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Original Research

The Prominent Frame Length of Dairy Cattle to Milk Delivery as A Opt Selection Yardstick

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Abstract

Body length in dairy cattle is an essential linear trait to thoroughly investigate because cattle's bodies are stretched horizontally, unlike humans. As a result, the current study aimed to identify dairy cattle's most prominent body length characteristics primarily related to milk delivery as a selection basis. One hundred twenty-one heads of Holstein cows were employed as a research sample. The samples were utterly lactating, with ages between 2 and 6 years. Principal component analysis (PCA), correlation, and regression were used consecutively to examine the data. The R type 4.2.1 with RStudio software was applied as an instrument for statistical analysis. A stipulated output of the PCA has unmasked four body length traits as major components, comprising absolute frame lengthiness (AFL), relative frame lengthiness (RFL), rump lengthiness (RML), and fore udder lengthiness (FUL). The correlation and regression analysis designated the FUL as the priority in dealing with the milk delivery characteristic, followed by the long distance between teats side-view (TSL). However, with PCA excluding TSL as a substantial component of body length, the second priority was given to the RFL. The ultimate recommendation is to prioritize the FUL trait for the initial cow selection program. Presumedly, the RFL could be used as the first initiative trait for the calf-heifer selection plan.

KEYWORDS
Body length dimension, Correlation, Cow breeding, Linear type trait, Principal component.

INTRODUCTION

Locomotion organ in the animal kingdom is diverse for each species. For instance, in the Gastropod genus, the movement organ is clustered in the cilia and muscular group (Copeland, 1922). Additionally, the locomotion organ in complex species of animals or multicellular creatures is a commonly used muscular system as a movement vehicle (Guillaud *et al.*, 2020). There are differences in the locomotion organ between humans and ruminants, such as humans walking with two legs while ruminants use four legs (Alexander, 1984). A different number of legs practised as a mobility instrument would result from the primary body position. The central body position in humans is vertically oriented, while in cattle horizontally oriented. Therefore, in the human body height dimension is massively enforced as a criterion to evaluate growth performance (Scheffler and Hermanussen, 2022). An issue arose when dealing with cattle gains measurement, which is merely focusing on the height dimension could increase the risk of bias. Then, the length dimension in cattle emanated to investigate tremendously. The whole examination of morphometrics subject in dairy cattle science is titled "linear type traits" (Williams *et al.*, 2022). However, the centrepiece of this paper is sharp-edged only to the body length features of dairy cattle.

Morphological frame length categories also shared several features related to the producing attributes. For instance, an investigation sought a regression model to predict milk delivery based on body length and udder morphometry (Soeharsono *et al.*, 2020). Others have stated that body length best predicts live weight (Prabowo *et al.*, 2012). According to those references, before the selection program, which is mainly for dairy cattle, is carried out, the linear type's body length must be considered a variable. Several linear body length types of dairy cattle are divided into more detailed and specific criteria, such as absolute frame lengthiness (Sieber *et al.*, 1988), relative frame lengthiness (Bayram *et al.*, 2006), rump or pelvic lengthiness (Ali *et al.*, 1984), fore udder lengthiness (Togla *et al.*, 2021), teat side-view lengthiness (Güler *et al.*, 2019), and teat lengthiness (Zwertvaegher *et al.*, 2011), respectively. It is still unclear which factors contributed the most to milk delivery in that length frame region. Furthermore, it is not easy to pinpoint the frame length linear traits most important for milk production in dairy cows. Over and above, the criteria of frame lengthiness should be examined excessively in number; thus, smallholder farmers are reluctant to perform selection projects due to time consumption and extravagantly spending resources. So, a maximum of one or two frame lengths criteria should be pinpointed for smallholder farmers.

Principal component analysis (PCA) is a technique that may be utilized to solve such problems quickly (Muslim and Bakhtiar, 2012). PCA is a statistical analysis that can simplify a vast volume of sheet data and retain only a few variables (Al-Kandari and Jolliffe, 2005). In other words, PCA allows us to compute a linear transformation that maps data from a high to a lower-dimensional space. Another piece of literature promoted the idea that PCA can reduce multidimensional data while maintaining

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the essential information in the data (Karamizadeh *et al*., 2013). For dimensional reduction of data sets, PCA evolved from principal feature analysis (PFA) in earlier studies (Lu *et al*., 2007). The evaluation mechanism of PCA used to select the significance of the feature component in the manner proposed took several eigenvectors into account (Song *et al*., 2010). Finding the fundamentally crucial body length linear aspects of milk production characteristics requires the simultaneous use of correlation and stepwise regression analytic methodologies. Finally, it was possible to identify the main characteristic of the body length linear type features in dairy cows and express it clearly; after this, the priority scale was determinable for the selection scheme.

MATERIALS AND METHODS

Grabbing the data

Given the significance of the research, 121 heads of a Friesian Holstein cow kept in Indonesia were used as samples. The age range of the samples included in this study was set out as 2 to 6 years old, and they were all lactating at the time. The cattle measuring stick and the calliper assessed the overall body length of dairy cattle. The fidelity of the measuring stick is 0.1 ad interim 0.01 for the calliper. Additionally, all variables use centimetres as the scale unit.

As a reason for the similar perception of measurement criteria, the definitions of each frame length are explained in detail and encoded for conciseness. The absolute frame lengthiness (AFL) is a measurement began at the tuber ischia (pin bone) and ends at the tuber humerus (shoulder point) (light green line in Fig. 1) (Black and Knapp Jr, 1938). The relative frame lengthiness (RFL) is the distance between the withers and the most posterior pins (tuber ischia) (purple line in Fig. 1) (ICAR, 2022c). The rump lengthiness (RML) is sized from the pin bone's extreme posterior (ischia) to the hook bone's extreme anterior (coxae) (red line in Fig. 1) (Lush and Copeland, 1930). The fore udder lengthiness (FUL) is grabbed from the attachment point of the udder to the abdominal wall with the front teat (blue line in Fig. 1) (White and Vinson, 1975). The udder lengthiness (UDL) is the distance between the udder's attachment point on the abdominal wall and the midpoint between the front and hind teats (shown in gold line in Fig. 1) (ICAR, 2022b). The teat side view lengthiness (TSL) is the lengthwise distance between teats from the side view (dark brown line in Fig. 1) (Rogers and Spencer, 1991). The teat lengthiness (TTL) is the size between the baseline of the udder and the end of the front teat (light blue line in Fig. 1) (ICAR, 2022a).

