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Review Article

The Relationship Between Different Body and Udder Shapes and Sizes with Milk Yield in Buffaloes

Kamil Uygar PINAR*[1], Mustafa GARİP[2]

[1] Vocational School of Technical Sciences, Mersin University, Mersin, Türkiye
[2] Department of Animal Science, Faculty of Veterinary Medicine, Selçuk University, Konya, Türkiye

*Corresponding author e-mail: uygarp@mersin.edu.tr

ABSTRACT

Several studies have been conducted with the objective of examining the potential relationship between different udder and body shapes and sizes and milk yield in buffaloes. In one study, it was stated that the relationship between milk yield and teat diameter was significant. In another study, conical and round teats were found to have the highest milk yield. Milk yield and udder width and lactation number were also positively correlated. It was found that there were some positive correlations between rear udder width, rear udder height, rear udder distance, udder length, front-rear teat distance; left rear teat length, left front teat length; right rear teat length and right front teat length. It was observed that body length was significantly associated with milk yield. While 1 cm increase in body length increased milk yield by 15.96 grams/day on average, each 1 cm increase in chest circumference increased milk yield by 17.96 grams/day. The highest milk yield was recorded at the height of the withers (145 cm) and at the depth of the chest (80 cm). A positive relationship was found between the distance between the hip bones and upper wedge angle and milk yield. Another study found that the thickness of the skin affects how much milk buffaloes produce. The thicker the skin in the flank and udder regions, the less milk the buffalo produces. The correlation coefficient in the flank region was -0.334 and in the udder region was -0.264.

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Mandalarda Farklı Vücut ve Meme Şekil ve Büyüklüklerinin Süt Verimi ile İlişkisi

ÖZET

Mandalarda farklı vücut ve meme şekil ve ölçüleri ile süt verimi arasındaki ilişkiyi inceleyen birçok çalışma yürütülmüştür. Yapılan bir çalışmada sadece meme başı çapı ile süt verimi ilişkisinin kayda değer olduğunu belirtilmiştir. Yapılan bir diğer çalışmada en yüksek süt verimini yuvarlak şekilli meme ile konik şekilli meme başından elde etmiştir. Ayrıca meme genişliği ile laktasyon sayısı ve süt verimi arasında pozitif korelasyon elde etmiştir. Arka meme genişliği, arka meme yüksekliği, arka meme mesafesi, meme uzunluğu, ön-arka meme uçları mesafesi; sol ön meme ucu uzunluğu, sol arka meme ucu uzunluğu; sağ arka meme ucu uzunluğu ve sağ ön meme ucu uzunluğu arasında pozitif korelasyon elde etmiştir. Vücut uzunlukları ile süt veriminin anlamlı şekilde ilişkisi olduğu gözlemlemiştir. Vücut uzunluğundaki 1 cm artış süt verimini ortalama 15,96 gram/gün artırırken, göğüs çevresindeki her 1 cm artış süt verimini 17,96 gram/gün arttırmıştır. En yüksek süt veriminin görüldüğü cidago yüksekliği 145 cm ve göğüs derinliği ise 80 cm olarak kaydedilmiştir. Kalça kemiği arasındaki mesafe ve üst kama açısı ile süt veriminin pozitif ilişkisi tespit edilmiştir. Mandalarda deri kalınlığı ile süt verimi arasında ilişki olduğu gözlemlenirken, böğür denilen yan kısımları (r=-0,334) ve meme (r=-0,264) bölgelerindeki deri kıvrım kalınlığındaki negative korelasyonlar önemli bulunmuştur.

