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The Using of Conspicuous of Body Angularities Type Traits to Milk Yields as Dairy Cattle Selection Preferences

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Abstract: Numerous papers have been published on body cattle angularities subject in a few backward decades. However, the preeminent body angularities to the milk yield are unstipulated assertively. Hence, the current odyssey was to determine the transcendence body angular of dairy cattle interrelated with the milk yield for selection preferences. In total, 121 head of Holstein cows and seven reputable cattle body angularities were engaged as samples and measured variables for investigation. The software R version 4.2.1 and RStudio was operated simultaneously to facilitate statistical analysis. Later, the principal components (PCA), correlation, and regression analysis were carried out in that order. The PCA specified the thurl angle (TLA), hock side view angle (HSA), hock back views angle (HBA), and fore udder angle (FUA) as crucial factors of body cattle angularities. Then, the correlation analysis appointed HBA and TLA in series as the best trait related to milk yields. The regression analysis was merely entrusted to the HBA as a factor for prognosticating milk yield potency. Thus, the upshot of the ongoing exploration prompted the HBA as the main priority for milk yield selection preferences, followed by TLA. Both were usable on the calf, heifer, and cow selection scheme but should be enforced regularly.

Keywords: Body curve, Body measurement, Correlation, Holstein cows, Principal component.

Introduction

Animal bodies are unique due to particular characteristics of each individual and distinctively one with the other despite being in one species. The particular investigation in this subject is well-known as Fibonacci numbers, Fibonacci sequence, Fibonacci spiral, growth patterns, and Fibonacci ratio or golden ratio (Kumari, 2016; Nematollahi *et al.*, 2020). Specifically, the Fibonacci ratio also discusses the body angularities established in nature. For instance, the golden angle is vital in hip and pelvis studies (Higuchi & Daisaka, 2021). Parallel with that issue, investigating the body angular in dairy cattle becomes an urgent topic.

Backward several decades, the study of the subject body angular of cattle was done by various investigators. They inventoried some body angular with indications associated with the expected production traits, such as the rib angle (José *et al*., 2021), the rump angle (Wall *et al*., 2005), the thurl angle or thurl position (Short *et al*., 1991), the hock back-view angle, the hock side view angle (Capion *et al*., 2008), the hoof angle (Hahn *et al*., 1984), and the fore udder attachment angle (Ekman *et al*., 2018). However, the seven body angular traits addressed previously, until hitherto, are never before determined in the foremost apparent correlation to milk yield capacity. Moreover, these noticed characteristics are overloaded, so implementing the dairy cattle selection program requires more effort, energy, time, and resources. Therefore, the magnitude number of traits is a burden, particularly for smallholder dairy farmers, to execute the selection program.

The principal component analysis (PCA) is a popular analytic instrument that uses complex mathematical concepts to minimize the dimensionality of enormous datasets (Salem & Hussein, 2019). This technique either has an elevation capacity for data interpretability or minimizes data loss simultaneously (Jolliffe & Cadima, 2016). The application of the PCA technique in dairy cattle science is abundant and familiar, like a paper published in Brazil about the evaluation of milk production and quality (Abreu *et al*., 2020). Furthermore, Pearson's correlation is widely known as a tool for examining the association level between the dependent and independent factors. In the meantime, the regression analysis can establish a linear model for predicting the dependent factor from the independent factor (Nelsen, 1998). Therefore, the combination of PCA and correlation regression analysis is expected to respond to the challenges mentioned in the current investigation. Eventually, to crack those issues, the present study was aimed at dimensional reduction of the body angular traits with the principal component analysis and identifying the most prominent body angular to milk yield with Pearson's correlation regression analysis.

Materials & Methods

Data collection

To collect the data, 121 Holstein cows were used as the sample. Entire cows are maintained in Indonesian commercial dairy farms with a 2-6 years old span and a lactation period. The dairy cattle body angular traits were measured using a digital protractor gauge in degrees scale (^{0}) with a precision of 0.05 mm. Itemized body angular characteristics were presented in table (1) and illustrated in fig. (1) independently.