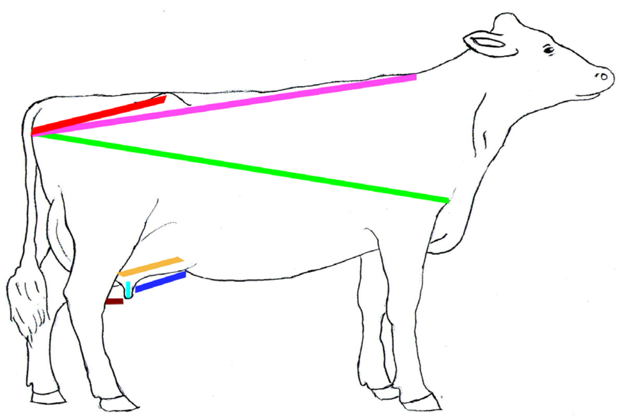

Fig. 1. Frame length properties quantification.

Meanwhile, data aggregation of the milk delivery was applied to the test interval day as an approach and given the symbol MDT_{day} (ICAR, 2014). The standardized milk delivery of 305 days with the symbol MDS_{305d} is also calculated to get rid of the bias of lactation days (Wiggans and Dickinson, 1965; Wiggans and Powell, 1980). Serial computations were also made for the mature equivalent of milk delivery with the mark MDM_{equ} to remove the sample adulthood discrepancy bias (Lush and Shrode, 1950).

Data statistical analysis

Implementing inference statistics is necessary to create a more substantial thesis. Nowadays, there are many computer programs to make statistical analysis processes faster and easier to handle. So, to generate statistical analysis output, R software version 4.2.1 with RStudio was chosen as the tool and ran simultaneously for this study's principal component analysis (PCA), correlation, and regression analysis. Then, the principal component analysis general model is given:

$Y=\Lambda F'+U$

let Y be the p ×T matrix of y_it, Λ be the p×K matrix of loadings, F be the T ×K matrix of f_{tk}, and U be p ×T matrix of u_{it}, respectively (Fan *et al*., 2016).

Meanwhile, the math formula for Pearson's correlation (1) and regression (2) are arranged like

$$r(t,\theta)=\frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}}$$ (1) Pandian and Kavitha (2018)

$$Y=m(x)+\sigma(x)\varepsilon$$ (2) Yao and Li (2014)

which is the $\bar{x}=\frac{\sum_{i=1}^{n}x_i}{n}$ and $\bar{y}=\frac{\sum_{i=1}^{n}y_i}{n}$, are the means of sample. Afterwards, m(x) is the $x^T\beta$, σ(x) is the $x^T\alpha$, and ε is the skewed density. The stepwise procedure is applied for regression.

RESULTS

Some statistical analysis aims to discover and enlighten the course of data interpretation processes. The performed statistical analyses were descriptive statistics, PCA, and correlation regression, as addressed in the material and method chapter. Descriptively statistics, the mean score and standard deviation of the AFL was 143.50±7.07 cm, RFL was 131.80±8.06 cm, RML was 47.93±4.71, FUL was 15.67±4.85 cm, UDL was 20.89±6.01, TSL was 6.90±1.64, and TTL was 4.43±1.01 cm. The most prolonged body length variable is absolute frame lengthiness (AFL), with teat lengthiness (TTL) as the shortest. Meanwhile, the average milk delivery test day (MDT_{day}) from entire specimens was 2556±329 kg. Then, the mean score of milk delivery standardized 305d (MDS_{305d}) was 2482±299 kg. Lastly, the average milk delivery mature commensurate (MDM_{equ}) was 2809±371 kg.

Before executing the PCA, the KMO and Bartlett's test of sphericity become an absolute provision in terms of checking the homogeneity of the data. The KMO overall score is 0.57, and Bartlett's test of sphericity with a p-value under 0.05 is output in this investigation, respectively. The results of the dairy cattle body length conducted by the KMO and Bartlett's test are calculated in full in Table 1. The data is homogeneous from those results, and PCA can be run as the next step.

In the wake of the principal component analysis undertaken, the earned eigenvector and loading factor are shown in Table 2;

meanwhile, the eigenvalue is in Table 3. Based upon the eigenvalue in Table 3 and the Scree-plot of PCA in Fig. 2a likewise, the highest proportion of dairy cattle body length that can explain by the total variances is principal component number 1 (PC1) as big as 73.97%, with a combination among AFL, RFL, RML, and FUL as factors. To it, PC2 is manifested coincident factors like PC1 but merely 14.47%, explaining the capability of the total variance. Hence, the PC1 extra PC2 could be used as a factor to adequately, with a total of 88.44% describing the capacity of the total variance. Then, in terms of establishing the linear equation, loading factors of principal components are usable as an account follows:

$PC\_1=0.621\log(x_1)+0.72\log(x_2)+0.277\log(x_3)+0.138\log(x_4)$

$PC\_2=0.207\log(x_1)+0.123\log(x_2)-0.327\log(x_3)-0.913\log(x_4)$

where, x_1: AFL; x_2: RFL; x_3: RML; and lastly x_4: FUL respectively.

