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GENETIC PARAMETERS OF UDDER TRAITS AND THEIR RELATIONSHIP WITH MILK YIELD IN SAHIWAL COWS OF PAKISTAN

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ABSTRACT

The present study was executed with the objectives to find out the heritability estimates for udder biometrics and genetic and phenotypic correlations between udder biometrics and milk yield in Sahiwal cows. There were 790 observations of udder measurements on 310 cows, progeny of 53 sires. The udder measurements were recorded at three stages of lactation. The model included fixed effects of herd, parity and stage of lactation. The linear and quadratic effect of age of cow at measurement was included as co-variable. The herd, stage of lactation and parity was a significant source of variation for udder length, width, depth, circumference, 305 day milk yield and test day yield ($P<0.001$). Age of the cow affected udder length, width, depth, circumference ($P<0.001$). The age of the cow was also a significant source of variation for 305-day milk yield and test day yield ($P<.05$). The univariate animal model heritability estimates for udder length, width, depth and circumference were 0.68±0.03, 0.66±0.03, 0.54±0.04 and 0.60±0.04, respectively. Highly positive genetic correlations were found among all udder measurements and ranged from 0.71±0.05 between udder length and udder depth to 0.84±0.02 between udder length and udder width. The genetic correlation of 305-day milk yield with udder length, udder width, udder depth and udder circumference were 0.38±0.02, 0.41±0.02, 0.35±0.02 and 0.36±0.02 respectively. The udder length had the highest phenotypic correlation with test day yield 0.45±0.02 at first stage of lactation followed by udder width (0.39±0.03), udder circumference (0.31±0.03) and udder depth (0.29±0.03). The magnitude of the phenotypic correlations for udder length and udder depth decreased in second and third stage of lactation and correlations for udder circumference were even negative in later stages of lactation with test day yield. The udder length, udder width, udder depth and udder circumference had genetic correlation of 0.40±0.02, 0.43±0.04, 0.36±0.03 and 0.37±0.03 with test day yield at first stage of lactation. The high heritability estimates for udder measurement traits indicate that selection will be effective on the basis of phenotype of the traits. The high genetic and phenotypic correlations of some udder measurements with milk yield traits indicate that same genes are responsible for the expression of the traits. While selecting for udder measurements a correlated response in milk yield is expected.

Keywords: Heritability, genetic, phenotypic correlations, udder measurements, Sahiwal cows, Pakistan.

INTRODUCTION

Milk yield is an important selection criterion in dairy cattle breeding. Some anatomical attributes are considered related to milk production. The udder of the cow is one of the most important criteria used to predict production performance. Type traits have been used as indirect selection criteria for herd life (Short and Lawstuen, 1992). Udder dimensions have been reported heritable (Qureshi *et al.*, 1980; Shanks and Spahr, 1982; Smith *et al.*, 1985; Kumar *et al.*, 2000). Type traits are recorded relatively early in life, of animals and are medium to high heritable (Dechow *et al.*, 2003), which makes selection relatively more efficient. Udder height was better predictor of lactation performance (Lin *et al.*, 1987). Differences in udder shape and size were reported heritable (Liebenberg and Jannermann, 1958). A large sized udder with large proportion of glandular tissue and a symmetrical shape is an asset to a milch animal (Sharma *et al.*, 1983). Daughters of high PD milk bulls had greater distance between teats, greater perimeters and larger areas of the udder floor (Petersen *et al.*, 1985). Udder length was significantly correlated with milk yield on the day of measurement. Phenotypic correlations between teat measurements and milk yield were significant (Tripathi *et al.*, 1982). Udder characteristics were reported important in relation to milk production where production records were lacking. (Akhtar and Thakuria, 1998). The work regarding udder biometrics and its additive genetic control have been lacking for Sahiwal cattle in Pakistan. The present study was executed with the objectives to find out the heritability estimates for udder biometrics and genetic and phenotypic correlations between udder biometrics and milk yield in Sahiwal cows.

