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Dairy Cattle Body Width Principal Component and the Correlation Level to Milk Yields as An Option for Selection Approach

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ABSTRACT

The body-width linear traits of dairy cattle affect their production capacity, particularly milk yield characteristics. Even so, the prominent dairy cattle body width linked to the milk yield up to this point is not explicitly articulated. Therefore, this exploration aimed to identify the best body width characteristic related to production capacity and milk yields as a selection criterion. The investigation samples were 121 heads of Friesian Holsteins raised in Indonesia. The total measured body width of dairy cattle was eleven variables. All parameters were examined on a centimeter unit scale. R software version 4.2.1 is synchronized with RStudio to implement principal component analysis (PCA), Pearson's correlation, and regression. The PCA uncovered the shoulder width (SHW), chest width (CHW), loin width (LNW), rump width (RMW), thurl width (TLW), pin width (PNW), and rear udder width (RUW) as significant elements of body width. Afterward, the highest relationship to milk yield characteristics was controlled by the rear udder width (RUW) and teat back-view width (TBW) traits serially. Due to the TBW being disqualified from the first principal component, its place is taken by the PNW trait. As an epilogue, exploiting the RUW trait as the main priority for the lactation cow selection scheme is strongly advocated. Meanwhile, the PNW trait is the initial priority for calves and heifers.

Keywords: body measurement; Holstein cows; linear type; relationship; width dimension

INTRODUCTION

Anthropometrics is familiar with body size as a variable to measure for assessment (Martínez-Rodríguez *et al.,* 2021). For instance, a study proposed implicating body width in the formula for calculating body mass index (BMI) (Alzyoud *et al.,* 2021). Hence, the width of the linear type trait is one of the essential variables to examine in terms of individual judgment for selection. In concert with the importance of the body width parameter, it is also adopted in dairy cattle science, exclusively in the subject related to studies of linear type traits.

It was universally known that body width in the linear type traits of dairy cattle science has already been investigated a vast amount. Unluckily, none of those studies claimed which part of the body width trait was the topmost related to milk yield. However, if the studies conducted by other researchers are inventoried, some important linear types of dairy cattle body width can be identified. Furthermore, the study that has been completed and is relevant to the body width of dairy cattle is divisible into some distinctive parts, for instance, neck width (Prabowo *et al.,* 2012); *tuber humerus* width or width at shoulders (Baimukanov *et al.,* 2022); relative chest width (ICAR, 2022); *lumbar* or loin width (Prabowo *et al.,* 2012); rump width, the width of hip or *tuber coxae* width (Batanov *et al.,* 2020); thurl width or *trochanter* width (Seo *et al.,* 2012); tail-root, tail base or tail head width (Bell *et al.,* 2020); ischia width or width of pins (Alcantara *et al.,* 2022); rear udder width (Basavaraj *et al.,* 2020); teats back view width (Guarín *et al.,* 2017), and teat width (Martin *et al.,* 2018). Thus, after stocktaking in the body width parts was completed, it uncovered 11 linear traits leastwise.

The eleven data sets collected before for the forthcoming watchfulness of dairy cattle body width were considered slightly big enough in numbers. Moreover, it will be better if those numbers of data sets can be compressed into the simplest ones. The well-known tool for carrying out that responsibility is "principal component analysis," or "PCA." The targets of PCA are to extract the essential material from large data sets, simplify the description of the data collection, and elevate interpretability without losing the vital information of the data (Jolliffe & Cadima, 2016; Kalaivani *et al.,* 2020). In addition, PCA has the competency to establish the linear model from the data sets entered in the running process of the principal component. It is exposed by both the eigenvector and eigenvalue produced by that operation. The score of eigenvectors can be used for the multiplier coefficient value for each variable, respectively, and the score of the eigenvalue exposes the percentage of variances that the established regression model can explain from the combination of the variables separately (Artigue & Smith, 2019). For example, a study implemented principal component analysis to identify the explaining capability of variability in milk yield and its constituents (Abreu *et al.,* 2020). Then, Pearson's correlation and regression analyses were also applied to determine the association level with the milk yields. Ultimately, the best body width linear trait could be identified and ranked in priority order to be mandated in the selection scheme for dairy cattle, and it developed into the primary goal of the current inspection.

MATERIALS AND METHODS

Gathering of the Data

The ethical clearance for this exploration had been approved by the Veterinary Medicine Faculty of Airlangga University Animal Care and Use Committee with decision number: 3.KE.137.12.2021. A research sample of 121 heads of the Friesian Holstein breed raised in Indonesia was used to conduct this experiment. The research site is in Jombang District, East Java Province, a commercial dairy farming called UD. Saputra Jaya. The cows used in this study at least entered the first period of lactation, or in the other condition, the range of age is 2-6 years old. The cattle measuring gauge and caliper were used as research instruments to examine the body width variables of dairy cattle with a precision level of 0.1 mm and 0.01 mm, respectively. Then, the centimeter unit scale was used to weigh the body width parameter entirely. In exact number and definition of the measured body width variables on dairy cattle in this study are shown in Table 1 and Figure 1 separately.