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INTRODUCTION

Buffaloes are hard tempered, water-loving, thick-skinned animals. Although buffaloes are very versatile animals, they are less adaptable to extreme hot and cold climates compared to various cattle. Although they are generally raised at low altitudes, it is known that they are also raised at altitudes above 2500 m in some regions such as Nepal and Papua New Guinea. (Şekerden, 2016). According to the latest data, cow's milk is the most produced milk in the world, followed by buffalo milk. (Aydoğdu and Şahin, 2022). Compared to cow milk, buffalo milk is a higher quality food source as it has high protein, fat and mineral substance content. The quality difference between buffalo and cow milk results in a high demand for buffalo milk in the production of by-products such as yoghurt, cream and milk powder. (Yılmaz and Kara, 2019). For buffalo breeders, using high-yielding females is one of the most important features desired in the farm from an economic perspective. In this article, the relationships between buffalo milk and body and breast sizes are examined.

BUFFALO MILK AND BREEDING

Buffalo milk represents 15% of global milk production, with 135 million litres produced annually. It is the most widely produced milk type in the world, following cow milk. (Aydoğdu and Şahin, 2022). In fact, it constitutes the largest part of milk production in some countries such as Nepal (Hayashi et al., 2013). The average dry matter content of buffalo milk is 17.2%, which is quite high compared to cow milk (12.6%). The high dry matter content provides economic advantages. For example, while 1 kg of cheese can be produced with 5 kg of buffalo milk versus 8 kg of cow's milk. Buffalo milk also contains 7.3% fat, 4.6% lactose, 5.0% crude protein, 0.91% crude ash (Ahmad et al, 2013). The most important reason why buffalo milk, which is higher quality and more nutritious than cow milk, lags behind cow milk production is that the production performance of cattle is considerably higher than that of buffaloes (Zicarelli et al, 2020). By-products such as cream, yogurt, ice cream, etc. are made from buffalo milk, and buffalo milk is also used in the production of milk powder due to its high dry matter and fat content (Yılmaz and Kara, 2019). As mentioned above, buffalo milk has many qualitative advantages compared to cow milk.

It can be observed that the majority (96.4%) of buffalo breeding worldwide is concentrated in Asia (Sarıözkan, 2011). A total of 72 different buffalo breeds have been identified globally, with 57 of these rearing in Asia. Of these, 22 are utilized in dairy farming. (Adkinson et al., 2021). Buffaloes benefit very well even from poor feed resources, and buffalo breeding is generally done by the public in family businesses (Alkhateeb et al., 2022).

Buffaloes are generally raised for milk production. Therefore, breeders take into account the high milk yield of the animals they will raise for the future. In a study, they found that the highest amount of milk produced during the lactation period of buffalos was 12.99-15.31 kg/day (Gu et al, 2017). Milk is secreted from the udder, and therefore the characteristics of the udder structures are directly related to milk yield, and in this context, the first structures to be examined in determining whether the selected animal is productive in terms of dairy farming are the udder and udder structures (Poudel et al, 2022).

RELATIONSHIP BETWEEN MORPHOLOGICAL CHARACTERISTICS OF UDDER AND TEAT AND MILK YIELD

The average udder length in buffaloes during different lactation periods is between 52.21±0.61 cm and 55.71±0.59 cm, udder width is between 48.61±0.60 cm and 53.87±0.70 cm, and udder depth is between 15.46±0.17 cm and 15.78±0.18 cm. The length of the nipples is 7.81±0.15 cm and the diameter is 2.76±0.02 cm. R.M.VThe study conducted by Prasad et al. (2010) revealed a positive correlation between the given breast and teat measurements and milk yield. However, only the correlation between milk yield and teat diameter was found to be significant. (Prasad et al., 2010).

Table 1. *Relationship between udder shape and milk yield in buffaloes (Poudel et al, 2022).*

		Daily Milk Yield (Kg)					Daily Milk Yield (Kg)		
Udder Shapes	**N**	**Mean ± S.E**	**Min.**	**Max.**	**Teat Shapes**	**N**	**Mean ± S.E**	**Min.**	**Max.**
Round	9	6.20 ± 0.58	3.00	8.60	Funnel	41	6.02 ± 0.30	3.00	9.00
Bowl	8	5.85 ± 0.75	3.00	9.00	Bottle	25	5.47 ± 0.35	3.00	8.60
Goaty	4	5.40 ± 0.88	3.20	7.20	Cylindrical	16	6.00 ± 0.35	4.20	9.00
Stepped	3	5.80 ± 1.13	4.20	8.00	Conical	14	6.18 ± 0.46	3.00	9.00
Overall Mean	24	5.90 ± 0.36	3.00	9.00	Overall Mean	96	5.90 ± 0.18	3.00	9.00

There was no difference between groups ($P < 0.05$).

