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Association of biometric characteristics of udder and teats with milk somatic cell count in indigenous Sirohi goats

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Abstract
Goat milk has higher Somatic Cell Count (SCC) and the ability to correctly interpret somatic cell counts in goat depends on an understanding of the various factors which may affect the number of somatic cells. The present investigation was carried out to investigate the association of biometric characteristics of udder and teats with milk Somatic Cell Count (SCC) in 105 lactating Sirohi goats maintained under arid region of Rajasthan at Sheep Breeding Farm, Fatehpur, Sikar. Udder and teat morphometric parameters were measured before milking in the beginning of the study. The overall arithmetic mean of test day SCC (absolute and logarithmic) in milk of Sirohi goat was found to be 8,22,009 ± 23451cells/ml of milk and 5.8940.141 respectively. Udder length, udder width, udder circumference, teat length, teat diameter and straight distance between teats had positive correlation with Log_{10}SCC while teat floor distance had negative correlation. It can be concluded factors like Udder and teat conformation traits should be considered at the time of selection of superior goats along with developing better selection strategies on milk yield per goat. SCC is the key component of national and international regulation for milk quality. More research work required for the formulations of quality standards for milk of native goat in the country.

Keywords: Biometric, characteristics, milk somatic, Sirohi goats

Introduction
Goat milk production is a dynamic and growing industry that is fundamental to the well being of millions of people worldwide and is an important part of the economy in many countries (Silanikove *et al*., 2010) [13]. Rajasthan state having highest goat population in country, 21.50 million of goat which is about 16 percent of total goat population in India. The Sirohi goat is a dual purpose breed used both for milk and meat. Sirohi goat constitutes about 14 per cent of total goat population of Rajasthan (Anonymous, 2014) [1]. India has a total Sirohi goat population of about 2.91 million, 99 per cent of which are found in Rajasthan only. Mastitis is an inflammation of the mammary gland which occurs after bacteria successfully traverse the teat orifice and cause an intra-mammary infection resulting in significant economic losses and an important threat affecting the global dairy industry (Wallenberg *et al*. 2002) [14]. Somatic cell count is a major indicator of health status of mammary gland in animals (Sharma *et al.*, 2016) [12]. However a positive relationship is controversial for goat (Cedden *et al.*, 2008) [4]. Goat milk has higher SCC than cow milk and sheep milk (Park, 1991; Zeng and Escobar, 1996) [9, 15]. According to National Mastitis council, to differentiate between healthy and infected udder secretion the limit of SCC has been decided as 10,00,000 cells/ml. (Hinckley and Williams., 1981) [7]. Udder and teat conformation traits are highly heritable and relationship between SCC and udder traits provide beneficial clues to breeders for accomplishing on the subject of selection of superior goats along with developing better selection strategies on milk yield per goat (Eyduran *et al.*, 2013) [6], hence the present study will be aimed to find out the influence of Udder and Teat morphometry on milk Somatic Cell Count in indigenous local Sirohi breed of goat in Rajasthan.

Material and Methods
Location: The study was conducted at Sheep breeding farm Fatehpur, Sikar. The altitude of Fatehpur city is 324 meter above mean sea level, latitude and longitude position being 27.98^{0}N and 74.95^{0}E, respectively.

Animal: Out of total number of goats in milk total, 105 healthy lactating Sirohi goats with no evidence of clinical mastitis were selected and the collection and analysis of milk samples were performed on the same day.

Collection of samples and diagnosis of Intra-mammary Infection: Representative milk samples were collected from udder halves of lactating goats. For this purpose, udder halves were designated as Left teat (LT) and Right teat (RT). About 30 ml of milk was collected aseptically in the clean sampling bottles after discarding the first 2-3 streaks of fore milk. The collected samples were brought to the laboratory immediately for further analysis. Within 6 h of collection, the milk samples were spread on 2 microscope slide areas, which were 10X10 mm^2 in size subsequently. The slides were fixed with pouring of ethyl alcohol for 2 minutes and the prepared smears were stained with the modified Newman's Lampert stain, by keeping the prepared slide in the staining solution for 1 to 2 minutes. The smears were gently washed in tap water and dried. The dried stained smears were examined under the oil immersion lens of the microscope. Thirty different fields per smear were observed, and the average number of somatic cells per field was calculated. The average number of cells per field was then multiplied by the microscopic factor of the microscope, i.e. 318471 to obtain the number of somatic cells per ml of the milk. Due to SCC not displaying a normal distribution, data of SCC were log transformed to base 10.