The milk yield test-day (MYT) data were estimated using the interval method (ICAR, 2014). Afterward, the total milk yields standardized with 305 days (Wiggans, 1965), and the whole milk yield mature equivalent (Lush & Shrode, 1950) was also calculated sequentially. For conciseness, the milk yield standardized was given badge MYS meantime, the whole milk yield mature equivalent was given the mark MYM.

Executed Statistical Analysis

In brief, R software version 4.2.1, in sync with RStudio software, was applied as a statistical analysis tool for running the principal component analysis (PCA), correlation, and regression. For comprehensive

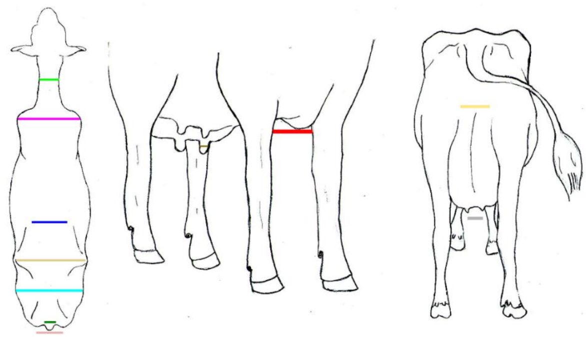

Figure 1. Metering of the cow's body widths trait (a) top-view, (b) front-lateral view, and (c) rear-view.

Table 1. Explanation and codes for the body width parameters in dairy cattle

Body width	Codes	Explanation	References
Neck width	NCW	Across measured from both lateral sides of *cervical vertebrae* in the center of the neck (Figure 1a light green line color)	(Prabowo *et al.,* 2012)
Shoulders width	SHW	The greatest transverse width through the shoulders in between both *tuber humerous* (Figure 1a purple line color)	(Musa *et al.,* 2021)
Chest width	CHW	Measured diagonally as the distance between the top of the front legs inside part (Figure 1b red line color)	(ICAR, 2022)
Loin width	LNW	The distance between both lateral sides of *lumbar vertebrae* in the center area (Figure 1a dark blue line color)	(Alassane *et al.,* 2018)
Rump width	RMW	The size between the outermost points of the hip (*tuber coxae*) to the back perpendicularly (Figure 1a gold line color)	(Gruber *et al.,* 2018)
Thurl width	TLW	Distance between the lateral surfaces of the *trochanters* (Figure 1a light blue line color)	(Vernooij *et al.,* 2020)
Tail-head width	THW	Breadth transverse in the area edge posterior of the *sacrum* (Figure 1a dark green line color)	(Prabowo *et al.,* 2012)
Pins width	PNW	Distance between dorsal tops of *tuber ischia* (Figure 1a pink line color)	(Gruber *et al.,* 2018)
Rear udder width	RUW	Measured as the udder width at the point where the rear udder is attached to the body (Figure 1c yellow line color)	(Bretschneider *et al.,* 2015)
Teat back-view width	TBW	The distance between teats from the rear-view (Figure 1c grey line color)	(Alimzhanova *et al.,* 2018)
Teat width	TTW	The front teat midpoint diameter (Figure 1b brown line color)	(Strapák *et al.,* 2017)

understanding, the mathematical model of PCA is given as follows:

$y = \beta_0 + Z\beta$ (Reris & Brooks, 2015)

where, y is the dependent variable, β_0 is the intercept, and β is the coefficient of Z.

In the meantime, the mathematical equation of Pearson's correlation (1) and regression (2) are described as follows:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (1)$$ (Okwonu *et al.*, 2020)

$$\hat{y} = \beta_0 + \beta_1 x_i + \cdots + \beta_k x_k + e_i \quad (2)$$ (Kang & Zhao, 2020)

with $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$, and $\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$, are the means of the sample. Then, $\hat{y}$ is the predicted value β_0 is the intercept, β_1 is the slope, e_i is a mark of i-th residual.

RESULTS

Since the collection process of evidence of dairy cattle body width was accomplished, those data were tabulated in Table 2 on the need to present the descriptive analysis. Afterward, the output of the descriptive analysis was shown in Table 2 circumstantially, and advanced information in Figure 2a Box-plot of dairy cattle body width also. The number of variables PCA analyzes was also figured out in Figure 2b.