As with other farm animals, buffaloes have more than one teat and teat shapes. There are 4 different teats: funnel, bottle, cylindrical and conical shaped teats and 4 different udder shapes: round, bowl, goat and step. Poudel et al. (2022) observed that; 26% bottle, 42.7% funnel, 14.6% conical, 16.7% cylindrical shaped teats and 37.5% round shaped udder, 33.3% bowl shaped udder, 16.7% goat shaped udder and 12.5% step shaped udder. Udder and teat shapes are shown in Figure 1 and Figure 2. In the study, buffaloes gave an average of 5.90 ± 0.36 kg of milk per day and the highest milk yield was observed in buffaloes with conical teats and round teats The relationship between udder shape and milk yield in buffaloes is shown in Table 1.. (Poudel et al, 2022).

Figure 1. *Bowl, round and goat-shaped breasts, respectively (Raju et al., 2020)*

In a separate study conducted in Lahore, Pakistan, investigating the effect of teat and udder shape on milk yield in buffaloes, the majority (78%) were found to be bowl-shaped, with 19.5% exhibiting a round shape, 2.5% displaying a goat-shaped morphology, and 89% exhibiting a cylindrical morphology. Additionally, 7% were observed to possess a funnel-shaped morphology. Bottle-shaped nipples were seen in 4% of cases. Additionally, the study examined the relationship between breast and teat area measurements and milk yield. In the study, measurements of breast depth (MD), breast length (MU), breast width (MG), nipple length (MBU) and nipple diameter (MBD) were taken. A positive correlation was identified between MG and lactation number (r = 0.341) and milk yield (r = 0.573). (Abdullah et al, 2013).

Figure 2. *Cylindricel, funnel and bottle shaped nipples respectively (Raju et al., 2020)*

In another study conducted with Dehong crossbred buffaloes, the average peak milk yield was found to be 9.60 ± 2.73 and the average udder dimensions are given as follows; breast depth 16.51 ± 10.05, rear breast width 8.07 ± 3.26, rear breast height 8.68 ± 3.92, rear breast height 50.74 ± 8.82, front nipple distance 7.18 ± 2.18, front nipple distance was measured as 7.73 ± 2.15 cm. The results of the evaluations, the presence of both negative and positive correlations between specific values and peak milk yield are given in table 2. Correlations were found to be positive in the following instances: The posterior udder height (r=0.32, P<0.01) demonstrated a positive correlation with the posterior udder width (r = 0.24, P < 0.01), posterior udder distance (r = 0.20, P < 0.01), udder length (r = 0.34, P < 0.01), anteroposterior teats distance (r = 0.40, P < 0.01), and left anterior teats distance (r = 0.38, P < 0.01). The correlation coefficients for teat length were (r = 0.25, P < 0.01) for the left teat, (r = 0.29, P < 0.01) for the left posterior teat, r = 0.22 (P < 0.01) for the right anterior teat, and (r = 0.25, P < 0.01) for the right posterior teat. The only negative correlation observed was for udder depth (r = -0.28, P < 0.01). (Gu et al., 2017).

