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Preferences of Istrian sheep udder shape type on farms that apply machine milking

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ABSTRACT

Istrian sheep is an indigenous endangered breed reared at extensive or semi-extensive farms in Croatia. The number of farms applying machine milking is increasing due to high quality dairy products. The objective of this work was to evaluate morphometry of the udder and milk flow kinetics in the Istrian sheep in Croatia, and to explore possible preferences of udder shape type on farms that apply machine milking. Using Lactocorder© (WMB; Switzerland) we measured milk flow kinetics in five commercial herds. Using digital photographs of the posterior view of the udder and Image Tool software we measured udder height, width, cisternal part below the teat orifice and the angle that teat closes with the vertical axis of the udder in eleven herds. Breeding values were estimated using univariate animal models and REML (Restricted Maximum Likelihood). Istrian sheep breed in Croatia has excellent udder shape for machine milking: desirable angle that teat closes with the vertical axis of the udder, and cisternal height below the teat orifice is small. Ewes that are machine milked have higher udder, lower cisternal part below the teat orifice, and teats are more vertically implanted, which is the udder conformation beneficial for more efficient machine milking. BLUP value differences indicated that machine milked herds tend to have ewes with smaller cisternal part below the teat orifice that are of less udder height in the beginning of lactation and wider at the end of lactation, although there is no official selection of udder shape.
(Keywords: udder morphometry; milkability; BLUP; dairy ewe)

INTRODUCTION

Istrian sheep (IST) is an autochthonous endangered breed, according to FAO, EU and IUCN categorisation. Registered population of 2 515 animals on 38 farms in Croatia makes it the smallest autochthonous sheep population used in dairy production in Croatia (*Mulc et al.,* 2012). Most of ewe milk is processed into hard artisanal cheese and crude on small family cheese dairies. The production is extensive or semi-extensive, with average herd size of 55 animals (*Mulc et al.*, 2012), and only few counting more than 200 animals. Herd size limitation exists due to milking effort, since the machine milking in IST is present only to some extent. In the last decades the number of sheep farms with machine milking is increasing, therefore it is important to know if IST is suitable for machine milking. Benefits of machine milking of ewes are maximal milk yield of better hygienic properties than properties of hand-milked milk, and easier stripping (*Dzidic,* 2013). Effective milkability depends on udder morphology (*Labussière*, 1988) and is important for sustainable milk production because it affects functional life span of the animals (*Casu et al.,* 2006). Milkability can be evaluated by analysis of the milk flow curves and milk flow parameters that describe the physiological response of ewe to machine milking (*Mayer et al.,* 1989; *Bruckmaier et al.,* 1997), and by analysis of udder morphometry (*Labussière,* 1988; *Fernandez et al.,* 1995). The need of vertically implanted teats at the lowest point of the cistern as improved udder traits (*Labussière,* 1988) is recognized in the selection objectives of ovine breeding schemes (*Casu et al.*, 2006; *Marie-Etancelin et al.*, 2006). The reason for the increased interest was "baggy udder", found in sheep selected for high milk yield. Milking of these "baggy udders" is not efficient because part of the cisternal milk remains below the teat orifice unless the milker applies manual manipulation of the udder during stripping (*Bruckmaier et al.*, 1997). Additionally, horizontally implanted teats cannot hold the weight of the milking unit, and it tends to fall off. That kind of additional manipulation during milking prolongs the total milking time of the herd, with milking already being one of the most time-demanding procedures on ewe milk farms. Therefore, the mammary gland morphology is an important factor in determining the aptitude for the machine milking of ewes.

In order to evaluate suitability of the Istrian sheep for machine milking, our objectives were to evaluate morphometry of the udder from digital photographs of the posterior view of the udder, to evaluate milk flow kinetics in the Istrian sheep on the farms that apply machine milking, and to explore possible preferences of udder shape type on farms.