The phenotypic association analysis among dairy cow body length needs to be implemented immediately to make the PCA on data interpretation more understandable. Therefore, the phenotypic relationship between dairy cow frame length and to milk delivery in Table 4 is presented ultimately to get holistic information. The most extensive positive relationship is held between AFL and RFL; oppositely, FUL with TTL is the lowest. Conversely, specific negative correlations between body length variables were also found after applying correlation analysis. Although, the negative correlation is at a deficient level.

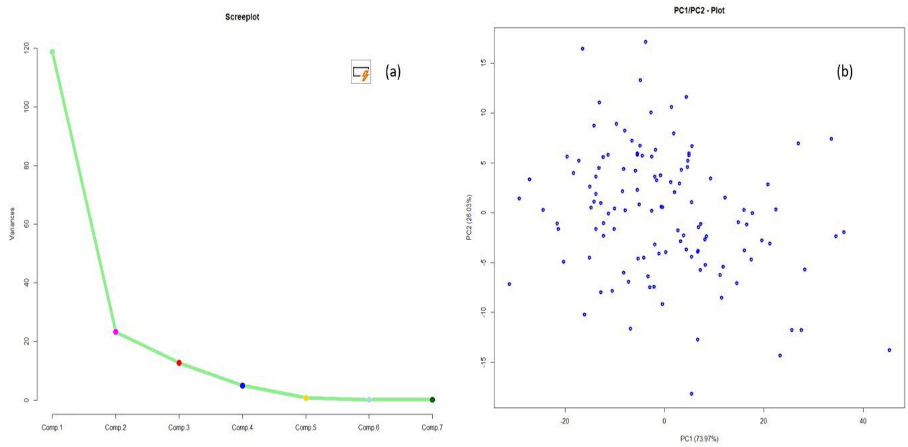

Fig. 2. Frame length of cow, (a) Scree-plot, and (b) PC1/PC2-scheme.

Table 1. Sample homogeneity score of KMO and Bartlett's check.

Procedure Type							Point
Kaiser-Meyer-Olkin factor adequacy (Roundly MSA):							0.57
MSA for every element:	AFL	RFL	RML	FUL	UDL	TSL	TTL
	0.53	0.55	0.9	0.61	0.59	0.46	0.04
Bartlett's test of sphericity	Chi-squared:			387.05			
	df:			21			
	p-value:			0			

AFL: absolute body lengthiness; RFL: relative frame lengthiness; RML: rump lengthiness; FUL: fore udder lengthiness; UDL: udder lengthiness; TSL: between teats side view lengthiness; TTL: teat lengthiness.

Table 2. Frame lengths eigenvector and loading factor of cow.

Traits	$Comb_1$	$Comb_2$	$Comb_3$	$Comb_4$	$Comb_5$	$Comb_6$	$Comb_7$
AFL	**0.62**	**0.21**	0.05	**0.73**	**0.18**	0.01	0.00
RFL	**0.72**	**0.12**	**0.23**	**-0.62**	**-0.16**	-0.01	-0.00
RML	**0.28**	**-0.33**	**-0.90**	0.08	-0.01	0.00	-0.01
FUL	**0.14**	**-0.91**	**0.37**	**0.11**	0.02	-0.02	-0.03
UDL	0.01	-0.04	0.01	0.00	-0.02	**0.58**	**0.81**
TSL	0.00	0.00	0.01	0.00	-0.02	**0.81**	**-0.58**
TTL	0.00	-0.00	0.02	-0.24	0.97	0.02	0.01

AFL: absolute frame lengthiness; RFL: relative frame lengthiness; RML: rump lengthiness; FUL: fore udder lengthiness; UDL: udder lengthiness; TSL: between teats side view lengthiness; TTL: teat lengthiness and bolded number: loading factors.

Table 3. Frame lengths eigenvalue of cow

Scores	$Comb_1$	$Comb_2$	$Comb_3$	$Comb_4$	$Comb_5$	$Comb_6$	$Comb_7$
Standard diversion	10.90	4.82	3.57	2.23	0.86	0.23	0.19
Shared of variance	0.74	0.14	0.08	0.03	0.00	0.00	0.00
Aggregate share	0.74	0.88	0.96	0.99	0.10	0.10	1

Comb1-7: the first to the seventh main constituents or combination factors.

Rapidly, following the use of the regression analysis stepwise procedure, the result was fully illustrated in Table 5. Then, the mathematical model to estimate the milk delivery on test interval day was figured out by the formula next

$MDT_{day-1st}=2101.784+28.969(x_4)$

$MDT_{day-2nd}=1261.251+27.827(x_4)+450.454(x_6)$

while computing the milk delivery standardized 305-d, follow the equation forward

$MDS_{305d-1st}=2032.421+28.701(x_4)$

$MDS_{305d-2nd}=1358.890+4.783(x_4)+104.170(x_6)$

and the edge, for predicting the milk delivery of mature equivalent, could be used in this model

$MDM_{equ-1st}=2440.486+23.541(x_4)$

$MDM_{equ-2nd}=1664.366+22.486(x_4)+415.934(x_6)$

where the $MDT_{day-1st}$ is the first model of milk delivery test interval; $MDT_{day-2nd}$ is the second linear model of milk delivery test interval; $MDS_{305d-1st}$ is the first formula of milk delivery standardized 305-d first; $MDS_{305-2nd}$ is the second formula of milk delivery standardized 305-d; $MDM_{equ-1st}$ is the first equation of the milk delivery mature equivalent; $MDM_{equ-2nd}$ is the second equation of the milk delivery mature equivalent; x_4: FUL; and x_6: TSL apiece.

The main finding of the investigation was that the PCA output identified the AFL, RFL, RML, and FUL traits as significant factors in the dairy cattle body length. At the same time, the correlation and regression analysis showed that the FUL and TSL traits have a better association with milk delivery than the other traits of body length in this exploration. There were marginally different outcomes when PCA and correlation regression analyses were used. As a result, comparative research should be used to draw a solid conclusion; the next chapter will go into greater depth about it.