The overall Kaiser-Meyer-Olkin (KMO) score brings in by this study is 0.74 in the number, along with the p-value of Bartlett's test of sphericity $p<0.0001$ in the amount a number as well. Therefore, these founded are under the condition of applying PCA (Carillo *et al.*, 2019; Firdaus *et al.*, 2021). Broadly, the product of KMO and Bartlett's test of sphericity is conferred in Table 3, respectively.

The eigenvector and eigenvalue produced in this analysis were expressed in Table 4 and Table 5 independently. The produced eigenvector is used as coefficient factors to create the regression function of the dairy cattle body width. Separately, the eigenvalue will capture the capability number of the variances to explain the model that has been established using the eigenvector. However, the generated eigenvector is well-suited to be continued for loading factor analysis for dimensional reduction of the body width variables of dairy cattle, as shown in Table 6. To establish the regression model of dairy cattle body width, refer to the loading factors in Table 6 as coefficients. The continued linear equation is the regression model as a product of that analysis:

$PC_1 = 0.325 \log(x_2) + 0.246 \log(x_3) + 0.380 \log(x_4) + 0.534 \log(x_5) + 0.544 \log(x_6) + 0.250 \log(x_8) + 0.192 \log(x_9)$

$PC_2 = 0.180 \log(x_1) + 0.224 \log(x_2) + 0.870 \log(x_3) - 0.310 \log(x_4) - 0.108 \log(x_5) - 0.220 \log(x_6)$

$PC_3 = 0.294 \log(x_1) + 0.715 \log(x_2) - 0.396(x_3) - 0.404 \log(x_4) + 0.161 \log(x_5) - 0.101 \log(x_8) - 0.208(x_9)$

$PC_{1,2 \text{ or } 3}$ is principal component number 1, 2, or 3; x_1 is NCW; x_2 is SHW; x_3 is CHW; x_4 is LNW; x_5 is RMW; x_6 is TLW; x_8 is PNW; and x_9 is RUW for the last.

The composite of those three principal components already has a capacity of 79.05% to explain the cumulative proportion of the total variances. Nevertheless, only PC_1 and PC_2 have potency for explaining the total variances higher than 10%, and PC_3 is excluded; all those data are comprehensively figured out in Table 5 and PCA Scree-plot in Figure 2c disjunctively. Nevertheless, again, PC_1 is the highest faculty for a representative of the total variances as significant as 55.05% in proportion. The rationale is that the combination of SHW, CHW, LNW, RMW, TLW, PNW, and RUW is the most crucial

Table 2. Descriptive statistic of dairy cattle body width

Body width	Min	1st quartile	Median	Mean		3rd quartile	Max
				Statistic	St. error		
NCW (cm)	11.40	13.90	14.90	15.20	0.17	16.30	21.50
SHW (cm)	32.00	38.70	41.20	40.98	0.34	42.90	51.30
CHW (cm)	7.40	15.70	17.70	18.41	0.37	20.70	29.80
LNW (cm)	28.10	35.20	37.80	37.74	0.35	40.20	46.90
RMW (cm)	36.10	42.70	45.80	45.94	0.40	49.10	59.40
TLW (cm)	35.60	42.40	45.30	45.69	0.41	48.70	60.50
THW (cm)	6.87	7.66	7.97	8.33	0.11	8.59	13.36
PNW (cm)	10.60	13.70	16.10	16.10	0.27	18.10	25.60
RUW (cm)	7.91	11.50	13.08	13.40	0.26	14.80	22.54
TBW (cm)	2.84	3.82	4.48	4.80	0.13	5.29	12.13
TTW (cm)	1.31	2.14	2.29	2.29	0.03	2.41	3.36
MYT (kg)	1789	2314	2538	2556	29.96	2729	3673
MYS (kg)	1985	2263	2448	2482	27.17	2646	3357
MYM (kg)	2105	2551	2764	2809	33.77	3043	3853

Note: NCW= Neck width; SHW= Shoulders width; CHW= Chest width; LNW= Loin width; RMW= Rump width; TLW= Thurl width; THW= Tail-head width; PNW= Pins width; RUW= Rear udder width; TBW= Teat back-view width; TTW= Teat width; MYT= milk yield test-day; MYS= milk yield standardized at 305 d MYM= total milk yield of the mature equivalent.