MATERIALS AND METHODS

The udder measurements were recorded on 310 cows kept at Government farms named Livestock Experiment Station Bahadurnagar District Okara, Livestock Experiment Station Jahangirabad District Khanewal and Livestock Experiment Station Khizerabad District Sargodha Punjab Pakistan from September 2005 to April 2006. The measurements were recorded before evening milking. There were thirty variables or factors based on direct udder measurements or derived from udder measurements. In order to reduce the number of the variables and to draw some meaningful conclusion the principal component analysis was performed using SPSS (19.0) computer Software. The Pearson's correlations among all the measurements were obtained. The variables having correlations higher than 0.850 were considered same and one of them was dropped. Similarly the traits that explained the same biological characteristics were merged together or their average values were used. After reduction there were eleven variables and two response variables that is 305-day yield and test day yield. The correlation matrix was extracted based on eigenvalues greater than 0.5 with maximum iteration up to 25 with display of rotated factor solution and scree plot. However the convergence was attained at 6 iterations. The KMO measure of sampling adequacy value was 0.803 that satisfy to perform principal component analysis. The six components including udder length, width, circumference, depth, 305-day milk yield and test day yield explained 86.601 % of the variance based on extraction sums of squared loadings. The residual correlations for all the measurements that explained the major variance were less than 0.05 which implies that actual correlations and reproduced correlations coincide well. The distribution of observation is given in Table 1.

The measurements were recorded on cows from parity first to fifth at three stages of lactation. The measurements were taken as per (Blake and McDaniel, 1979; Qureshi *et al.* 1980; Sharma *et al.* 1983; Petersen *et al.* 1985; Baruah *et al.* 1991). All the measurements were recorded before evening milking of the cows while cows were having about 12 hours milk in the udder. The descriptions for the udder measurements are given in Table 2.

Table 1. Distribution of observations on udder measurements at three farms

Effect	Level	Number of cows	Number of Observations
Herd	Bahadurnagar	127	331
	Jahangirabad	88	210
	Khizerabad	95	249
Parity	First parity	107	259
	Second and later parities	203	531
Stages of lactation	1 (15-45 days)	310	310
	2 (90-120 days)	262	262
	3 (165-195 days)	218	218

Table 2. Descriptions for udder measurements

Trait	Description
Udder length	Distance from the rear attachment of udder (more cut up in thighs) to the point where fore udder blends smoothly with the body passing cloth tape in between right and left teats.
Udder width	Average of two distances a) Distance between two lateral lines at the base of udder near flank/stiffle joint passing cloth tape in between fore and hind teats. b) Distance between two lateral lines at the base of udder near flank/stiffle joint passing cloth tape front of fore teats.
Udder circumference	Average of two measurements a) Cloth tape was passed round the udder near the base of udder close to body. b) Cloth tape was passed round the udder near the emergence of teats.
Udder depth	The difference between two measurements a) Vertical distance from ground floor to the base of udder near flank. B) Vertical distance from ground floor to the udder floor at lowest point.

The average milk yield of the cows recorded thrice (a day before measurement, on the day of measurement and after the day of measurement) was taken as test day yield. The 305- day milk yield calculated on the basis of the weekly supervised records was utilized to find out phenotypic and genetic correlation with udder measurements. The component plot in rotated space has been displayed in Figure 1. The component plot indicates that udder length, width, depth and circumference were close to 305 day milk yield and test day milk yield. The other traits in the component plot were dropped because these were not extracted and were contributing very little to explain the variance. This is shown in Figure 2.