Table 2. *Relationship between udder lengths and milk yield in buffaloes (Gu et al, 2017)*

	PMY	UD	RUW	RUH	UH	DFT	DRT	DFRT	LFTL	LRTL	RFTL	RRTL	MV	TC
PMY	1	-0.28**	0.24**	0.32**	0.34**	0.19*	0.20**	0.40**	0.25**	0.29**	0.22**	0.251**	-0.09	0.09
UD	-	1	-0.07	-0.25**	-0.21**	-0.23**	-0.18**	-0.14*	-0.01	-0.07	-0.00	-0.06	0.11	-0.01
RUW	-	-	1	-0.03	0.33**	0.22**	0.14*	0.34**	0.20**	0.12	0.19**	0.12	-.16*	0.19**
RUH	-	-	-	1	0.08	0.14*	0.02	0.18*	0.04	0.17*	0.01	0.14*	-0.03	0.06
UH	-	-	-	-	1	0.20**	0.13	0.35**	0.04	0.17*	-0.04	0.06	-0.10	0.11
DFT	-	-	-	-	-	1	0.67**	0.41**	-0.12	-0.09	-0.04	-0.01	-0.19**	-0.09
DRT	-	-	-	-	-	-	1	0.28**	-0.03	-0.03	0.12	0.06	-0.06	-0.03
DFRT	-	-	-	-	-	-	-	1	0.19**	0.20**	0.14	0.16*	-0.19**	-0.07
LFTL	-	-	-	-	-	-	-	-	1	0.68**	0.71**	0.58**	-0.03	0.20**
LRTL	-	-	-	-	-	-	-	-	-	1	0.43**	0.69**	0.08	0.23**
RFTL	-	-	-	-	-	-	-	-	-	-	1	0.56**	-0.05	0.21**
RRTL	-	-	-	-	-	-	-	-	-	-	-	1	0	0.21**
MV	-	-	-	-	-	-	-	-	-	-	-	-	1	0.12
TC	-	-	-	-	-	-	-	-	-	-	-	-	-	1

** (P<0.01) and * (P<0.05).
PMY: peak milk yield; UD: udder depth; RUW: rear udder width; RUH: rear udder height; UH: udder height; DFT: distance of fore teats; DRT: distance of rear teats; DFRT: distance of fore-rear teats; LFTL: left fore teat length; LRTL: left rear teat length; RFTL: right fore teat length; RRTL: right rear teat length; MV: mammary vein and TC: teat conformation.

In a study revealing the close relationship between the size of the milk vein and milk components, the positive relationship between the size of the milk vein and the components Lactose% (0.044), SNF% (0.086), Ash% (0.031) and Protein% (0.064) was presented (Javed et al, 2013).

THE RELATIONSHIP BETWEEN BODY SIZE AND MILK YIELD IN BUFFALOES

A substantial corpus of research has been undertaken with the objective of examining the relationship between milk yield and body measurements.. Larger animals have higher fat storage ability and secrete higher quality and higher amounts of milk without consuming feed. In the study conducted by Jaayid et al., 2011), they found a positive significant relationship between body length (0.320) and breast circumference (0.365) and milk yield.

A significant increase in milk yield is observed as body length increases from 165 cm to 170 cm. The increase in body length above 170 cm increases milk yield, but this increase is not as high as the increase in milk yield up to 170 cm. A 1 cm increase in body length increased milk yield by an average of 15.96 grams.

A comparison of chest circumference lengths revealed that the highest milk yield was obtained in animals with a chest circumference of 200-210 cm. Furthermore, it was demonstrated that an increase of 1 cm in chest circumference resulted in an increase of 17.96 grams of milk yield. The highest milk yield was recorded at 145 cm wither height and 80 cm chest depth (Jaayid et al., 2011).

In another study, a positive relationship was found between the distance between the hip bone and the upper wedge angle and milk yield. In this study, it was found that animals with wider hip bone distance and higher upper wedge angle had higher milk yield (Dahiya et al, 2020).

According to the study conducted by Zhang et al., it was observed that buffaloes with high hind legs, short teat crossing distance and narrow teat circumference were less likely to suffer from mastitis than other buffalos (Zhang et al, 2023).

In another study conducted by Mirza et al. in Pakistan (2015), they reported that heart circumference and milk yield were significantly positively related. They stated that the relationship between milk yield and heart circumference could be taken into account in indirect selection for milk yield.