Statistical analysis

Entire data were analyzed statistically using instrument R version 4.2.1 with RStudio software concurrently. Principal component analysis, correlation analysis, and regression analysis were carried out in turn, and each analysis method's mathematical equation was as follows:

$$PC_i = \hat{\beta}_1 x + \hat{\beta}_0 \qquad \text{(Xu, 2014)}$$

PC_i is the principal component i^{-th}, β_i is the coefficients, and the x is the independent variable. While Pearson's product-moment correlation (1) and regression (2) are illustrated in the formula next:

$$r = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{(N\sum x^2) - (\sum x)^2 (N\sum y^2) - (\sum y)^2}}$$

$$\hat{Y} = \beta_0 + \beta_1 x_1 + \beta_m x_m$$

(Oknowu *et al.,* 2020; Slinker & Glantz, 2008)

With r is Pearson's product-moment correlation coefficient, N is the number of pairs value, $\sum xy$ is the product summary of x and y, $\sum x$ is the value summary of x, and $\sum y$ is the value summary of y. Particularly, the stepwise method is applied for regression analysis. While $\hat{Y}$ is the estimated score, β_0 is the intercept, x_1 to x_m is the value of a variable.

Furthermore, information on milk yield was gathered using an interval test day (Sargent *et al*., 1968). The mathematical formula of the test interval day method is as follows:

$$MYT = I_0M_1 + I_1\frac{M_1 + M_2}{2} + \dots + I_{n-1}\frac{M_{n-1} + M_n}{2} + I_nM_n$$

(Gantner *et al*., 2009)

Table (1): Explication and encodes of dairy cattle body angular.

Body angular	Code	Explication	References
Rib angle	RBA	The generated angle between the slats' slope and the Lumbar Vertebrae's horizontal position (light green line in Fig. 1a)	(José *et al*., 2021)
Rump angle	RMA	The slope developed between the hip and the pin in the quadrant perspective, and the hip is the pivot point (purple line in Fig. 1a)	(Shapiro & Swanson, 1991)
Thurl angle	TLA	The triangle corner is constructed by a body part's hip, trochanter, and pin (red line in Fig. 1a)	(Short *et al*., 1991)
Hock side view angle	HSA	The corner is constructed on the anterior hocks of the hind leg from a lateral view (blue line in Fig. 1a)	(ICAR, 2022)
Hock back view angle	HBA	The corner established on the outer area of the hind leg hocks from the rear view (gold line in Fig. 1b)	(ICAR, 2022)
Hoof angle	HFA	Pointing to the triangle corner assembled by the floor horizontally, the edge of the hoof, and the hairline on the right rear hoof front region (light blue line in Fig. 1a)	(José *et al*., 2021),
Fore udder angle	FUA	Focus on the angle created by the fore ligament suspensory's attachment to the abdominal wall (dark green line in Fig. 1a)	(ICAR, 2022).

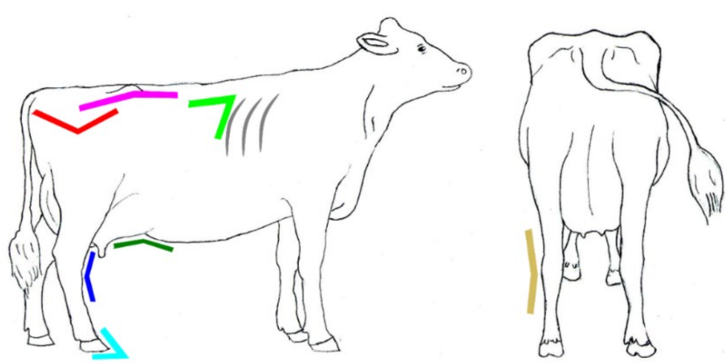

(a) (b)

Fig. (1): Body angular weighing illustration, (a) side view; RBA: -, RMA: -, TLA: -, HSA: -, HFA: -, FUA: -, and (b) back view; HBA: -.

As explained, MYT is the milk yield test day, I_0 is the interval between the first-day lactation and the first recorded day, I_1 to I_n is the interval between two recorded milk yields, and M_1 to M_n is the milk yield 24-h. Besides that, the milk yield standardized 305-d (MYS) and the milk yield mature equivalent (MYM) serially were computed likewise (Çilek & Tekin, 2006).