DISCUSSION

Before moving forward, it is essential to do comparison research by comparing the descriptive data to that of another discovery. Embark with the absolute frame lengthiness (AFL) has a range of 147 – 169 cm (Sieber *et al*., 1989), 149 – 170 cm (Touchberry and Lush, 1950), 135 – 144 cm (Bayram *et al*., 2006), 142 – 197 cm (Cerqueira *et al*., 2013), meanwhile, the relative frame lengthiness (RFL) has a space between 114 – 121 cm (Ural and Baritci, 2013), 132 – 148 cm (Bene *et al*., 2007), 122 – 160 cm from varies breed (Bene *et al*., 2007), and 105 ± 6.89 cm in Bali breed cattle (Baliarti *et al*., 2021). Then, the rump lengthiness (RML) has a range of 45 – 66 cm (Gruber *et al*., 2018), 38 – 48 cm (Bene *et al*., 2007), 50 – 54 cm (Zavadilová *et al*., 2009a) or pelvic length 53 cm (Bures *et al*., 2008), and 49 – 57 cm (Sieber *et al*., 1988). Next, the fore udder lengthiness (FUL) has a scope between 10 – 29 cm (Xu *et al*., 2022); in the meantime, the udder lengthiness (UDL) is 25 – 36 cm (Nosirov *et al*., 2021). Continued by the teat side-view length (TSL) has a scale between 7 – 12 cm (Ural and Baritci, 2013); meanwhile, the teat lengthiness (TTL) is 2 – 10 cm (Xu *et al*., 2022), 2.5 – 10 cm (Hickman, 1964), 2.3 – 6.4 cm (Mingoas *et al*., 2017), and 4 – 8 cm (Ural and Baritci, 2013). Referring to the literature about the body length of cattle and encountered with the current compiled data could be inferred that in a harmonic situation. Afterwards, each body length should be criticized comprehensively for a holistic understanding.

Due to their solid phenotypic association, the AFL and RFL linear types would be the first trait to be discussed together. Regarding milk delivery, fat yield, solid non-fat (SNF), and fat-cor-

Table 4. Relationship coefficient among cow frame length and milk delivery.

Relation	AFL	RFL	RML	FUL	UDL	TSL	TTL	MDT_{day}	MDS_{305d}	MDM_{equ}
AFL	1									
RFL	0.91**	1								
RML	0.55**	0.54**	1							
FUL	0.19*	0.26**	0.32**	1						
UDL	0.18	0.24**	0.33**	0.70**	1					
TSL	0.11	0.14	-0.03	0.05	0.14	1				
TTL	-0.08	0.11	0.01	0.01	-0.02	-0.02	1			
MDT_{day}	0.12	0.18*	-0.02	0.43**	0.42**	0.33**	-0.07	1		
MDS_{305d}	0.21*	0.26**	0.08	0.47**	0.45**	0.29**	-0.01	0.90**	1	
MDM_{equ}	0.16	0.23*	-0.03	0.31**	0.22*	0.27**	0.06	0.73**	0.85**	1

AFL: absolute frame lengthiness; RFL: relative frame lengthiness; RML: rump lengthiness; FUL: fore udder lengthiness; UDL: udder lengthiness; TSL: between teats side view lengthiness; TTL: teat lengthiness; MDT_{day}: milk delivery test day; MDS_{305d}: milk delivery standardized 305d; MDMequ: milk delivery mature equivalent.
** Relationship is crucial at the 0.01 level (2-tailed).
* Relationship is crucial at the 0.05 level (2-tailed).

Table 5. Frame length to milk delivery of regression design.

Design		Milk delivery-$_{test\ day}$ (MDT_{day})		Milk delivery-$_{standardized\ 305d}$ (MDS_{305d})		Milk delivery-$_{mature\ equivalent}$ (MDM_{equ})	
		β	Rectified R^2	β	Rectified R^2	β	Rectified R^2
1	Intercept	2101.78	0.175*	2032.42	0.211*	2440.49	0.087*
	FUL	28.97		28.70		23.54	
2	Intercept	1261.25	0.262*	1358.89	0.278*	1664.37	0.142*
	FUL	27.83		4.78		22.49	
	TSL	450.45		104.17		415.93	

FUL: fore udder lengthiness; and TSL: between teats side view lengthiness
*p-value < 0.01.

rected milk (FCM), respectively, the AFL has a positive correlation, but with fat percentage and estimated feed efficiency (EFE) negative association (Bayram *et al*., 2006). Discrepancy discovery stated that this trait has an insignificant correlation with the fat milk percentage, milk delivery, and FCM (Sieber *et al*., 1988). Still, it has a high genetic correlation with the gain (Gilbert *et al*., 1993). Hence, this trait is moderately associated with live weight (Lukuyu *et al*., 2016). Meanwhile, the RFL trait has a high correlation in the amount 0.57 with the live weight on average from the total various breeds of cattle (Bene *et al*., 2007). Concerning the accuracy of the measurement, this trait is recommended with three times repetitions of measurement (Touchberry and Lush, 1950). Therefore, it applied to the current investigation. These qualities depend on the number of parties (Kincaid and Touchberry, 1966).