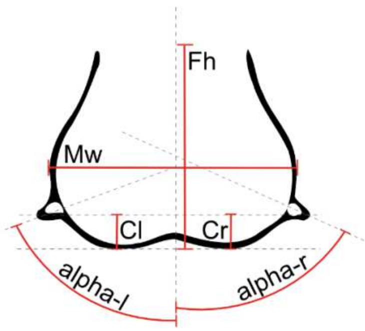
MATERIAL AND METHODS

Milk flow kinetics during machine milking of IST was measured in five commercial herds using Lactocorder© (WMB; Switzerland) specially calibrated for milking of the ewes (*Dzidic et al.,* 2004). The milking time, milk yield, peak, and average flow rate were obtained in early (first 3 months), mid- (months 4 and 5) and late lactation (months 6 to 8) during year 2010. The animals were milked twice a day and there were 148 morning and 418 evening measurements ranging from eight to 188 days in lactation. Milk production lasted 8 h during the day and 16 h through the night. Milking units were used at a milking vacuum of 37 kPa, pulsation rate 120 cycles/min and pulsation ratio 50:50. The milk was collected in buckets. Teat cups were attached to the udder without previous touching of the udder. Milking routine was finalized with manual udder massage and lifting of the lowest part of the udder in order to position the teats as low as possible when the milk flow dropped below 100 g/min with teat cups still attached.

Digital photographs of 258 ewe’s posterior view of the udders were taken prior to evening milking on eleven commercial farms in Istria three times during lactation. Six of the farms performed milking by hand and five farms used machine milking. External udder shape was measured from the digital photographs using Image Tool software as shown in *Dzidic et al.* (2009): udder height (Fh); udder width (Mw); part of the left (Cl) and right (Cr) udder cistern that is below the teat orifice; and the left (Alpha-l) and right (Alpha-r) teat angle, as the angle declines from the vertical axis of the udder (inter-mammary groove) (*Figure 1*).

Figure 1

Udder shape measurements



Udder height (Fh); udder width (Mw); part of the left (Cl) and right (Cr) udder cistern that is below the teat orifice; and the left (alpha-l) and right (alpha-r).

Descriptive statistics for data and development of the fixed part of the model were obtained using GLM procedure (*SAS*, 2011). Breeding values were estimated using univariate animal models and REML in AS-Reml program release 3 (*Gilmour et al.*, 2009). Fixed environmental factors to be included in the models were additionally explored in AS-Reml program release 3, according to results of building successively univariate analysis of variance. Udder shape traits (Fh, Mw, Alpha, Cis) and milk flow kinetics (Mt, My, Avgm, Mmf) during machine milking were explored using the general univariate mixed model shown in Equation 1. Farm, litter size, number of lactation and day of measurement are defined as fixed influences in udder shape models. Milk flow kinetics model included additional fixed effect of milking interval. Modelling Cis and Alpha included additional fixed effect of the udder half with two levels. Additive genetic value of the individual and permanent environmental effect within the day of measuring were the random effects in udder shape models. Additive genetic value of the individual was the random effect in milk flow kinetics model. Additionally, Mmf model included random effect of permanent environment. Pedigree of IST is recorded by Croatian Agricultural Agency. In the genetic models, all available relationships of 22 042 identities for the period 1989 – 2012, spanning over 9 generations, were used.

Equation 1

$$y_{ijkln} = \mu + D_i + S_j + L_k + F_l + F_l{*}L_k + a_{ni} + p_{ni}{*}D_i + e_{ijkln}$$

Where: y_{ijkln} = individual observation of Fh, Mw, Alpha, Cis, Mt, My, Avgm, Mmf; μ = intercept; D_i = fixed effect of measuring day (i = 1, 2 and 3); S_j = fixed effect of litter size (j = 1 and 2+); L_k = fixed effect of the lactation number (k = 1, 2, 3, 4 and 5+); F_l = fixed effect of the farm (l = 1 to 11 for udder shape traits, and 1 to 5 for milk flow kinetics); a_n = the random additive genetic effect of animal; p_{ni} = the random permanent environmental effect within day of measurement (for Alpha and Cis); e_{ijkln} = the residual.