Results & Discussion

Total data collected in the current exploration were tabulated and descriptively described in table (2). Although the range was broader, the data mean was within the proportionate range of the other researcher's findings. A comparison study with other findings is crucial to verify the current investigation data. Various pieces of evidence related to the normal range of the cattle body angularities were uncovered, such as the rib angle (RBA) range of 52.18 ± 5.73°, the rump angle (RMA) 88.75 ± 4.31° (Hakim *et al., 2020)*, the hock side view angle (HSA) 134 - 160° (Dubey *et al*., 2014), the hoof angle (HFA) 42-45° (Hahn *et al*., 1984), 48.39° (Dubey *et al*., 2014), and 41-46° (Bretschneider *et al*., 2015), the fore udder angle (FUA) mean 138.14° (Bretschneider *et al*., 2015) and 127.38° (Dubey *et al.,* 2014). The hock back-view angle (HBA) or rear leg rearview (RLRV) cannot find the juxtaposition score. However, the current investigation means data was within other researcher findings, although the range is wider than it generally.

Table (2): Descriptive statistic of dairy cattle body angular

Body angular	Min	1st quartile	Median	Mean		3rd quartile	Max
				Statistic	St. error		
RBA (°)	34.75	49.10	54.38	54.37	0.69	58.55	72.25
RMA (°)	169.80	181.90	184.10	184.90	0.43	188.10	198.70
TLA (°)	83.65	107.60	114.05	114.66	1.10	124.65	142.25
HSA (°)	120.80	142.90	147.70	148.50	0.89	155.70	174.90
HBA (°)	142.90	161.80	167.60	166.50	0.66	172.20	178.50
HFA (°)	21.40	34.85	38.90	38.60	0.58	42.70	54.05
FUA (°)	95.55	130.75	138.10	137.67	1.40	147.20	174.65
MYT (kg)	1789.00	2314.00	2538.00	2556.00	29.96	2729.00	3673.00
MYS (kg)	1985.00	2263.00	2448.00	2482.00	27.17	2646.00	3357.00
MYM (kg)	2105.00	2551.00	2764.00	2809.00	33.77	3043.00	3853.00

RBA :rib angle ;RMA: rump angle ;TLA: thurl angle ;HSA: hock side-view angle ;HBA: hock back-view angle ; HFA: hoof angle ;FUA fore udder angle; MYT: milk yield test-day; MYS: milk yield standardized 305-d ;MYM : milk yield mature equivalent

Henceforth, inspecting the Kaiser Meyer Olkin (KMO), the Measures Sampling Adequacy (MSA), and Bartlett's test score before executing the Principal Component Analysis is an obligatory condition. The KMO-MSA scores in the current investigation were upper than 0.5 but waived the rump angle (RMA). However, the overall KMO-MSA score test was upper than 0.5 on average. Consecutively, Bartlett's test output was less than 0.01 likewise (Table 3). The KMO-MSA and Bartlett's test scores are presented in table (3) extensively. Therefore, the current study complied with the provision to perform PCA.

Table (3): KMO-MSA and Bartlett's test of dairy cattle body angular.

Test type							Score
Kaiser-Meyer-Olkin (KMO) factor adequacy				(Overall MSA)			0.68
MSA for each item:	RBA	RMA	TLA	HSA	HBA	HFA	FUA
	0.77	0.38	0.77	0.68	0.70	0.56	0.63
Bartlett's test of sphericity	Chi-squared		116.83				
	Df		21				
	p-value		0.000				

:RBA: rib angle; RMA: rump angle; TLA: thurl angle; HSA: hock side-view angle; HBA: hock back-view angle; HFA hoof angle; FUA fore udder angle

Since the PCA was performed, the eigenvector, loading factor, and eigenvalue are essential outputs to assess. The eigenvector of the present study is provided in table (4), while the loading factor is in table (5) separately. Meanwhile, the eigenvalue was served in table (6) and fig. (2a) consecutively. Stationed upon the earned eigenvalue, the principal component 1 (PC_1) had the greatest capacity to account for total variation, even though merely 44.41%. They followed PC_2 as big as 23.13% and PC_3 as much as 11.30%. To grab greater than 70% capability to explain the total variance, PC_1 to PC_3 should be applied concurrently. However, according to those three principal components, the thurl angle (TLA), the hock side view angle (HSA), and the hock back view angle (HBA) characteristics were constantly adopted as loading factors (Table 5) to establish the principal component. This situation implied that the TLA, HSA, and HBA were essential traits in the perspective of the body angularities dimension of the dairy cattle.