They seriated with the RML trait that would be disassembled clearly. This trait was relatively easier to measure than other traits (Gruber *et al*., 2018). It was discovered that there was no significant relationship between the skeletal measurements of pelvic length with any of the milk delivery, fat yield, or fat-corrected milk variables (Sieber *et al*., 1988). Nevertheless, the RML has genetic correlations with a length of productive life of 0.17 negatively, while the length of productive life corrected for milk production in the first lactation was 0.10 negatively as well (Zavadilová *et al*., 2009a). In contrast to AFL and RFL, the RML characteristic increased linearly with the parity number (Sieber *et al*., 1988). For among fourth parity, the correlation for pelvic length was slightly significant ($P<0.05$) and positive (Sieber *et al*., 1989). Purebred breeders placed one of their primary emphasis on rump lengthiness traits (Gonyon *et al*., 1986). The heritability of rump traits is slightly higher than that of reproductive traits (Shapiro and Swanson, 1991). A descendant heifer from a sire with a wider rump tends to express closely with their ancestor, although the length rump is better than the progenitor (Gowen, 1933). However, both rump characteristics were associated with a significant probability of culling (Zavadilová *et al*., 2009b). Then, rump lengthiness showed a linear relationship to longevity (Zavadilová *et al*., 2009b).

The following traits are both FUL and UDL traits. The FUL trait with longevity has a genetic correlation as significant as 0.16 positively (Zavadilová *et al*., 2009a). Additionally, there is a genetic link between the FUL characteristic and milk output of up to 0.31 (Norman and Van Vleck, 1972). Then, the FUL exhibits an intermediate optimum as related to longevity. The most critical udder-type traits were fore udder lengthiness and rear udder attachment (Zavadilová *et al*., 2009b). Cases with shallow scores for fore udder lengthiness were linked to a higher probability of culling than cows with long fore udders; cows with intermediately long fore udders had the lowest risk of culling (Zavadilová *et al*., 2009b). Various explorations have supported the claim (Short and Lawlor, 1992); (Larroque and Ducrocq, 1999); (Caraviello *et al*., 2003; Schneider *et al*., 2003). Meanwhile, the UDL trait with milk delivery has a positive connection (Mingoas *et al*., 2017). Another researcher agreed with that (Rohayem *et al*., 2019). The reproduction, milking potency, and longevity characteristics were affected by this trait (Török *et al*., 2021). This characteristic, combined with the ligament suspensory, becomes the standard for culling cows, especially those with low scores (Jovanovac and Raguž, 2011). Advanced insight into this trait could be stressed to SNPs in a region around 90 Mb on BTA6 in genomic research (Flury *et al*., 2014).

The TSL and TTL traits continued it. The span between teats is influenced greater by the width of the udder than their length (Kuczaj, 2003). Before and after milking, teat and udder conformation absolute reduction was influenced by breed and lactation stage but not by the parity of the cows (Sabuncuoglu and Coban, 2007). In most cases, the hind teats were significantly shorter than the front teats, the teat lengthiness significantly increased with increasing parity, and the front teats were more extended and broader than the hind teats (Zwertvaegher *et al*., 2012). However, the increase in teat lengthiness was not significant from the second parity onwards in front teats (Zwertvaegher *et al*., 2012). The teat lengthiness (TTL) mainly depends on the breed of cows (Wufka and Willeke, 2001). Teat lengthiness to the length of productive life has a genetic correlation of as much as 0.16 negatively, while the length of productive life corrected for milk production in the first lactation is as big as 0.14 negatively likewise (Zavadilová *et al*., 2009a). A longer TTL is greater potency to suffer subclinical mastitis, especially upper than 5 cm (Siagian and Amidjaya, 2022). Instead, a strong correlation between the incidence of mastitis and teat diameter was discovered, whereas the length of the teat proved unrelated to the incidence of mastitis (Hickman, 1964). Nevertheless, this trait has a negative relationship with peak yield or milking rate (Hickman, 1964). After the first 30 days in milk, teat lengthiness substantially and significantly increased, whereas teat diameters decreased (Zwertvaegher *et al*., 2012). As supplementary, the teat lengthiness heritability score is 0.36 ± 0.04, while the genetic correlation is 0.05 ± 0.00 (Tapkı *et al*., 2020).

As a recap, the current investigation of all pieces of published works presented beforehand indicated condition in concert generally. However, dealing with several calamitous traits expressed by several body lengths, especially in an extreme situation, should be handled with caution. For instance, correlations between estimated feed efficiency (EFE) and body measurements indicated that longer and significantly heavier cows were less efficient than more miniature cows (Bayram *et al*., 2006). Therefore, the most desired cow is the shortest but has high milk delivery productivity but should be considered the biological burden.

CONCLUSION

According to the findings of the current investigation, the significant constituents of body length are made up of absolute frame lengthiness (AFL), relative frame lengthiness (RFL), rump lengthiness (RML), and the fore udder lengthiness (LFU). The LFU is the most prominent body length trait in milk delivery characteristics, followed by the teat side-view length (TSL). As a result, the LFU trait was prioritized first as a selection basis to increase milk production in dairy cattle. Due to the TSL trait being eliminated from the principal component of body length, the RFL trait was selected as the second priority for the selection scheme. As the ultimate recommendation, the LFU applies to the cow selection program. Meanwhile, the RFL is assumably implementable in the calf-heifer selection program because the LFU during this period is imperceptible, but specific data should be provided to ratify it.

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CONFLICT OF INTEREST

The authors pronounced that there are no conflicts of interest. The wordsmith reported no pecuniary espouse from any institution for perpetrating this study. A portion of PRABOWO's PhD thesis was used to create this script.