RESULTS AND DISCUSSION

Table 1

Mean values of morphometric and milk flow kinetics traits studied in Istrian sheep

	Mw	Fh	Alpha	Cis	Avgm	Mmf	My	Mt
Mean	13.5	14.1	29.4	1.4	0.5	0.5	0.5	1.2
SE	0.45	1.84	3.88	0.24	0.05	0.07	0.06	0.14

Mw - Maximum udder width (cm); Fh - Full udder height (Fh); Alpha - angle that teat closes with the vertical axis of the udder (^{o}); Cis - Height of the cisternal part below the teat orifice (cm).

Milk flow kinetics trait means are shown in Table 1. Average milk flow in Istrian sheep is appropriate, comparable to European dairy sheep, and supported by the conclusions on excellent udder shape. Mean average milk flow was similar as reported by *Casu et al.* (2008), and to the values reported for Lacaune and East Friesian (*Bruckmaier et al.*, 1997), or Istrian crossbreeds (*Dzidic et al.*, 2009), but lower than in Sardinian ewes (*Carta et al.*, 2000). Mean peak flow rate was lower than all the reported values: remarkably lower than in *Casu et al.*, 2008 (19.7 ml/s), lower than in French dairy ewes (*Marie-Etancelin et al.*, 2006), lower than that found for Slovak dairy ewes (*Tančin et al.*, 2011; *Kulinova et al.*, 2010; *Mačuhova et al.*, 2011) and in Istrian crossbreeds (*Dzidic et al.*, 2004; 2009). Peak flow rate mean was most similar to the Mmf of 75% Istrian crossbreeds that had the lowest Mmf in comparison with crossbreeds with lower percentage of Istrian genetic background as reported by *Dzidic et al.* (2004). Peak flow rate in Istrian sheep is lower than in European dairy breeds. Intrinsic factors influencing the peak flow rate, such as teat sphincter opening characteristics, can be improved through selection. However, environmental sources constant through lactation affecting the peak flow rate could be symptomatic of insufficient adaptation of milking setting or machine characteristics to the breed (type and shape of liners, diameters of milk lines and tubes, air entry flow), especially as the lactation stage advances and milk production declines. Mean milking time (Mt) was lower than the range reported for Lacaune and East Friesian (*Bruckmaier et al.*, 1997), and higher than reported for Slovak dairy ewes (*Tančin et al.*, 2011, *Kulinova et al.*, 2010; *Mačuhova et al.*, 2011). Mean milk quantity per milking was lower than the range reported for Lacaune and East Friesian (*Bruckmaier et al.*, 1997), and by *Casu et al.* (2008), or in Istrian crossbreeds (*Dzidic et al.*, 2004; 2009) but similar to total milking yield found for Slovak dairy ewes (0.32-0.55 kg: *Tančin et al.*, 2011; 0.41: *Kulinova et al.*, 2010; *Mačuhova et al.*, 2011) as could be expected.

The mean values of udder shape traits are shown n Table 1. The Fh mean increased in mid-lactation and decreased at the lactation end. The udder had the highest Fh in third lactation ewes. Maximum udder width and Cis means were decreasing towards the end of lactation. Alpha did not change within or among lactations, indicating the permanence of the teat angle measurement during the life time of the IST ewe, as well as independence on the udder milk content during the IST lactation. This means that only one measurement during life time would be enough in case of udder assessment for obtaining animals' breading values if such assessment was introduced to IST breeding plan. Cis mean was the lowest in the first lactation and was increasing for every following lactation, and it was highest for ewes in the 5th and later lactations.

Table 2

Mean differences of ewe mean measurements, and BLUPs of udder shape traits regarding type of milking applied on farm of Istrian sheep