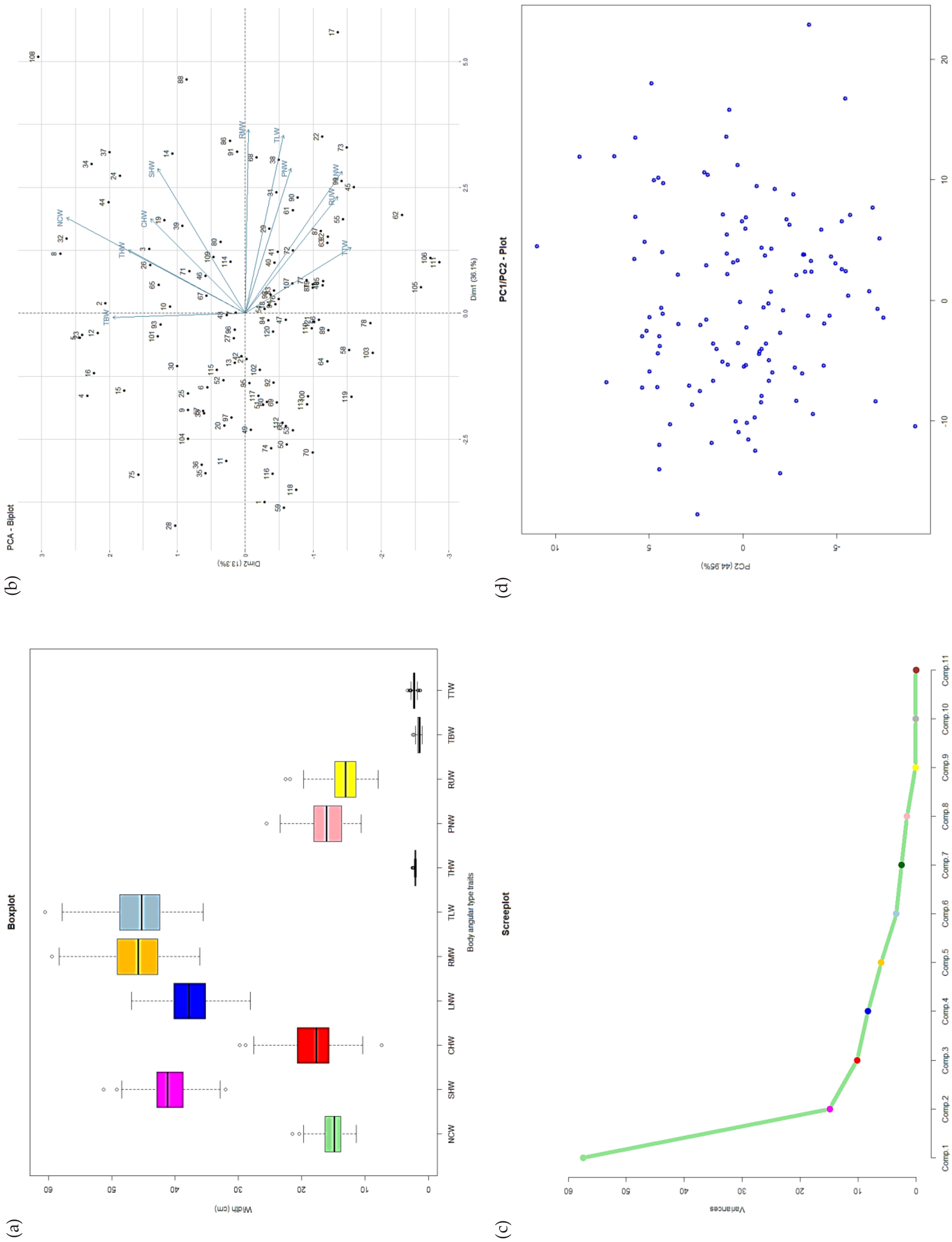

Figure 2. Dairy cattle body width. [a] Box-plot (NCW= Neck width; SHW= Shoulders width; CHW= Chest width; LNW= Loin width; RMW= Rump width; TLW= Thurl width; THW= Tail-head width; PNW= Pins width; RUW= Rear udder width; TBW= Teat back-view width; TTW= Teat width), [b] PCA biplot (dim= dimension), [c] Scree-plot (comp= component), and [d] PC1/PC2-plot (PC= principal component).

Table 3. The Kaiser-Meyer-Olkin (KMO) and Bartlett's test of dairy cattle body width

Test type	Score										
Kaiser-Meyer-Olkin factor adequacy (Overall MSA)	0.74										
MSA for each item:	NCW	SHW	CHW	LNW	RMW	TLW	THW	PNW	RUW	TBW	TTW
	0.55	0.82	0.89	0.8	0.77	0.77	0.57	0.80	0.79	0.28	0.67
Bartlett’s test of sphericity	Chi-squared	513.83									
	df	55									
	p-value	0									

Note: NCW= Neck width; SHW= Shoulders width; CHW= Chest width; LNW= Loin width; RMW= Rump width; TLW= Thurl width; THW= Tail-head width; PNW= Pins width; RUW= Rear udder width; TBW= Teat back-view width; TTW= Teat width; MSA= Measure of sampling adequacy; df= degrees of freedom.