REFERENCES

Al-Kandari, N.M., Jolliffe, I.T., 2005. Variable selection and interpretation in correlation principal components. J. Environmetrics. 16, 659-672. https://doi.org/10.1002/env.728

Alexander, R.M., 1984. Walking and running: Legs and leg movements are subtly adapted to minimize the energy costs of locomotion. J. Am. Sci. 72, 348-354. http://www.jstor.org/stable/27852758

Ali, T.E., Burnside, E., Schaeffer, L., 1984. Relationship between external body measurements and calving difficulties in Canadian Holstein-Friesian cattle. J. Dairy Sci. 67, 3034-3044. https://doi.org/10.3168/jds.S0022-0302(84)81669-0

Baliarti, E., Setiawan, I., Widi, T., Suhartanto, B., Maulana, H., Atmoko, B., Astrini, A., 2021. Performances of Bali cow kept by the palm oil farmers in Rokan Hulu, Riau. IOP Conf. Ser.: Earth Environ. Sci., Surakarta, Indonesia. p.902012053 https://doi.org/10.1088/1755-1315/902/1/012053

Bayram, B., Güler, O., Yanar, M., Akbulut, Ö., 2006. Relationships among body weight, body measurements and estimated feed efficiency characteristics in Holstein Friesian cows. Tekirdağ Ziraat Fak. Derg. 3, 64-67. https://dergipark.org.tr/en/pub/jotaf/issue/19058/201582

Bene, S., Nagy, B., Nagy, L., Kiss, B., Polgár, J.P., Szabo, F., 2007. Comparison of body measurements of beef cows of different breeds. J. Arch. Anim. Breed. 50, 363-373. https://doi.org/10.5194/aab-50-363-2007

Black, W., Knapp Jr, B., 1938. Correlation of body measurements of slaughter steers with rate and efficiency of gain and with certain carcass characteristics. J. Agric. Res. 56, 465 - 472. https://naldc.nal.usda.gov/download/IND43969183/PDF

Bures, D., Barton, L., Zahrádková, R., Teslík, V., Fiedlerová, M., 2008. The calving difficulty is related to body weights and measurements of cows and calves in a herd of Gascon breed. Czech J. Anim. Sci. 53, 187. https://doi.org/10.17221/312-CJAS

Caraviello, D., Weigel, K., Gianola, D., 2003. Analysis of the relationship between type traits, inbreeding, and functional survival in Jersey cattle using a Weibull proportional hazards model. J. Dairy Sci. 8, 2984-2989. https://doi.org/10.3168/jds.S0022-0302(03)73896-X

Cerqueira, J., Araújo, J., Vaz, P., Cantalapiedra, J., Blanco-Penedo, I., Niza-Ribeiro, J., 2013. Relationship between zoometric measurements in Holstein-Friesian cow and cubicle size in dairy farms. Int. J. Morphol. 31, 55-63. https://doi.org/10.4067/S0717-95022013000100008

Copeland, M., 1922. Ciliary and muscular locomotion in the gastropod genus Polinices. The Biological Bulletin. 4, 132-142. https://doi.org/10.2307/1536576

Fan, J., Liao, Y., Wang, W., 2016. Projected principal component analysis in factor models. J. Ann. Stat. 44, 219. https://doi.org/10.1214/15-AOS1364

Flury, C., Boschung, C., Denzler, M., Bapst, B., Schnyder, U., Gredler, B., Signer-Hasler, H., 2014. Genome-wide association study for 13 udder traits from linear type classification in cattle. 10th World Congress of Genetics Applied to Livestock Production, Vancouver, Canada. p.830 https://arbor.bfh.ch/id/eprint/7406

Gilbert, R., Bailey, D., Shannon, N. 1993. Body dimensions and carcass measurements of cattle selected for postweaning gain fed two different diets. J. Anim. Sci. 71, 1688-1698. https://doi.org/10.2527/1993.7171688x

Gonyon, D., Allaire, F., Harvey, W., 1986. Quantifying dairy breeding goals. 2. Perceived relative contributions of type traits to total merit. J. Dairy Sci. 69, 484-492. https://doi.org/10.3168/jds.S0022-0302(86)80427-1

Gowen, J.W., 1933. On the genetic constitution of Jersey cattle, as influenced by inheritance and environment. J. Genet. 18, 415-440. https://doi.org/10.1093/genetics/18.5.415

Gruber, L., Ledinek, M., Steininger, F., Fuerst-Waltl, B., Zottl, K., Royer, M., Krimberger, K., Mayerhofer, M., Egger-Danner, C., 2018. Body weight prediction using body size measurements in Fleckvieh, Holstein, and Brown Swiss dairy cows in lactation and dry periods. J. Arch. Anim. Breed. 61, 413-424. https://doi.org/10.5194/aab-61-413-2018

Guillaud, E., Seyres, P., Barriere, G., Jecko, V., Bertrand, S.S., Cazalets, J.R., 2020. Locomotion and dynamic posture: the neuro-evolutionary basis of bipedal gait. J. Neurophysiol. Clin. 50, 467-477. https://doi.org/10.1016/j.neucli.2020.10.012

Güler, O., Diler, A., Yanar, M., Aydın, R., Kocyıgıt, R., 2019. Appraisal of linear type traits in Simmental cows reared on the high altitude of Eastern Turkey. J. Agric. Sci. 26, 331-338. https://doi.org/10.15832/ankutbd.532130

Hickman, C., 1964. Teat shape and size in relation to production characteristics and mastitis in dairy cattle. J. Dairy Sci. 47, 777-782. https://doi.org/10.3168/jds.S0022-0302(64)88763-4

ICAR., 2014. International Agreement of Recording Practices - ICAR Recording Guidelines. Berlin, Germany. International Committee Animal Recording Press. pp. 637. https://pecuaria.pt/docs/Guidelines_2014.pdf

ICAR., 2022a. Appendix 1 of Section 5 of the ICAR Guidelines - The standard trait definition for Dairy Cattle ICAR Guidelines. Utrecht, Netherlands, The Global Standard for Livestock Data Press. pp. 16. https://www.icar.org/Guidelines/05-Conformation-recording-Appendix-1.pdf

ICAR., 2022b. Appendix 2 of Section 5 of the ICAR Guidelines - The standard trait definition for Dairy Cattle ICAR Guidelines. Utrecht, Netherlands, The Global Standard for Livestock Data Press. pp. 14. https://www.icar.org/Guidelines/05-Conformation-recording-Appendix-2.pdf

