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Association Between Body and Udder Measurement Traits and Milk Yield of Holstein Cows

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ABSTRACT

The association between body and udder measurements can be used towards the improvement of milk yield. Hence, this study aimed to identify the udder measurement traits and body measurement traits that may be used by farmers to increase milk yield of Holstein cows. The study was conducted at Limpopo Dairy Farm in Makhado Local Municipality at Louis Trichardt, Limpopo Province, South Africa where a total of 50 lactating Holstein cows were used. Pearson's correlation technique was used for data analysis. Findings between body measurement traits and milk yield showed that milk yield had a highly positive significant ($p < 0.01$) correlation with rump height ($r = 0.55$), and positive significant ($p < 0.05$) with withers height ($r = 0.44$) and body length ($r = 0.42$). Results between udder measurement traits and milk yield showed that milk yield had a highly positive significant ($p < 0.01$) correlation with udder length before milking ($r = 0.57$), udder circumference before milking ($r = 0.55$) and udder circumference after milking ($r = 0.51$) The results also showed that milk yield had a positive significant ($p < 0.05$) correlation with teat diameter before milking ($r = 0.30$), teat length before milking ($r = 0.31$), teat circumference before milking ($r = 0.36$) and udder length after milking (0.47). The findings imply that all traits correlated with milk yield can be used to enhance milk yield of Holstein cows through selection during breeding.

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INTRODUCTION

Holstein cattle breed is a breed that was developed in Europe and is easily identified by its characteristic color markings and high milk yield (Gaur *et al.,* 2022*)*. Milk production plays an important role in the provision of food security in the country. However, farmers lack understanding about which features may be employed to boost milk yield, and production levels are insufficient to meet the country's growing population (Idowu and Adewumi, 2017; Makamu *et al*., 2023). Milk production accounts for up to18% of the total value of agricultural production within the country and as such it is the single most important sector (Rasmussen *et al.,* 2002). According to Youssef *et al.* (2014), body measurements of an animal is of importance to the farmers as it can be used for feeding, administering of medication, selection for breeding and management on the farm. Kouri *et al.* (2019), reported that body weight and udder measurements play a significant role in milk yield. Based on the authors' knowledge, there is limited evidence on relationship between body measurements, udder measurements and milk yield of Holstein cows. The objective of the study was to determine the relationship between body, udder measurement traits and milk yield of Holstein cows. This study might help the Holstein cattle farmers to know the body and udder measurement traits that might be used to improve milk yield through selection during breeding.

MATERIALS AND METHODS

Study area and experimental animals

The study was conducted at Limpopo Dairy Farm in Makhado Local Municipality at Louis Trichardt (23°06'18.6"S 29°49'45.9"E), Limpopo Province, South Africa. The summers are long, warm, and partly cloudy and the winters are short, cool, dry, and clear. Over the course of the year, the temperature typically varies from 7.78°C to 27.78° C and is rarely below 5°C or above 33.33°C (Nyahunda and Tirivangasi, 2019). According to weather spark, the average annual temperature is 18.9 °C (66.0 °F) in Louis Trichardt, and the rainfall here is around 540 mm per year. Total of 50 lactating cows at the same parities, stage of lactations and age between 2 to 3 years, were randomly selected from the herd.

Research design

Cross-sectional design was used as the experimental design in this study. Cross-sectional study is a type of research design in which data are collected from many different individuals at a single point in time, in this type of research, variables are observed without influencing them (Setia, 2016). Udder and teat measurements were taken in the morning before and after milking. Mammary type scores, udder and teat measurements were taken from each cow once during lactation.

Data collection

Body measures were taken as reported by Pesmen and Yardimci, (2020). These measurements were taken after 8 hours of feed restriction. The height of wither (WH) was measured as the distance from the platform's surface to the withers. Body length (BL) was taken as the distance between the occipital joint and the first caudal vertebra. A tape measure was used to measure the heart girth (HG) directly behind the scapula, the sternum height (SH) as the distance between the floor and the ventral side of the sternum, and the rump height (RH) as the distance between the floor and the dorsal border of the pelvic girdle. External udder measurements were taken as reported by Merkhan and Alkass, (2021), and they included udder length (UL) from attachment to center of udder and udder circumference (UC) above teats measured using a flexible tape. Right and left teat length (TL) were measured using a caliper from the connection of the teat with the udder to the tip of the teats. Teat diameter (TD) was measured at the center of the teats, udder width (UW) above the teats at the back of the udder, and distance between teats (DBT) between two teats attached to the udder. These measurements were taken before and after milking. All precautions were taken before the animals were milked. Milk yield measurements were taken from the farm's records, which the farm provided.