In the study by Dhillod et al. (2017), they found that body weight, mouth width and abdominal circumference are linked to milk yield. They also reported that body length and body depth were positively related to milk yield, but this relationship was not significant (Dhillod et al, 2017). In a study conducted on Iraqi buffaloes, it was found that body weight, body length and heart circumference had a positive relationship with milk yield, and the highest relationship with milk yield was with body weight (Alkhateeb et al., 2021).

A study looked at how skin thickness affects milk yield and content in buffaloes. The results indicated a correlation between these two variables. There is a link between milk yield and skinfold thickness. In particular, the correlations in skinfold thickness, particularly in the flank regions (-0.334) and breast regions (-0.264), were found to be statistically significant. It has been demonstrated that skin thickness exerts a significant influence on milk flow rate. Animals with thin and medium skin thickness in the neck, chest, flank and udder areas exhibited a higher milk flow rate than those with thick skin. (Barati et al, 2017). The effect of skin thickness on milk fat is presented in Figure 3.

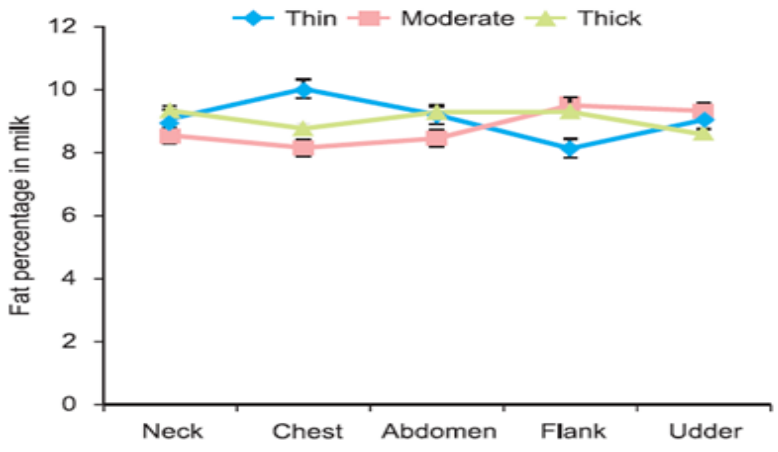

Figure 3. *Relationship between skin thickness in different areas and milk fat in buffaloes (Barati et al, 2017).*

CONCLUSION

Breeders can benefit from some body measurements, breast and teat shapes and sizes when choosing high-yielding buffaloes in terms of milk. The measured characteristics of the breast can generally be given as breast width, breast depth, nipple diameter, nipple length, breast length, breast height, and distance between nipples. While the teat shapes are funnel, bottle, cylindrical and conical shaped teat, the breast shapes are round shaped, bowl shaped, goat shaped and step shaped. Many studies have been conducted examining the relationship between these measurements and shapes and milk yield. A negative correlation has been identified between udder depth and milk yield, while a positive correlation has been observed between other measurements and milk yield. Furthermore, cows with round breasts and conical teats gave the most milk.

Characteristics that have a positive correlation with milk yield are chest circumference, body length, hip bone distance, chest depth and upper wedge angle. The results demonstrated that an increase of 1 cm in body length was associated with on average increase in milk yield of 15.96 grams, while an increase of 1 cm in breast

circumference was associated with an average increase in milk yield of 17.96 grams. The breast depth at which the highest milk yield was observed was 80 cm and the height of the cidago at which the highest milk yield was observed was 145 cm. It has been observed that animals with normal and thin skin thickness have higher milk yield and milk flow rates**.**

In conclusion, it has been observed that there is a relationship between milk yield and body and udder size of buffaloes.

CONFLICT OF INTEREST

The authors stated that they had no conflicts of interest.

AUTHOR CONTRIBUTION

All authors contributed equally.

ETHICAL APPROVAL

The study, entitled "**The Relationship Between Different Body and Udder Shapes and Sizes With Milk Yield In Buffalo**", was conducted in accordance with the relevant scientific, ethical and citation rules. No falsification was made of the collected data, and this study has not been sent to any other academic media for evaluation. As it does not require ethics committee approval, it can be considered to be in accordance with the relevant ethical standards.

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