Evaluation of Udder and Teat Morphometry

In the present study, udder and teat measurement i.e. udder length, udder width, udder circumference above teats, straight distance between teats, teat length, teat diameter and teat floor distance were measured to analyze the effect of udder and teat morphometry on SCC. To study the effect of udder and teat morphometry on SCC for convenience divide the whole group in to two subgroups more than and less than 1.0 million cells/ml and consider as healthy and subclinical mastitis (SCM) group respectively. Udder and teat morphometry was defined as per the detail given by Upadhyay *et al*. (2014) which were evaluated by physical examination of udder and each teat. Udder length was considered as the distance between fore attachment of udder with the abdominal wall to the udder cleft which was measured with the help of measuring tape and Udder width was considered as the distance between the widest parts of the udder measured from the lateral side which was measured with the help of measuring tape. Udder circumference above teats was considered as the maximum diameter of udder just above teat which was measured with the help of measuring tape.

Teat length was considered as the distance between lines parallel to bifurcation to the tip of longer teat while Teat diameter was considered as the average diameter of the teat at the mid of teat length which was measured by the help of vernier callipers. Straight distance between teats was considered as the distance between both the sphincters of the teats while Teat floor distance was considered as the minimum distance between teat end and ground which was measured by measuring tape. Statistical analysis: The Correlation coefficients of log10SCC with udder and teat morphometry was done by using SPSS software statistical package (16.0).

Results

In present study all pooled and udder halves wise milk samples were subjected to SCC analysis. The arithmetic mean ± SE of SCC (absolute and logarithmic) of pooled milk sample were 8,22,009 ± 23415 cells/ml of milk and 5.894 ± 0.141 respectively. Range of SCC varied from 2,91,132 cells/ml to 13,74,733 cells/ml of milk samples collected from farm (Table 1). The SCC cells/ml converted into log scale to minimize the heterogeneity of variance. Udder half-wise means ± SE of Log10SCC has been presented in the Table 2 where highest values found in right udder half i.e., 5.899±0.045.

Table 1: Mean ± SE values and range of somatic cell counts

Number of observations	Mean ± SE (cells/ml)	Mean ± SE (Log_{10}SCC)	Range (cells/ml)
105	8,22,009±23415	5.894 ± 0.141	2,91,132- 13,74,733

Table 2: Udder half-wise Mean ± SE values of Log_{10}SCC

Number of Different Udder halves		Number of observations	Mean ± SE Log_{10}SCC
Overall mean		105	5.893± 0.021
Left udder half	210		5.889±0.044
Right Udder half		105	5.899±0.045

Effect of Udder length on SCC

Data of the present study revealed that the udder length was found to be higher in the SCM group animals than healthy animals. The average (±SE) value of udder length was observed in healthy and SCM udders 4.519 ± 0.148 cm and 7.666± 0.363 cm respectively. This indicates the pendulous udder is prone to sub clinical mastitis in comparison of normal udder. Similar findings were reported by Huntley *et al*. (2012) [8], Cabal *et al*. (2013) [3] and Sharma *et al*. (2016) [12]. The correlation between udder length and Log10SCC was positive but non-significant (Table 3) while the mean udder length of healthy and SCM group of animals were significantly ($P< 0.01$) differed from each other (Table 4).

Table 3: Mean ± SE values of udder length and level of significance

Particulars	Number of observations	Mean ± SE of Udder length (cm)
Healthy	72	$4.513±0.148^a$
SCM	33	$7.666±0363^b$
Average	105	5.504±0.208

Mean with different superscript differ significantly from each other ($P< 0.05$)

Table 4: Correlation coefficients of Log_{10}SCC with Udder length

		Log_{10}SCC	**Udder length (cm)**
Log_{10}SCC	Pearson Correlation	1	0.443
	Sig. (2-tailed)		0.067
	N	105	105
Udder length	Pearson Correlation	0.443	1
	Sig. (2-tailed)	0.067	
	N	105	105

Effect of Udder width on SCC

Data of the present study revealed that the udder width was found to be higher in the SCM group animals than healthy animals. The average (±SE) value of udder width was observed in healthy and SCM udders 9.138± 0.153 cm and 10.424 ± 0.222 cm respectively. The correlation between udder width and Log10SCC was positively significant (P< 0.05) (Table 5) and the mean udder width of healthy and SCM group of animals were also significantly (P< 0.01) differed from each other (Table 6).