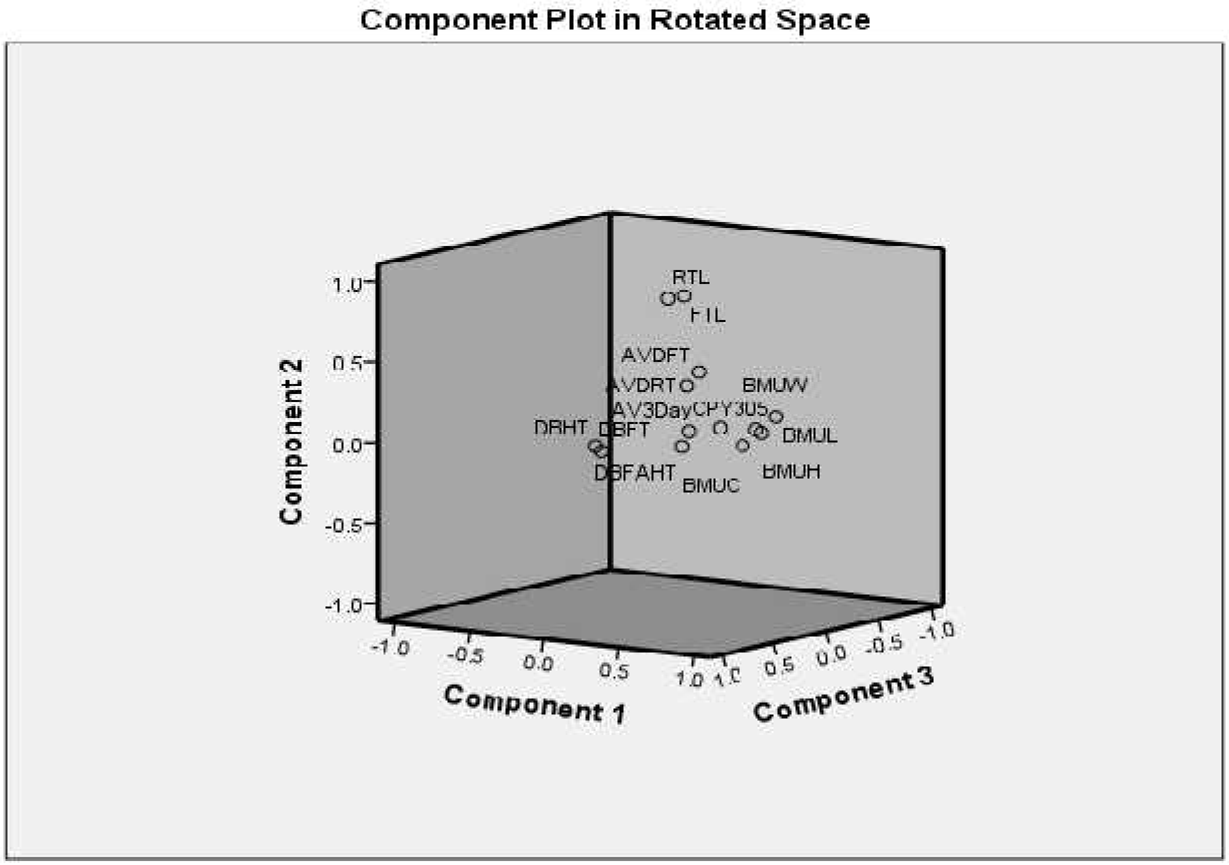

Figure 1. Component plot in rotated space

Statistical Analysis: The mixed model included fixed effects of herd, parity and stages of lactation. There were three levels for herd, two level for parity i,e first parity and second and later parity) and three levels for stage of lactation. The linear and quadratic effect of age of cows at measurement was fitted as co-variable. Non significant interaction effect of parity by stages of lactation was dropped from the final model. For estimation of heritability a univariate animal model was assumed. The genetic and phenotypic correlations between udder measurements and milk yield were estimated in a bivariate animal model analysis. The stage of lactation was included for estimation of genetic parameters. The phenotypic correlations were estimated with nearest day yield (test day yield). The variances and co-variances were estimated by residual or restricted maximum likelihood (REML) procedures developed by Patterson and Thompson (1971). The final model assumed the following mathematical form.

$$Y_{ijklm} = \mu + H_i + P_j + T_k + b_1(a_{ijklm}) + b_2(a_{ijklm})^2 + A_l + e_{ijklm}$$

Where

μ = Overall mean

Hi = effect of ith herd (1-3)

P_j = effect of jth parity group (1-2)

T_k = effect of kth stage of lactation (1-3)

A_l = random animal effect

a_{ijklm} = age at classification with b_1 and b_2 the linear and quadratic regression coefficients of trait on age at measurement

e_{ijklm} = random error

The analysis was performed using ASREML version 2.0 computer software (Gilmour *et al.*, 2007). The Scree plot is given Figure 2 in with Eigenvalues higher than 0.5 are plotted versus components. It can be seen that the graph values become straight from component seven to onward. It means that these components contribute very low toward explanation of the variance. So these components were dropped from the analysis.