Table 4. Eigenvector of the principal component of dairy cattle body width

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8	PC_9	PC_{10}	PC_{11}
NCW	0.0887	0.1802	0.2942	-0.0065	-0.0218	0.1139	0.2881	-0.8806	0.0000	-0.0182	-0.0272
SHW	0.3245	0.2238	0.7153	-0.0874	0.4714	-0.0016	-0.2445	0.2253	-0.0058	0.0061	0.0055
CHW	0.2464	0.8697	-0.3956	0.1400	-0.0212	-0.0499	-0.0306	0.0535	0.0106	0.0001	0.0013
LNW	0.3804	-0.3104	-0.4036	0.3540	0.6344	0.1829	0.1529	-0.1040	-0.0121	-0.0195	-0.0084
RMW	0.5344	-0.1077	0.1614	0.0829	-0.3590	-0.2316	0.6419	0.2734	0.0002	0.0232	0.0051
TLW	0.5444	-0.2199	-0.0522	0.1354	-0.4223	-0.0014	-0.6422	-0.2079	-0.0026	-0.0105	-0.0091
THW	0.0040	-0.0003	0.0019	0.0062	-0.0229	0.0028	0.0027	-0.0258	-0.0550	-0.1249	0.9903
PNW	0.2499	0.0201	-0.1005	-0.6308	-0.0556	0.7110	0.0765	0.1183	-0.0147	0.0181	0.0053
RUW	0.1920	-0.0651	-0.2085	-0.6567	0.2528	-0.6257	-0.0490	-0.1621	0.0049	0.0025	0.0025
TBW	-0.0009	0.0101	0.0057	-0.0156	-0.0152	-0.0091	0.0106	0.0279	-0.5429	-0.8281	-0.1339
TTW	0.0091	-0.0073	0.0072	-0.0133	-0.0009	0.0137	0.0075	0.0182	0.8377	-0.5449	-0.0218

Note: NCW= Neck width; SHW= Shoulders width; CHW= Chest width; LNW= Loin width; RMW= Rump width; TLW= Thurl width; THW= Tail-head width; PNW= Pins width; RUW= Rear udder width; TBW= Teat back-view width; TTW= Teat width; PC= principal component.

Table 5. Eigenvalue of the principal component (PC) of dairy cattle body width

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8	PC_9	PC_{10}	PC_{11}
Standard deviation	7.5811	3.8591	3.1866	2.8797	2.4498	1.8402	1.5788	1.2473	0.2896	0.2207	0.1115
Proportion of variance	0.5505	0.1427	0.0973	0.0794	0.0575	0.0324	0.0239	0.0239	0.0008	0.00047	0.0001
Cumulative proportion	0.5505	0.6932	0.7905	0.8699	0.9274	0.9598	0.9837	0.9837	0.9994	0.9999	1.0000

variable in the dairy cattle body width compared to another combination. In the discussion chapter, those variables will be put as the highlight spot.

The phenotypic correlation among dairy cattle body width is displayed in Table 7 in detail. The relationship between dairy cattle body width linear type traits is dominantly in the situation positive score. The highest relationship is grabbed between RMW and TLW, followed by LNW and RMW, and SHW and RMW consecutively. Additionally, the lowest relationship is held between THW and RUW. Later, Pearson’s correlation and regression stepwise method were executed, and the output of body width with a weightier association with the milk yields could be identified clearly. The rear udder width (RUW) has the most remarkable correlation than the other traits, followed by the teat back-view width (TBW), next by the width of the pins (PNW), continued by the rump width (RMW), and so forth in series like described in Table 7 in detail. The regression analysis stepwise method also suggested the RUW and TBW for constructing the linear mathematical model for predicting the milk yields from a cow, as expressed in Table 8 beneath likewise. The explicit linear model of body width linear type traits for the interval method’s total milk yield test day is presented as follows:

$MYT_{1st} = 1947.989 + 45.344\ (x_9)$

$MYT_{2nd} = 1401.472 + 43.445(x_9) + 372.987(x_{10})$

which, to total milk yield standardized 305-d formula is followed:

$MYS_{1st} = 1817.752 + 49.573(x_9)$

$MYS_{2nd} = 1290.773 + 47.742(x_9) + 359.652(x_{10})$

eventually, the total milk yield of the mature equivalent is described as:

$MYM_{1st} = 2220.369 + 43.947(x_9)$

$MYM_{2nd} = 1539.423 + 41.581(x_9) + 464.731(x_{10})$

MYT_{1st} is the first formula of the interval method’s total milk yield test day, MYT_{2nd} is the second formula of the interval method’s total milk yield test day. Meanwhile, MYS_{1st} is the first formula of total milk yield