Statistical analysis

Pearson’s correlation was used to determine the relationship between traits as to achieve objective. Statistical Package for Social Sciences (IBM SPSS, 2020) version 27.0 software was used for analysing the data. A probability of 5% was used for significance and 1% for highly significant between traits.

RESULTS AND DISCUSSION

Descriptive statistics

A descriptive summary of body measurement traits, udder measurement traits and milk yield of Holstein cows is shown in Table 1. The mean value for MY was found to be 14.62L. HG had the highest mean value of 223.76cm followed by BL at 168.73cm and TLA 5.35cm which had the lowest mean value. TDA had the highest CV value of 18.00% and RH had the lowest CV value of 5.68%.

Table 1. Descriptive statistics of measured traits

Traits	Mean	SD	SE	CV
BW (cm)	621.24	70.06	10.01	11.28
MY (l)	14.62	2.21	0.32	15.18
WH (cm)	147.37	12.71	1.82	8.63
SH (cm)	93.16	8.07	1.15	8.67
HG (cm)	223.76	26.67	3.81	11.92
BL (cm)	168.73	11.31	1.62	6.70
RH (cm)	160.18	9.10	1.29	5.68
ULB (cm)	51.57	3.06	0.44	5.93
UCB (cm)	154.73	12.89	1.84	8.33
UDB (cm)	37.41	4.41	0.63	11.80
TDB (cm)	15.59	1.80	0.26	11.56
TLB (cm)	6.22	1.01	0.14	16.15
TCB (cm)	10.00	1.10	0.16	10.99
ULA (cm)	46.45	4.18	0.60	8.99
UCA (cm)	129.14	13.56	1.94	10.50
UDA (cm)	33.24	3.97	0.57	11.94
TDA (cm)	10.18	1.83	0.26	18.00
TLA (cm)	5.35	0.80	0.11	15.05
TCA (cm)	7.96	1.06	0.15	13.31

Legends: Udder length before milking (ULB), Udder length after milking (ULA), Udder circumference before milking (UCB), Udder circumference after milking (UCA), udder diameter before milking (UDB), Udder diameter after milking (UDA), Teat diameter before milking (TDB), Teat diameter after milking (TDA), Teat length before milking (TLB), Teat length after milking (TLA), Teat circumference before milking (TCB), Teat circumference after milking (TCA), Milk yield (MY), Body length (BL), Rump height (RH), Wither's height (WH), Sternum height (SH), Heart girth (HG), Milk yield (MY), Body weight (BW).

Phenotypic correlations between body measurement traits and udder measurement traits

The phenotypic correlation between body measurement traits and udder measurement traits is presented in Table 2. All the udder measurement traits had no significant correlation ($p > 0.05$) with BW except a positive significant correlation ($p < 0.05$) with UDA and negative significant correlation ($p < 0.05$) with TDA. The findings of this study are in line with the study of Singh and Gupta (2015), which stated that there was no significant correlation between udder measurement traits and body measurement traits in Karan Swiss cows except for udder measurement traits such as udder circumference before and after milking, udder length, and teat circumference before milking, which had a significant correlation with body measurement traits such as body length, rump height. These results suggest that improving BW might also increase UDA but decrease TDA in Holstein cows.

Phenotypic correlation between udder measurement traits and milk yield

Table 3 presents the relationship between milk yield and udder measurement traits. The findings showed that MY had a highly positive significant ($p < 0.01$) correlation with ULB, UCB and UCA. The results also showed that MY had a positive significant ($p < 0.05$) correlation with TDB, TLB, TCB and ULA. This study agrees with Rogers and Spencer, (2003) who found that the correlation coefficients between milk yield and udder measuring characteristics in Brown Swiss and Jersey cows of Karan were not significant but opposes this study on the results which found that teat circumference, teat length, and teat diameter had no effect on milk yield in Brown Swiss and Jersey cows in Karan. These results suggest that ULB, UCB, UCA, TDB, TLB, TCB and ULA might be used as selection criterions for improving milk yield.