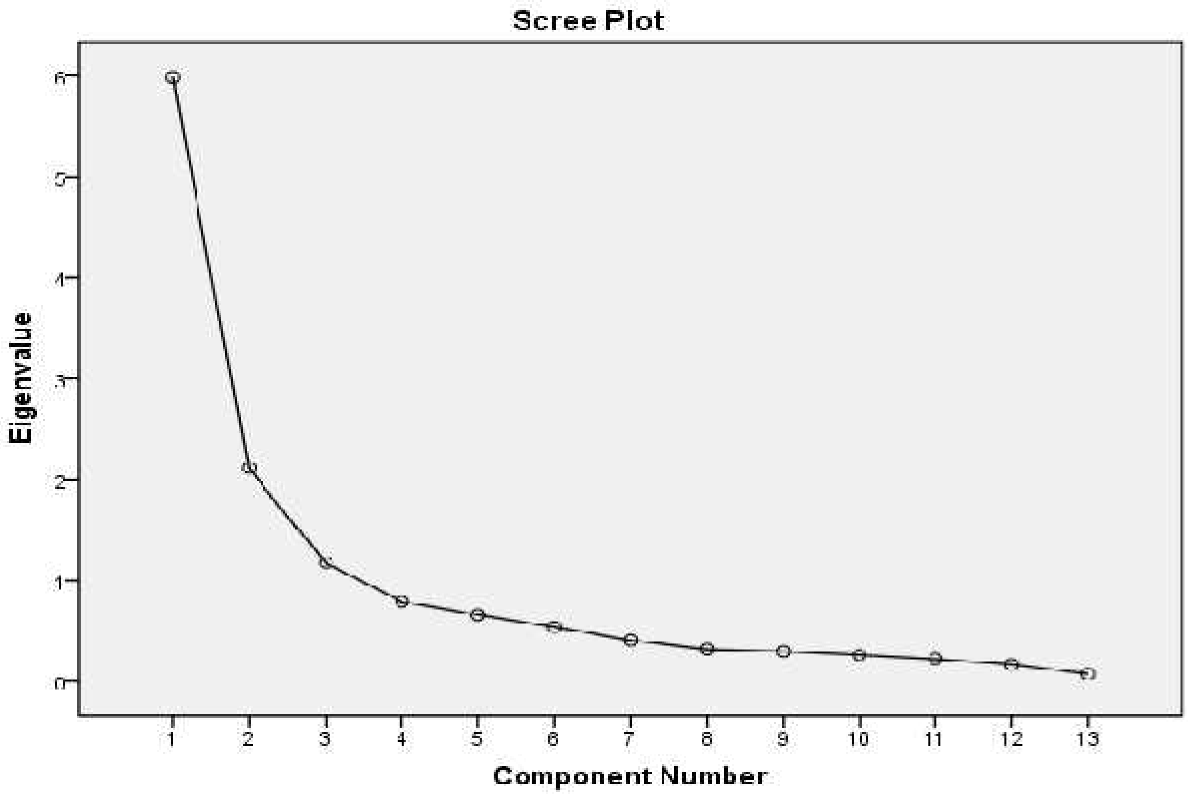

Figure 2. Scree plot of the Principal Components drawn at Eigen values higher than 0.5

RESULTS

The effect of non-genetic factors on udder parameters and milk yield are presented in Table 3

The herd, stage of lactation and parity was a significant source of variation for udder length, width, depth, circumference, 305 day milk yield and test day yield (P<0.001). Age of the cow affected udder length, width, depth, circumference (P<0.0001). The age of the cow was also a significant source of variation for 305-day milk yield and test day yield (P<.05). The herd differences might be due to management, the feed availability and other housing facilities because differences in overall management were observed at these farms. The stage of lactation might influence all the measurements because of effects of proceeding lactation on udder measurements and on milk yield. The parity differences were justified because of development of udder from lactation first to onward.

Table 3. Effect of non-genetic factors on udder measurements and milk yield!

Traits/Factors	Herd	Stage of lactation	Parity	Age of cow at measurement
305-day milk yield	***	***	***	*
Test day milk yield	***	***	***	*
Udder length	***	***	***	***
Udder width	***	***	***	***
Udder depth	***	***	***	***
Udder circumference	***	***	***	***

! ***= (P<0.001), ** (P<0.01), * (P<0.05)

Heritability Estimates: The Genetic parameters for udder measurements are presented in Table 3. Heritability estimates for most of the traits were in medium to high range. The standard errors of the heritability are very low which implies that the measurements were clustered near the means and have less spread. The genetic correlations among the udder traits were very high which implies that the same genes were involved in the expression of the udder measurements. The genetic correlations of all the udder measurements were in medium range with 305-day milk yield. It means that selection for udder measurement could bring associated change in 305-day milk yield.