Table 6. Loading factors of the principal component of dairy cattle body width

	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8	PC_9	PC_{10}	PC_{11}
NCW		0.180	0.294			0.114	0.288	0.881			
SHW	0.325	0.224	0.715		-0.471		-0.245	-0.225			
CHW	0.246	0.870	-0.396	-0.140							
LNW	0.380	-0.31	-0.404	-0.354	-0.634	0.183	0.153	-0.104			
RMW	0.534	-0.108	0.161		0.359	-0.232	0.642	0.273			
TLW	0.544	-0.22		-0.135	0.422		-0.642	-0.208			
THW										-0.125	0.990
PNW	0.250		-0.101	0.631		0.711		0.118			
RUW	0.192		-0.208	0.657	-0.253	-0.626		-0.162			
TBW									-0.543	-0.828	-0.134
TTW									0.838	-0.545	

Note: NCW= Neck width; SHW= Shoulders width; CHW= Chest width; LNW= Loin width; RMW= Rump width; TLW= Thurl width; THW= Tail-head width; PNW= Pins width; RUW= Rear udder width; TBW= Teat back-view width; TTW= Teat width; PC= principal component.

Table 7. Phenotypic correlation of dairy cattle body width to milk yields

Corr.	NCW	SHW	CHW	LNW	RMW	TLW	THW	PNW	RUW	TBW	TTW	MYT	MYS	MYM
NCW	1.000													
SHW	0.577**	1.000												
CHW	0.311**	0.307**	1.000											
LNW	0.017	0.344**	0.207*	1.000										
RMW	0.375**	0.590**	0.321**	0.673**	1.000									
TLW	0.234**	0.494**	0.292**	0.204*	0.863**	1.000								
THW	0.281**	0.153	0.100	0.363**	0.235**	0.256**	1.000							
PNW	0.231*	0.356**	0.279**	0.366**	0.525**	0.533**	0.073	1.000						
RUW	0.025	0.249**	0.176	-0.201*	0.407**	0.402**	0.011	0.570**	1.000					
TBW	0.019	0.019	0.077	0.152	0.019	-0.061	0.125	0.073	0.056	1.000				
TTW	0.068	0.186*	-0.009	0.147	0.243**	0.214*	0.007	0.267**	0.159	-0.204*	1.000			
MYT	0.101	0.242**	0.104	0.147	0.295**	0.204*	0.041	0.342**	0.390**	0.312**	0.085	1.000		
MYS	0.095	0.268**	0.139	0.173	0.337**	0.247**	-0.025	0.364**	0.470**	0.334**	0.17	0.903**	1.000	
MYM	0.007	0.133	0.075	0.09	0.230*	0.142	-0.069	0.177	0.335**	0.339**	0.103	0.733**	0.851**	1.000

Note: ** Correlation is significant at the 0.01 level (2-tailed).* Correlation is significant at the 0.05 level (2-tailed). NCW= Neck width; SHW= Shoulders width; CHW= Chest width; LNW= Loin width; RMW= Rump width; TLW= Thurl width; THW= Tail-head width; PNW= Pins width; RUW= Rear udder width; TBW= Teat back-view width; TTW= Teat width; MYT= milk yield test-day; MYS= milk yield standardized at 305 d; MYM= total milk yield of the mature equivalent.

Table 8. The regression coefficient of body width to milk yields

Model		MYT		MYS		MYM	
		β	Adjusted R square	β	Adjusted R square	β	Adjusted R square
1	Intercept	1.947.989	0.145**	1.817.752	0.214**	2.220.369	0.105**
	RUW	45.344		49.573		43.947	
2	Intercept	1.401.472	0.223**	1.290.773	0.304**	1.539.423	0.464**
	RUW	43.445		47.742		41.581	
	TBW	372.987		359.652		464.731	

Note: **p-value<0.01. RUW= Rear udder width; TBW= Teat back-view width; MYT= milk yield test-day; MYS= milk yield standardized at 305 d; MYM= total milk yield of the mature equivalent.

standardized at 305 d, MYS_{2nd} is the second formula of overall milk yield standardized at 305 d. Moreover, MYM_{1st} is the first formula for the total milk yield of the mature equivalent, MYM_{2nd} is the second formula for the aggregate milk yield of the mature equal. In addition, x_9 is the RUW, and x_{10} is the TBW, respectively. The MYM_{2nd} possessed the highest determination coefficient of those regression models. Oppositely, MYM_{1st} was the lowest. Those highest scores were earned when the RUW and TBW worked together. Nevertheless, at the time, merely a single trait was used as a factor to predict the milk yields, the RUW linear type was pinpointed as the best trait to do that job, mainly to estimate milk yield standardized at 305 days.