Effect of Udder circumference on SCC

Data of the present study revealed that the udder circumference was found to be higher in the SCM affected animals than the healthy animals. The average (±SE) value of udder circumference was observed in healthy and SCM udders 23.402 ± 0.399 cm and 24.606± 0.577 cm respectively. This indicate the more voluminous udder have prone to sub clinical mastitis in respect of normal udder. Similar findings were reported by Rupp *et al*. (2011) [10].

The correlation between udder circumference and Log10SCC was positive but non-significant (Table 7) while the mean udder circumference of healthy and SCM group of animals were significantly (P< 0.01) differed from each other (Table 8).

Table 5: Mean ± SE values of udder width and level of significance

Particulars	**Number of observations**	**Mean ± SE of Udder width (cm)**
Healthy	72	9.138 ± 0.153^{a}
SCM	33	10.424 ± 0.222^{b}
Average	105	9.542±0.138

Mean with different superscript differ significantly from each other (P< 0.05)

Table 6: Correlation coefficients of Log_{10}SCC with Udder width

Log10SCC		**Udder width (cm)**	
Log_{10}SCC	Pearson Correlation	1	0.223*
	Sig. (2-tailed)		0.022
	N	105	105
Udder width	Pearson Correlation	0.223	1
	Sig. (2-tailed)	0.022	
	N	105	105

* Significant (p< 0.05)

Table 7: Mean ± SE values of udder circumference and level of significance

Particulars	**Number of observations**	**Mean ± SE of Udder circumference (cm)**
Healthy	72	23.402 ± 0.399^{a}
SCM	33	24.606 ± 0.577^{b}
Average	105	23.781±0.331

Mean with different superscript differ significantly from each other (P< 0.05)

Table 8: Correlation coefficients of Log_{10}SCC with Udder circumference

Log_{10}SCC			**Udder circumference (cm)**
Log_{10}SCC	Pearson Correlation	1	0.118
	Sig. (2-tailed)		0.232
	N	105	105
Udder circumference	Pearson Correlation	0.118	1
	Sig. (2-tailed)	0.232	
	N	105	105

Effect of Teat Length on SCC

Data of the present study revealed that the teat length was found to be higher in the SCM affected animals than the healthy animals. The average (±SE) value of teat length was found in healthy and SCM udders 9.472 ± 0.166 cm and 11.636± 0.339 cm respectively. This indicates that the incidence of SCM was increased with increasing length of teat. Higher incidence of SCM and SCC in large teat length as compared to small teat length and the significant effect of the teat length on SCC because of increased likelihood of teat end lesion in longer teats. Similar findings were reported by Huntley *et al*. (2012) [8], Cabal *et al*. (2013) [3] and Sharma *et al*. (2016) [12]. The correlation between teat length and Log10SCC was highly positive significant (P< 0.01) (Table 9) and the mean teat length of healthy and SCM group of animals was also highly significantly (P< 0.01) differed from each other (Table 10). Several authors (Bardakcioglu *et al*., 2011; Eyduran *et al*., 2013 [2, 6] and Sharma *et al*., 2016) [12] reported significant positive correlation between teat length and milk SCC. Contrary to this Sari *et al*. (2015) [11] found the non-significant effect of udder score on somatic cell count in Tuj breed of sheep in Turkey.

Effect of Teat diameter on SCC

Data of the present study revealed that the average (±SE) value of teat diameter in healthy and SCM udders was observed 7.888 ± 0.289 cm and 10.878± 0.281cm respectively. It was observed that the Teat diameter was found to be higher in the SCM affected animals than healthy animals. Similar findings were reported by Huntley *et al*. (2012) [8], Cabal *et al*. (2013) [3] and Sharma *et al*. (2016) [12]. The correlation between teat diameter and Log10SCC is high positively significant (P< 0.01) (Table 11) and the mean teat diameter of healthy and SCM group of animals was also highly significantly (P< 0.01) differed from each other (Table 12).The previous studies had also reported a positive correlation of teat diameter with SCC and stated that goats with thick teats had the higher risk of mastitis in respect of thin teats (Bardakcioglu *et al*., 2011; Rupp *et al*., 2011 and Sharma *et al*., 2016) [2, 10, 12]. The most significant cause of intra mammary infections is the entrance of microorganisms into the mammary duct. The anatomical structure of the teat

duct either facilitates or complicates the entrance of microorganisms. This, in turn, suggests the increase of disposition to mastitis with an increase in the diameter of the teat duct (Coban *et al*., 2009) [5].

