fact indicates that breeding goals in dairy sheep in Slovakia are being successfully followed.

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