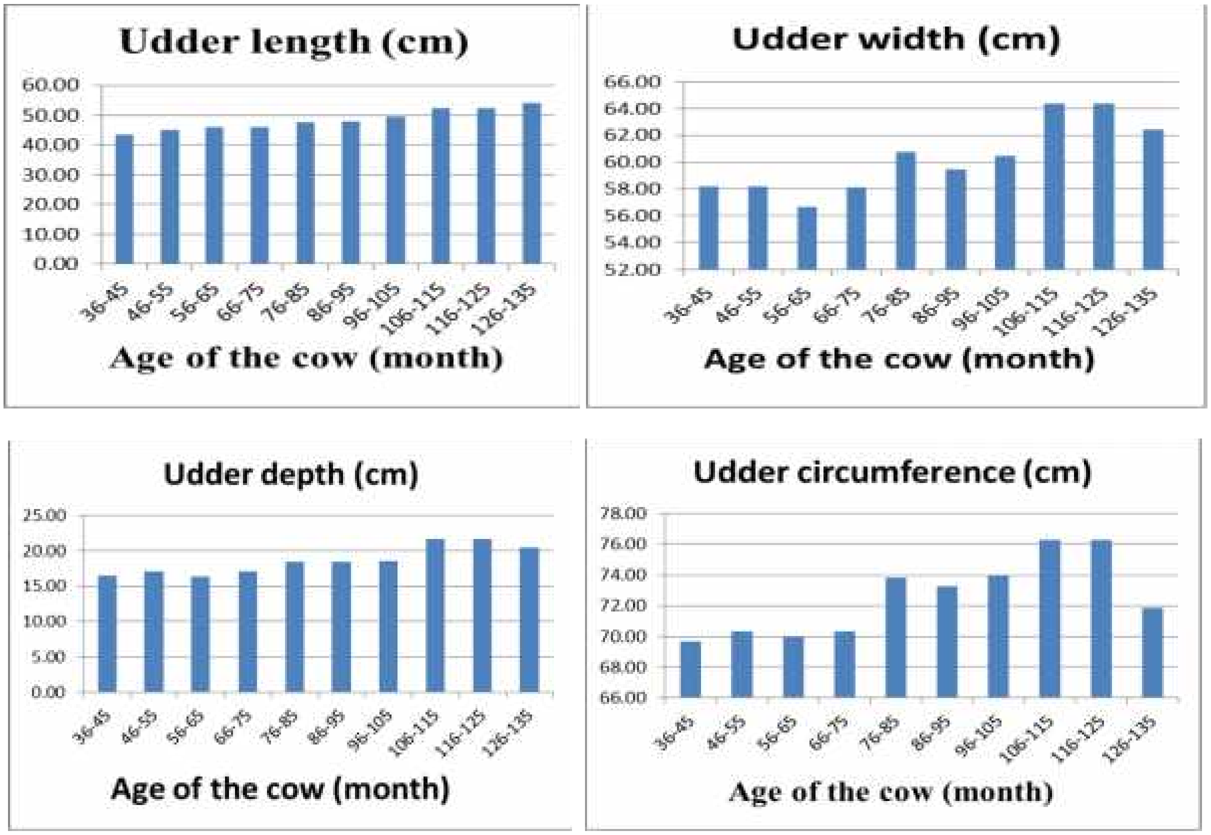

Figure 3. The Effect of age of cow at classification on udder measurements

Table 3. The heritability and genetic correlations among udder measurements and 305-day milk yield!.

Traits	Udder length	Udder width	Udder depth	Udder Circumference	305-day yield
Udder length	0.68±0.03	0.84±0.02	0.71±0.05	0.72±0.04	0.38±0.02
Udder width		0.66±0.03	0.92±0.02	0.83±0.03	0.41±0.02
Udder depth			0.54±0.04	0.77±0.06	0.35±0.02
Udder circumference				0.60±0.04	0.36±0.02

! Heritability=on the diagonal, Genetic correlations= above diagonal

The phenotypic correlations of nearest day milk yield (test day yield) with udder measurements are presented in Table 4. The udder length had the highest phenotypic correlation with test day yield at first stage of lactation followed by udder width, udder circumference and udder depth. The magnitude of the phenotypic correlations for udder length and udder depth decreased in second and third stage of lactation and correlations for udder circumference were even negative in later stages of lactation with test day yield. The genetic correlations of test day yield with udder measurements at three stages of lactation were almost of same magnitude and direction as that of phenotypic correlations.