Table 9: Mean ± SE values of Teat length and level of significance

Particulars	Number of observations	Mean ± SE of Teat length (cm)
Healthy	72	9.472±0.166[a]
SCM	33	11.636±0..339[b]
Average	105	10.152±0..183

Mean with different superscript differ significantly from each other (*P*< 0.01)

Table 10: Correlation coefficients of Log_{10}SCC with Teat length

Log10SCC			Teat length (cm)
Log10SCC	Pearson Correlation	1	0.301**
	Sig. (2-tailed)		0.002
	N	105	105
Teat length	Pearson Correlation	0.301	1
	Sig. (2-tailed)	0.002	
	N	105	105

* Significant (*p*< 0.05)

Table 11: Mean ± SE values and range of Teat Diameter and level of significance

Particulars	Number of observations	Mean ± SE of Teat Diameter (cm)
Healthy	72	7.888±0.289[a]
SCM	33	10.878±0.281[b]
Average	105	8.828±0.255

Mean with different superscript differ significantly from each other (*P*< 0.05

Table 12: Correlation coefficients of Log_{10}SCC with Teat Diameter

Log10SCC			Teat Diameter (cm)
Log10SCC	Pearson Correlation	1	0.330*
	Sig. (2-tailed)		0.001
	N	105	105
Teat Diameter	Pearson Correlation	0.330	1
	Sig. (2-tailed)	0.001	
	N	105	105

* Significant (*p*< 0.05)

Effect of Straight distance between teats on SCC

Data of the present study revealed that the Straight distance between teats were found to be higher in the SCM affected animals than the healthy animals. The average (±SE) value of straight distance between teats was observed in healthy and SCM udders 4.680± 0.193 cm and 4.818± 0.283 cm respectively. This indicates the more distance between teats leads to least chances of infection of sub clinical mastitis. Similar findings were reported by Ceddan *et al*. (2008) [4]. Data of the present study revealed that the Significant correlation level between Straight distance between teats and Log10SCC is non-significant (P>0.05) (Table 13) also the mean Straight distance between teats of healthy and SCM group of animals were non-significantly (P>0.05) differed from each other (Table 14).

Effect of Teat floor distance on SCC

Data of the present study revealed that the teat floor distance was found to be higher in the healthy animals than the SCM affected animals. The average (±SE) value of teat floor distance was observed in healthy and SCM udders 32.694± 0.342 cm and 28.121± 0521respectively. This indicate the pendulous udder have prone to sub clinical mastitis in respect of normal udder due to their increased tendency to become soiled and more susceptible to lesions, hence being contaminated with environmental pathogens and developed mastitis (Sharma *et al*., 2016) [12]. The teat floor distance and Log10SCC is negatively correlated from each other (P>0.01) (Table 15) and also the mean teat floor distance of healthy and SCM group of animals were significantly (*P*< 0.01) differed from each other (Table 16).

Table 13: Mean ± SE values and range of Straight Distance between Teats and Level of significance

Particulars	Number of observations	Mean ± SE of Straight Distance between Teats (cm)
Healthy	72	4.680±0.193
SCM	33	4.818±0.283
Average	105	4.723±0.159

Mean with different superscript differ significantly from each other (*P*< 0.05)

Table 14: Correlation coefficients of Log_{10}SCC with Straight distance between Teats

Log10SCC			Straight distance between Teats (cm)
Log10SCC	Pearson Correlation	1	-0.070
	Sig. (2-tailed)		0.479
	N	105	105
Straight distance	Pearson Correlation	-0.070	1
between Teats	Sig. (2-tailed)	0.479	
	N	105	105

Table 15: Mean ± SE values and range of Teat Floor Distance and level of significance

Particulars	Number of observations	Mean ± SE of Teat Floor Distance (cm)
Healthy	72	32.694±0.342[a]
SCM	33	28.121±0.521[b]
Average	105	31.257±0.353

Mean with different superscript differ significantly from each other (*P*< 0.01)

Table 16: Correlation coefficients of Log_{10}SCC with Teat Floor Distance

Log10SCC			Teat Floor Distance(cm)
Log10SCC	Pearson Correlation	1	-0.466**
	Sig. (2-tailed)		0.000
	N	105	105
Teat Floor Distance	Pearson Correlation	-0.466**	1
	Sig. (2-tailed)	0.000	
	N	105	105

** Highly Significant (*p*< 0.01)

Conclusion

It is concluded from the present study that the udder and teat morphometry characteristics suchas udder length, udder width, udder circumference above teats, teat length and teat diameter, straight distance between teats and teat floor distance have some degree of association with prevalence of subclinical mastitis. Therefore their inclusion in selection and breeding programme as indicator trait may help to improve udder health and at the time of formulation of quality standards for goat milk.

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