DISCUSSION

In the contingency for determining the normality of the data, the comparative study is essential to apply immediately. To do this, the following pieces of literature are boundary scores for each variable of dairy cattle body width, which have been done by other investigators accordingly. Neck width in Bali cattle is 20.10 cm (Sampurna *et al.*, 2014) and 14-34 cm in Simmental Ongole crossbreed (Prabowo *et al.*, 2012). On another topic, in terms of the design of self-locking head rail for mature cows, the span must be 18 cm (Endres *et al.*, 2005). Shoulders width in the 36-53 cm range from Pallaresa cows breed (Pares-Casanova *et al.*, 2013). Meanwhile, the chest width is 20-38 cm (Hakim *et al.*, 2020). Then, the loin width is 31-34 cm (Babich *et al.*, 2016). The rump width is 40-56 cm (Slimene *et al.*, 2020). Thurl width is in the range of 40-56 cm (Slimene *et al.*, 2020), 41-54 cm (Houssou *et al.*, 2023), and 37 cm in Hanwoo cattle average (Naserkheil *et al.*, 2020). The rear udder width is 15-18 cm (Bretschneider *et al.*, 2015). Pin width is 14-21 cm (Tőzsér *et al.*, 2022). The Teat back-view width range is 2.27-9.97 cm, whereas the teat width is 1.8-2.9 cm (Bobić *et al.*, 2014). After this, Holstein's average daily milk yield in Indonesia is 10.4±5.19 kg/day (Mariana *et al.*, 2020). Based upon all those references mentioned before and then compared with the found in this investigation is considered standard data. However, the variances are in the wide range, which might be caused by unclassified of the sample.

Deliberate discussion would be initiated with the shoulders width (SHW) variable as a topic. Shoulder width is strongly correlated with the live weight in Belgian Blue calf (Tuska *et al.*, 2022) and in various breeds of bulls (Musa *et al.*, 2021; Wnek *et al.*, 2019). Thus, the SHW is an essential factor in establishing a model of feedlot evaluation criteria (Aytekin *et al.*, 2018). The newest papers on milk yield could be found in goat and buffalo species. For instance, the SHW is significantly correlated with the milk yield in Egyptian Buffaloes (Rohayem *et al.*, 2019). In ad interim, on the Kilis goat breeds, the SHW also significantly correlates with milk yield (Tilki & Keskin, 2021). Harmonically, the PCA analysis output of the current investigation is pointed out this trait as a pivotal factor in building the first model of the principal component. The correlation analysis also indicated a significant correlation between milk yield test day and standardized milk yield 305 days, although insignificant with the total milk yield of mature equivalent.

It was continued with the chest width (CHW) parameter as a subject to discuss. The lactation period significantly influences this trait (Marinov *et al.*, 2015). Afterward, this trait substantially correlates with the milk yield trait (Soni *et al.*, 2020) and has a robust genetic relationship with the loin strength but a low connection with the milk yield (Xue *et al.*, 2022). Another stated that this trait is also related to the dairy strength trait (Manafiazar *et al.*, 2016). Besides that, the combination of the chest's width and the body's depth significantly affected longevity (Török *et al.*, 2021). Parallelly, the PCA output showed that this trait was an essential characteristic in dairy cattle body width despite being designated as an insignificant factor when linked to milk yield by correlation analysis.

The ensuing variable that would be elaborated bodily is the width of the loin (LNW) trait topic. This trait is related to muscular development in the Bon cattle breed in Colombia (Ríos *et al.*, 2022). Furthermore, this trait is essential to reproduction performance and milk yield in Brazilian buffalo (Araújo de Melo *et al.*, 2020). Afterward, the loin width significantly correlates with the chest girth and pin width linear type traits (Nikitović *et al.*, 2022). The present investigation result classified this trait as a critical component in dairy cattle body width by PCA, even though insignificant correlated to milk yield. It was disqualified as a predictor factor to milk yield by correlation and regression analysis stepwise method.

Due to the result of this investigation, the phenotypic correlation between rump width to thurl width is the highest one, as big as 86.3%, and then the discussion works simultaneously. The subject of rump width is the parameter investigated, figured with some works of literature is founded. The stage of lactation has a significant relationship to the rump width (Güler *et al.*, 2019; Khan & Khan, 2015). The width of the rump also positively correlates to age and parity (Shahid *et al.*, 2022). This trait significantly correlates positively with milk yield, especially in the early lactation period (Soni *et al.*, 2020). The RMW trait also has a positive phenotypic correlation to milk yield, but the genetic correlation is negative (Ermetin & Dağ, 2021). Others claimed this trait related to milk yield negatively despite being very low (Bitaraf Sani *et al.*, 2022). In turn, this trait is unrelated to the lactation persistency level in Polish Holstein Friesian (Otwinowska-Mindur *et al.*, 2016). Besides, this trait has a high heritability score and moderately correlates to longevity (Kern *et al.*, 2015). In addition, the rump angle compared to the rump width affects the more fabulous parturition course (Sawa *et al.*, 2013). The succeeding trait is thurl width, which correlates considerably positively with the daily milk yield in Sahiwal breed cattle (Khan & Khan, 2016). This trait significantly relates to living weight and chest width (Slimene *et al.*, 2020). Therefore, the thurl width is vital in examining the carcass quality of Tazegzawt sheep in Algeria (El-Bouyahiaoui *et al.*, 2021). Diverse perspective, this trait has a heritability score of 0.13 (Naserkheil *et al.*, 2020). It is connected with the fertility level in dairy cows because it also affects the Feto-pelvic disproportion (Gehrke *et al.*, 2013). It could be resumed that RMW and TLW traits are closer to the body weight characteristics. Nevertheless, the current findings indicated that these traits are notable as linear type trait in dairy cattle, and it has a significant positive relationship with the milk yield.