ICAR., 2022c. Appendix 3 of Section 5 of the ICAR Guidelines - The standard trait definition for Dairy Cattle ICAR Guidelines. Utrecht, Netherlands, The Global Standard for Livestock Data Press. 23pp. https://www.icar.org/Guidelines/05-Conformation-recording-Appendix-3.pdf

Jovanovac, S., Raguž, N., 2011. Analysis of the relationships between type traits and longevity in Croatian Simmental cattle using survival analysis. J. Agric. Conspec. Sci. 76, 249-253. https://hrcak.srce.hr/file/107293

Karamizadeh, S., Abdullah, S.M., Manaf, A.A., Zamani, M., Hooman, A., 2013. An overview of principal component analysis. J. Signal Inform. Process. 4, 173-175. https://doi.org/10.4236/jsip.2013.43B031

Kincaid, H. L., Touchberry, R., 1966. Effects of parity order on production and body measurements. J. Dairy Sci. 49, 301-306. https://doi.org/10.3168/jds.S0022-0302(66)87852-9

Kuczaj, M., 2003. Analysis of changes in udder size of high-yielding cows in subsequent lactations with regard to mastitis. Electronic J. Polish Agric. Univ. Ser. Anim. Husb. 1, 1-5. http://www.ejpau.media.pl/volume6/issue1/animal/art-02.html

Larroque, H., Ducrocq, V., 1999. Phenotypic relationship between type and longevity in the Holstein breed. Interbull Bulletin. 631, 96–103. https://journal.interbull.org/index.php/ib/article/view/631

Lu, Y., Cohen, I., Zhou, X.S., Tian, Q., 2007. Feature selection using principal feature analysis. The 15th ACM international conference on Multimedia, Champaign Urbana. p. 301–304. https://doi.org/10.1145/1291233.1291297

Lukuyu, M.N., Gibson, J.P., Savage, D., Duncan, A.J., Mujibi, F., Okeyo, A., 2016. Use of linear body measurements to estimate live weight of crossbred dairy cattle in smallholder farms in Kenya. J. Springer Plus. 5, 1-14. https://doi.org/10.1186/s40064-016-1698-3

Lush, J.L., Copeland, O., 1930. A study of the accuracy of measurements of dairy cattle. J. Agric. Res. 41, 37-49. https://naldc.nal.usda.gov/download/IND43967818/PDF

Lush, J.L., Shrode, R.R., 1950. Changes in milk production with age and milking frequency. J. Dairy Sci. 33, 338-357. https://doi.org/10.3168/jds.S0022-0302(50)91909-6

Mingoas, K.J.P., Awah-Ndukum, J., Dakyang, H., Zoli, P.A., 2017. Effects of body conformation and udder morphology on milk yield of zebu cows in North region of Cameroon. J. Vet. World. 10, 901-905. https://doi.org/10.14202/vetworld.2017.901-905

Muslim, A., Bakhtiar, T., 2012. Variable selection using principal component and Procrustes analyses and its application in educational data. J. Asian Sci. Res. 2, 856-865. https://archive.aessweb.com/index.php/5003/article/view/3435

Norman, H., Van Vleck, L.D., 1972. Type appraisal: III. Relationships of first lactation production and type traits with lifetime performance. J. Dairy Sci. 55, 1726-1734. https://doi.org/10.3168/jds.S0022-0302(72)85750-3

Nosirov, B., Safarov, M., Gaipov, M., Askarkhodjayeva, S., Soatov, U., Javkarashev, K.T., 2021. Correlation of udder shape, size and udder size of Bushuev breed of cows with milk yield. XXII Int. Sci. Conference Energy Management of Municipal Facilities and Sustainable Energy Technologies, Voronezh, Rusia. p. 244–02048. https://doi.org/10.1051/e3sconf/202124402048

Pandian, P., Kavitha, K., 2018. On the correlation between two real interval sets. J. Phys.: Conf. Ser. p.1000: 012055. https://doi.org/10.1088/1742-6596/1000/1/012055

Prabowo, S., Panjono, Rusman., 2012. Carcass weight predictor variables of live Simmental crossbreed Ongole bulls. Bull. Anim. Sci. 36, 95-102. https://doi.org/10.21059/buletinpeternak.v36i2.1585

Rogers, G., Spencer, S., 1991. Relationships among udder and teat morphology and milking characteristics. J. Dairy Sci. 74, 4189-4194. https://doi.org/10.3168/jds.S0022-0302(91)78614-1

Rohayem, A., El-khashab, M.A., Semaida, A., 2019. Relationship of udder and body measurements with milk yield in Holstein cows reared in Egypt. Fayoum J. Agric. Res. Dev. 33, 148-155. https://doi.org/10.21608/FJARD.2019.210641

Sabuncuoglu, N., Coban, O., 2007. Relationship between udder and teat conformation and milk yield performance in dairy cows pre- and post-milking. Can. J. Anim. Sci., 87, 285-289. https://doi.org/10.4141/A06-074

Scheffler, C., Hermanussen, M., 2022. Stunting is the natural condition of human height. Am. J. Hum. Bio. 34(5), e23693. https://doi.org/10.1002/ajhb.23693

Schneider, M.D., Dürr, J., Cue, R., Monardes, H., 2003. Impact of type traits on functional herd life of Quebec Holsteins assessed by survival analysis. J. Dairy Sci. 8, 4083-4089. https://doi.org/10.3168/jds.S0022-0302(03)74021-1

Shapiro, L. S., Swanson, L., 1991. Relationships among rump and rear leg type traits and reproductive performance in Holsteins. J. Dairy Sci. 74, 2767-2773. https://doi.org/10.3168/jds.S0022-0302(91)78456-7

Short, T., Lawlor, T., 1992. Genetic parameters of conformation traits, milk yield, and herd life in Holsteins. J. Dairy Sci. 75, 1987-1998. https://doi.org/10.3168/jds.S0022-0302(92)77958-2