Table 2. Phenotypic correlation between body measurement traits and udder measurement traits

	BW	WH	SH	HG	BL	RH	ULB	UCB	UDB	TDB	TLB	TCB	ULA	UCA	UDA	TDA	TLA
BW																	
WH	0.22^{ns}																
SH	-0.29^{ns}	0.42*															
HG	0.08^{ns}	-0.08^{ns}	-0.17^{ns}														
BL	0.19^{ns}	0.47*	-0.01^{ns}	-0.04^{ns}													
RH	-0.19^{ns}	0.62**	0.43*	-0.12^{ns}	0.53**												
ULB	-0.03^{ns}	0.52**	0.27^{ns}	-0.27^{ns}	0.48*	0.75**											
UCB	0.00^{ns}	0.24^{ns}	0.15^{ns}	-0.12^{ns}	0.24^{ns}	0.50**	0.55**										
UDB	0.00^{ns}	0.36*	0.23^{ns}	0.03 ^{ns}	0.27^{ns}	0.57**	0.39*	0.42*									
TDB	0.11^{ns}	0.17^{ns}	-0.09^{ns}	-0.16^{ns}	0.36*	0.26^{ns}	0.41*	0.25^{ns}	0.28^{ns}								
TLB	-0.03^{ns}	0.49*	0.24^{ns}	-0.18^{ns}	0.31*	0.67**	0.72**	0.33*	0.50**	0.50**							
TCB	0.06^{ns}	0.36*	0.38*	-0.01^{ns}	0.33*	0.67**	0.55**	0.39*	0.60**	0.17^{ns}	0.43*						
ULA	0.09^{ns}	0.25^{ns}	0.05^{ns}	-0.21^{ns}	0.24^{ns}	0.34*	0.67**	0.38*	-0.06^{ns}	-0.11^{ns}	0.23^{ns}	0.17^{ns}					
UCA	-0.04^{ns}	0.44*	0.45*	0.08^{ns}	0.24^{ns}	0.64**	0.62**	0.54*	0.34*	0.12^{ns}	0.63**	0.58**	0.41*				
UDA	0.35*	0.40*	0.05^{ns}	0.20^{ns}	0.17^{ns}	0.31*	0.34*	0.20^{ns}	0.27^{ns}	0.01^{ns}	0.33*	0.21^{ns}	0.24^{ns}	0.32*			
TDA	-0.38*	0.03^{ns}	0.29^{ns}	-0.03^{ns}	-0.14^{ns}	0.31*	0.26^{ns}	0.24^{ns}	0.37*	0.24^{ns}	0.25^{ns}	0.35*	0.13^{ns}	0.33*	-0.05^{ns}		
TLA	0.10^{ns}	0.36*	0.05^{ns}	-0.03^{ns}	0.26^{ns}	0.42*	0.43*	0.15^{ns}	0.46*	0.42*	0.73**	0.31*	0.06^{ns}	0.33*	0.18^{ns}	0.11^{ns}	
TCA	0.14^{ns}	0.17^{ns}	0.22^{ns}	0.12^{ns}	0.12^{ns}	0.26^{ns}	0.46*	0.14^{ns}	0.28^{ns}	0.20^{ns}	0.56**	0.52**	0.22^{ns}	0.52**	0.16^{ns}	0.13^{ns}	0.51**

Udder length before milking (ULB), Udder length after milking (ULA), Udder circumference before milking (UCB), Udder circumference after milking (UCA), udder diameter before milking (UDB), Udder diameter after milking (UDA), Teat diameter before milking (TDB), Teat diameter after milking (TDA), Teat length before milking (TLB), Teat length after milking (TLA), Teat circumference before milking (TCB), Teat circumference after milking (TCA), Milk yield (MY), Body length (BL), Rump height (RH), Wither's height (WH), Sternum height (SH), Heart girth (HG), Milk yield (MY), Body weight (BW), Non-significant (ns), Correlation is significant at 0.05 level, (*), Correlation is significant at a 0.01 level (**).