Following RMW and TLW, the variable of pin width (PNW), rear udder width (RUW), and teat back view width (TBW) are undertaken concurrently as well. The width of the chest, thurl, and udder were affected significantly by the classification of age, herd, lactation stage, and parity, respectively (Khan & Khan, 2015). In addition, all udder traits measured had a significant correlation from low to moderate with milk yield (Basavaraj *et al.,* 2020). The udder width has a strong positive correlation with thurl width, so the construction is that cows with wider bases have wider udders than narrow ones (Bradford, 2013). Thus, the portion of the rear udder has a link with the milk yield (Alimzhanova *et al.,* 2018). Moreover, the rear udder width heritability score is 0.19 significantly but insignificant related to mastitis (Zavadilová *et al.,* 2020). In addition, rear udder width is mainly associated with the calving interval and service per conception (Gaviria & Zuluaga, 2014). Meanwhile, the pin width (PNW) trait correlates poorly with the milk yield standardized 305d (Xue *et al.,* 2022). The PNW traits in dairy cattle have a moderate heritability score (Wongpom *et al.,* 2013) and are crucial factors in Hungarian Holstein dairy cattle related to longevity (Török *et al.,* 2021). Another point of view, this trait has a significant connection with the residual feed intake (RFI) level in dairy cattle (Manafiazar *et al.,* 2016). Despite being genetically uncorrelated, it is also linked with a cow's body condition score (Gruber *et al.,* 2018; Junior *et al.,* 2021). Pin width work with the hip bone improves the calving course (Tőzsér *et al.,* 2022). Afterward, the teat back views width (TBW), or teat placement, was a noticeable characteristic in the dairy cattle selection program (Yeman *et al.,* 2015) even though the heritability score was almost none (Ermetin & Dağ, 2021). Rear teat placement or the span between the hind teat increased the hazard ratio (HR) of the risk of culling (Grzesiak *et al.,* 2022). In-line evidence also found in the current study indicated that these three traits are connected with the milk yield capacity in dairy cattle. It is shown by the PCA output involved the RUW and PNW traits as factors to compose the first principal component but eliminated the TBW. However, the TBW trait significantly correlated to the milk yield as the second highest from all body widths.

Ancillary brightness, neck width (NCW), or neck thickness in dairy cattle was commonly used as a masculinity criterion in dairy judging. Generally, the neck area in the Holstein breed is broader and thicker than the local breed (Diwan, 2017). Therefore, the best neck width in the score is moderate, not too thick or thin. However, greater neck thickness is better for beef cattle because the skinfold thickness in the neck area is related to the body condition score (BCS) (Zhang *et al.,* 2019). In harmonic, tail head width (THW) or tail root is also related to BCS, influencing milk yield and reproductive performance (Abdel-Lattif, 2022). Therefore, both of these traits indirectly influenced the milk yield. In concert, the output of the current exploration indicated a similar symptom underlying the PCA, correlation, and regression analysis output, coincide designated the NCW and THW as unimportant body width parts to milk yield potency.

CONCLUSION

The possibility of illation able to be attracted from the result and discussion was pointed out the shoulder width (SHW), chest width (CHW), loin width (LNW), rump width (RMW), thurl width (TLW), pin width (PNW), and rear udder width (RUW) as crucial traits in the dairy cattle body width. After that, the rear udder width (RUW) and teat back view width (TBW) as the most significant association with milk yields. Due to the TBW trait being eliminated from the substantial components in dairy cattle body width accordingly, the TBW was replaced with PNW. Ultimately, in the contemplation of the application selection program in dairy cattle was recommended to emphasize the RUW trait as the initial priority and PNW trait as the second priority. However, the RUW trait is suitable for the selection scheme of the cattle that would enter the first period of lactation and onwards, while the PNW is fit for calf and heifer as the final recommendation. Enforcing the result of current exploration in the dairy cattle selection program is expected to improve the milk yield capacity of each cow, mainly in smallholder dairy farming.

CONFLICT OF INTEREST

All of the scriptwriters certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript. This paper is summarized from a piece of Sigid PRABOWO's Ph.D. thesis.

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