Siagian, T.B., Amidjaya, S.H., 2022. Correlation between teat length and lactation periods on the level of subclinical mastitis occurrence in Sappy Valley Farm. 2nd International Conference on Applied Sciences. p. 34800031. https://doi.org/10.1051/e3sconf/202234800031

Sieber, M., Freeman, A., Kelley, D., 1988. Relationships between body measurements, body weight, and productivity in Holstein dairy cows. J. Dairy Sci. 71, 3437-3445. https://doi.org/10.3168/jds.S0022-0302(88)79949-X

Sieber, M., Freeman, A., Kelley, D., 1989. Effects of body measurements and weight on calf size and calving difficulty of Holsteins. J. Dairy Sci. 72(9), 2402-2410. https://doi.org/10.3168/jds.S0022-0302(89)79373-5

Soeharsono, S., Mulyati, S., Utama, S., Wurlina, W., Srianto, P., Restiadi, T.I., Mustofa, I., 2020. Prediction of daily milk production from the linear body and udder morphometry in Holstein Friesian dairy cows. J. Vet. World. 13, 471. https://doi.org/10.14202/vetworld.2020.471-477

Song, F., Guo, Z., Mei, D., 2010. Feature selection using principal component analysis. Int. Conf. On System Sci., Engineering Design and Manufacturing Informatization, Yichang, China. pp. 27–30. https://doi.org/10.1109/ICSEM.2010.14

Tapkı, İ., Tapkı, N., Güzey, Y.Z., Selvi, M.H., 2020. Genotypic correlations among first lactation profitability, linear type traits and production characteristics of Holstein Friesian cows in Turkey. J. Anim. Prod. 61, 83-90. https://doi.org/10.29185/hayuretim.630155

Togla, O., Kadyan, S., Bhardwaj, S., Kumar, I., Gujral, S., Wani, Y.M., 2021. Udder type traits: A selection criterion in indigenous dairy cattle. J. Pharm. Innov. 10, 2639-2643 https://www.thepharmajournal.com/archives/2021/vol10issue11S/PartAA/S-10-11-181-324.pdf

Török, E., Komlósi, I., Szőnyi, V., Béri, B., Mészáros, G., Posta, J., 2021. Combinations of linear type traits affecting the longevity in Hungarian Holstein-Friesian cows. J. Anim. 11, 3065. https://doi.org/10.3390/ani11113065

Touchberry, R.W., Lush, J., 1950. The accuracy of linear body measurements of dairy cattle. J. Dairy Sci. 33, 72-80. https://doi.org/10.3168/jds.S0022-0302(50)91866-2

Ural, D.A., Baritci, İ., 2013. Determination of the relationship between some udder and body traits of Holstein cows by canonical correlation analysis. Kocatepe Vet. Derg. 6, 11-17. https://doi.org/10.5578/kvj.5476

White, J., Vinson, W., 1975. Relationships among udder characteristics, milk yield, and nonyield traits. J. Dairy Sci. 58, 729-738. https://doi.org/10.3168/jds.S0022-0302(75)84635-2

Wiggans, G., Dickinson, F., 1965. Handbook of standardization of NCDHIP dairy cattle lactation records. National Cooperative Dairy Herd Improvement Program Press, Maryland, USA. p. 7. https://queries.uscdcb.com/publish/dhi/handbook/recstd.pdf

Wiggans, G., Powell, R., 1980. Projection factors for milk and fat lactation records: Dairy herd improvement letter. U.S. Department of Agriculture, Science and Education Administration Press, Beltsville Md, Federal Research Northeastern Region, USA. p. 14. https://archive.org/details/dairyherdimprove563unit/page/n1/mode/2up

Williams, M., Sleator, R.D., Murphy, C.P., McCarthy, J., Berry, D., 2022. Re-assessing the importance of linear type traits in predicting genetic merit for survival in an ageing Holstein-Friesian dairy cow population. J. Dairy Sci. 105, 7550-7563. https://doi.org/10.3168/jds.2022-22026

Wufka, M., Willeke, H., 2001. Einfluss von rasse und laktationsnummer auf eutermerkmale bei milchkühen. J. Archiv. Anim. Breed. 44, 497-504. https://doi.org/10.5194/aab-44-497-2001

Xu, L., Luo, H., Zhang, X., Lu, H., Zhang, M., Ge, J., Zhang, T., Yan, M., Tan, X., Huang, X., 2022. Factor analysis of genetic parameters for body conformation traits in dual-purpose Simmental cattle. J. Anim. 12, 2433. https://doi.org/10.3390/ani12182433

Yao, W., Li, L., 2014. A new regression model: modal linear regression. Scand. J. Stat. 41, 656-671. https://doi.org/10.1111/sjos.12054

Zavadilová, L., Němcová, E., Štípková, M., Bouška, J., 2009a. Relationships between longevity and conformation traits in Czech Fleckvieh cows. J Czech J. Anim. Sci. 54, 385-394. https://doi.org/10.17221/1685-CJAS

Zavadilová, L., Štípková, M., Němcová, E., Bouška, J., Matějíčková, J., 2009b. Analysis of the phenotypic relationships between type traits and functional survival in Czech Fleckvieh cows. Czech J. Anim. Sci. 54, 521-531. https://doi.org/10.17221/29/2009-CJAS

Zwertvaegher, I., Baert, J., Vangeyte, J., Genbrugge, A., Van Weyenberg, S., 2011. Objective measuring technique for teat dimensions of dairy cows. J. Biosyst. Eng. 110, 206-212. https://doi.org/10.1016/j.biosystemseng.2011.08.009

Zwertvaegher, I., Van Weyenberg, S., Piepers, S., Baert, J., De Vliegher, S., 2012. Variance components of teat dimensions in dairy cows and associated factors. J. Dairy Sci. 95, 4978-4988. https://doi.org/10.3168/jds.2011-5296