Table 3. Phenotypic correlation between udder measurement traits and milk yield

	MY	ULB	UCB	UDB	TDB	TLB	TCB	ULA	UCA	UDA	TDA	TLA	TCA
MY													
ULB	0.57**												
UCB	0.55**	0.55**											
UDB	0.09^{ns}	0.39*	0.42*										
TDB	0.30*	0.41*	0.25^{ns}	0.28^{ns}									
TLB	0.31*	0.73**	0.33*	0.50**	0.50**								
TCB	0.36*	0.55**	0.39*	0.60**	0.17^{ns}	0.43*							
ULA	0.47*	0.67**	0.38*	-0.06^{ns}	-0.11^{ns}	0.23^{ns}	0.17^{ns}						
UCA	0.51**	0.63**	0.54**	0.34*	0.11^{ns}	0.63**	0.58**	0.41*					
UDA	0.28^{ns}	0.34*	0.20^{ns}	0.27^{ns}	0.01^{ns}	0.33*	0.21^{ns}	0.24^{ns}	0.31*				
TDA	0.03^{ns}	0.26^{ns}	0.24^{ns}	0.37*	0.24^{ns}	0.25^{ns}	0.35*	-0.13^{ns}	0.33*	-0.05^{ns}			
TLA	-0.10^{ns}	0.43*	0.15^{ns}	0.46*	0.42*	0.73**	0.31*	0.06^{ns}	0.33*	0.18*	0.11^{ns}		
TCA	-0.04^{ns}	0.46*	0.14^{ns}	0.28^{ns}	0.20^{ns}	0.56**	0.52**	0.22^{ns}	0.52**	0.16^{ns}	0.13^{ns}	0.51**	

Udder length before milking (ULB), Udder length after milking (ULA), Udder circumference before milking (UCB), Udder circumference after milking (UCA), udder diameter before milking (UDB), Udder diameter after milking (UDA), Teat diameter before milking (TDB), Teat diameter after milking (TDA), Teat length before milking (TLB), Teat length after milking (TLA), Teat circumference before milking (TCB), Teat circumference after milking (TCA), Milk yield (MY), Non-significant (ns), Correlation is significant at 0.05 level, (*), Correlation is significant at a 0.01 level (**).

Table 4. Phenotypic correlation between body measurement traits and milk yield

	BW	MY	WH	SH	HG	BL	RH
BW							
MY	0.14^{ns}						
WH	0.22^{ns}	0.44*					
SH	-0.29^{ns}	0.27^{ns}	0.42*				
HG	0.08^{ns}	-0.22^{ns}	-0.08^{ns}	-0.17^{ns}			
BL	0.19^{ns}	0.42*	0.47*	-0.01^{ns}	-0.04^{ns}		
RH	-0.19^{ns}	0.55**	0.62**	0.43*	-0.12^{ns}	0.53**	

Body length (BL), Rump height (RH), Wither's height (WH), Sternum height (SH), Heart girth (HG), Milk yield (MY), Body weight (BW), Non-significant (ns), Correlation is significant at 0.05 level, (*), Correlation is significant at a 0.01 level (**)

Phenotypic correlation between body measurement traits and milk yield

Table 4 shows the association between body measurement traits and milk yeald. Results recognized that all body measurement traits had no significant correlation ($p > 0.05$) with MY except RH which had a highly positive significant correlation ($p < 0.01$), and WH and BL which had positive significant correlation ($p < 0.05$). This study supports the findings of Kouri *et al*. (2019), who discovered that milk yield was positively correlated with body length in Damascus and Zaraibi goats. This study also agrees with the findings of Yousseff *et al*. (2014), who found a positive correlation between body length and milk output in Damascus and Zaraibi goats in Egypt. These findings suggest that rump height, withers height and body length of Holstein cattle might be used as selection criteria for improving milk yield during breeding.

CONCLUSIONS

The study concludes that body weight had a positive relationship with udder diameter after milking and negative relationship with teat diameter after milking. Milk yield had a positive significant correlation with rump height, withers height, body length, udder length before milking, udder circumference before milking, udder circumference after milking, teat diameter before milking, teat length before milking, teat circumference before milking and udder length after milking. The study implies that all traits correlated with milk yield can be used to improve milk yield of Holstein cows through selection during breeding.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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