Table 4. The phenotypic correlations of nearest day milk yield (test-day yield) with udder measurements at three stages of lactation.

Stage of lactation		Udder length	Udder width	Udder depth	Udder Circumference
I	Phenotypic	0.45±0.02	0.39±0.03	0.29±0.02	0.31±0.03
	Genetic	0.40±0.02	0.43±0.04	0.36±0.03	0.37±0.03
II	Phenotypic	0.13±0.02	0.47±0.03	0.15±0.02	-0.16±0.03
	Genetic	0.12±0.03	0.47±0.03	0.26±0.03	-0.24±0.03
III	Phenotypic	0.13±0.03	0.47±0.03	0.16±0.03	-0.16±0.02
	Genetic	0.13±0.02	0.47±0.02	0.26±0.03	-0.24±0.03

DISCUSSION

Heritability for udder depth was higher in present findings than that reported by (Koenen and Groen, 1998) for Holsteins 0.35. Higher than current study heritability estimate (0.76±0.33) for udder length, comparable with current study 0.63±0.32 for udder width and 0.57±0.16 for udder depth were reported for Gir cows (Qureshi *et al.*, 1980). Higher than present heritability estimates for udder depth has been reported for Iraqi buffaloes (Jaayid *et al.*, 2011). The heritability is a ratio between additive genetic variance and total phenotypic variance. The phenotypic variance can further be partitioned into genetic variance and environmental variance. When the portion of environmental variance is increased, then the heritability estimate will be low. The classifiers itself and traits definition may become source to increase environmental variance resulting in reduced estimate for additive portion of variance. As a result heritability estimates will be low. In this study all the measurements were made by one classifier that reduced the environmental variance and yielded high heritability estimates. The high heritability estimates indicate that the traits under discussion are under good genetic control and could be improved through selection. The standard errors for the heritability estimates are low even though the number of observation is not large. The reason behind is that all the measurements were recorded by one person. The traits measurements were very carefully and precisely recorded. This resulted in reduced variation that otherwise could be observed when there are different classifiers. As a result more uniform means were obtained for the three herds. It looks that data were dispersed very close to mean values. That might be reason for low estimates of standard errors.

The phenotypic correlations between test day yield and udder length, width and depth in present study were higher than reported for Gir cows (Tripathi *et al.*, 1982). Phenotypic correlations of udder length, width and depth with test day yield in present study were higher than that reported for Gir cows (Qureshi *et al.*, 1980). The phenotypic correlations of 305-day milk yield with udder length (0.45±0.05) and udder width (0.48±0.05) were lower than reported by Suzuki *et al.* (1963). The phenotypic correlation (0.31±0.03) between average udder circumference and test-day yield was comparable to that reported for Swamp buffaloes (Akhtar and Thakuria, 1998).

The phenotypic correlations indicate that all the traits were experiencing same type of environment. The correlations between breeding values are taken as genetic correlations. The genetic correlations between any two traits indicate that one and same genes are responsible for the expression of the traits. The positive genetic correlation indicates that selection of one trait will bring a correlated change in the other trait. The negative genetic correlations between any two traits dictate that improvement through selection in one trait will deteriorate the other one. The knowledge of genetic correlations between traits helps to cut short the long list of traits and include the most important in selection indices.

The milk recording in Sahiwal cows is still in infancy and very little percent of the total population is put under recording. So the information regarding udder measurements could help to select the animals at farmer level under field conditions. The udder measurement could help to develop regression equations to get an estimate of the milk capabilities of the cows. There are different types of records being utilized to evaluate the cows and find the top ranking cows. Many of the selection indices put some weightage to type traits. Udder is the most important component amongst the type traits. So such information could be included in some selection index or even this could be utilized as separate. The milk recording schemes need a lot of finance and many schemes go through the lactation period to get lactation yield. So if regression equations are developed, then milk yield could be predicted using udder measurements and time could be saved. The Sahiwal cows are known docile cows. It has been observed that while taking udder measurements many of the cows were relaxed although there were a few exceptions.

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