	Machine milking			Hand milking		
	Mean ± SE	Min.	Max.	Mean ± SE	Min.	Max.
Mw	10.71 ± 0.12	7.56	15.84	11.27 ± 0.21	8.30	14.15
Fh	13.65 ± 0.14	8.83	21.41	13.02 ± 0.29	9.21	17.21
Alpha	38.17^{a} ± 0.77	7.31	74.29	42.62^{b} ± 1.17	13.00	82.01
Cis	1.33^{c} ± 0.04	0	4.16	1.76^{d} ± 0.07	0	4.40
B-Fh1	-0.11^{c} ± 0.024	-1.15	1.17	0.26^{d} ± 0.034	-0.46	1.60
B-Fh2	-0.10^{a} ± 0.022	-1.54	1.05	-0.21^{b} ± 0.031	-1.43	0.60
B-Fh3	0.03^{c} ± 0.021	-0.82	1.10	-0.07^{d} ± 0.014	-0.57	0.44
B-Mw1	-0.01^{c} ± 0.020	-0.74	0.94	0.14^{d} ± 0.022	-0.80	0.97
B-Mw2	-0.03^{c} ± 0.018	-0.60	0.79	-0.12^{d} ± 0.019	-0.75	0.39
B-Mw3	0.03^{a} ± 0.013	-0.56	0.80	-0.02^{b} ± 0.011	-0.40	0.53
B-Alpha	1.06 ± 0.444	-19.16	24.47	1.46 ± 0.402	-15.27	16.88
B-Cis	-0.02^{a} ± 0.030	-1.18	2.04	0.12^{b} ± 0.034	-1.17	2.00

Means in the rows with superscript differ regarding the type of milking applied: ^{a,b} $P < 0.001$; ^{c}, ^{d} $P < 0.01$. SE – standard error; Mw - Udder width (cm); Fh - Udder height (Fh); Alpha - angle that teat closes with the vertical axis of the udder (^{o}); Cis - Height of the cisternal part below the teat orifice (cm); B-Fh1- Udder height BLUP during the 1st measuring day (cm); B-Fh2- Udder height BLUP during the 2nd measuring day (cm); B-Fh3- Udder height BLUP during the 3rd measuring day (cm); B-Mw1- Udder width BLUP during the 1st measuring day (cm); B-Mw2- Udder width BLUP during the 2nd measuring day (cm); B-Mw3 - Udder width BLUP during the 3rd measuring day (cm) ; B-Alpha – BLUP value of the teat angle (^{o}) ; B-Cis – BLUP value of the height of the cisternal part below the teat orifice (cm).

When examining the means of udder shape traits measurements and BLUPs, we found differences between udder shape of ewes from farms that milk by hand and the farms that apply machine milking (Table 2). Significant differences of means between ewes milked by machine and by hand were found in teat angle and cistern height averages, but not in udder height and width averages across lactation. Teat angle averages across lactation, and range, were smaller in ewes on farms that apply machine milking. Cistern height was smaller in machine milked ewes as well, however, the range did not differ remarkably. All BLUP values showed differences, except for teat angle indicating that the farmers prefer similar teat position in both milking systems. The BLUP values for Fh and Mw were predicted separately for beginning, mid-, and late lactation. BLUP values for Cis were negative (-0.02) for machine milked ewes, and positive in hand milked ewes (0.12), showing the same pattern as the measurements:

smaller cisternal part below the teat orifice in machine milked ewes. BLUP values for full udder height in the beginning of lactation were negative in machine milked ewes (-0.11), opposed to hand milked ewes (0.26), indicating that sheep with shorter, compact udder are preferred at machine-milking farms. This result could also be related to the cistern size results, since the Fh measurement includes Cis as shown on Figure 1. Mid- and late lactation Fh BLUP values showed the opposite pattern, and the udder was higher in machine milked ewes (-0.10 and 0.03 respectively). Udder width BLUPs across whole lactation were showed wider udder tendency in machine milked ewes.

CONCLUSION

Istrian sheep breed in Croatia has excellent udder shape for machine milking: desirable angle that teat closes with the vertical axis of the udder, and cisternal height below the teat orifice is small.

Although there is no official selection of udder traits in IST, differences between udder shape of ewes from farms that milk by hand and the farms that apply machine milking were found, indicating that there are different preferences of the owners. Herds that are machine milked have ewes with higher udder, teats that are more vertically implanted, and lower cisternal part below the teat orifice, which is the udder conformation that is beneficial for more efficient machine milking. BLUP value differences indicated that machine milked herds tend to have ewes with smaller cisternal part below the teat orifice that are of less udder height in the beginning of lactation and wider at the end of lactation, which indicates possible selection of ewes that are milked more efficiently and easier on farms that apply machine milking.

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