The loading factor shown in table (5) could be used to construct the mathematically linear model for PCs 1 through 3. Therewithal, the developed linear equation of the body angular principal component was determined as follows:

$$\mathrm{PC}_1 = 0.436\, log(x_3) + 0.327\, log(x_4) + 0.23\, log(x_5) + 0.798\, log(x_7)$$

$$\mathrm{PC}_2 = 0.207\, log(x_1) + 0.652\, log(x_3) + 0.329\, log(x_4) + 0.252\, log(x_5) - 0.587\, log(x_7)$$

$$\mathrm{PC}_3 = 0.156\, log(x_2) - 0.577\, log(x_3) + 0.741\, log(x_4) + 0.277\, log(x_5) + 0.115\, log(x_6)$$

which is x_1: RBA; x_2: RMA; x_3: TLA; x_4: HSA; x_5: HBA; x_6: HFA; and x_7: FUA.

Passingly, table (7) completely delivered the degree of correlation between body angularities traits and milk yields. The highest significant association between body angularities was conveyed by the HBA and HSA traits positively. Adversely, the lowest was expressed between RBA and RMA but insignificant. Moreover, the negative association was submitted between the RMA to the TLA, HFA, and FUA reciprocally. Regarding the relationship to the milk yield characteristics, the HBA delivered the superlative output followed by TLA related to milk yield. However, only HBA significantly correlated with the milk yield standardized 305-d and milk yield mature equivalent, while the milk yield test day was insignificant. Thus, the HBA was preferred as the most salient trait.

Table (4): Eigenvector of the dairy cattle body angular principal component.

Traits	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7
RBA	0.0978	0.2067	-0.0031	-0.9418	-0.1908	0.1538	0.0261
RMA	-0.0479	0.0921	-0.1556	0.0276	-0.2251	-0.0442	-0.9547
TLA	0.4365	0.6519	0.5767	0.1950	0.0291	0.0984	-0.0590
HSA	0.3269	0.3295	-0.7411	0.1897	-0.0392	0.4249	0.1315
HBA	0.2304	0.2516	-0.2768	-0.0406	-0.0999	-0.8836	0.1212
HFA	0.0321	0.0839	-0.1152	-0.1852	0.9490	-0.0580	-0.2011
FUA	0.7979	-0.5874	0.0637	-0.0481	0.0006	0.0080	-0.1090

RBA :rib angle ;RMA :rump angle ;TLA: thurl angle ;HSA :hock side-view angle; HBA : hock back-view angle HFA: hoof angle ;FUA fore udder angle, PC_{1-7}: principal component 1 to7

Table (5): Loading factor of the dairy cattle body angular principal component.

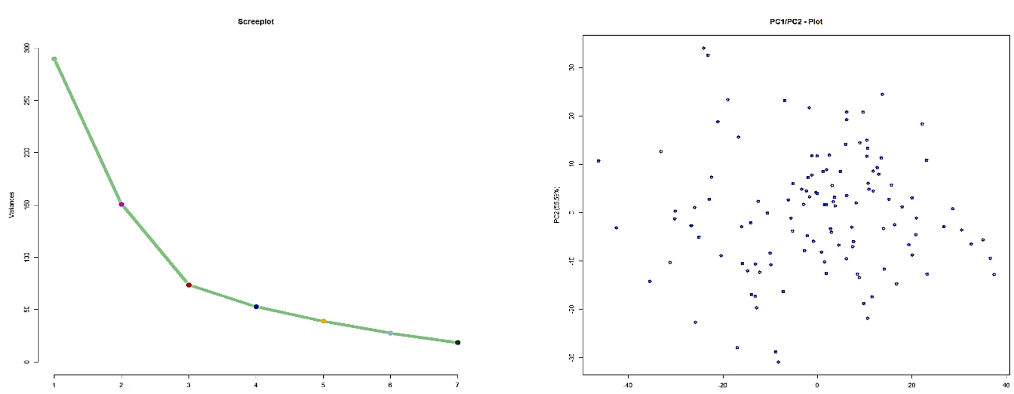
Traits	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7
RBA		0.207		0.942	0.191	0.154	
RMA			0.156		0.225		-0.955
TLA	0.436	0.652	-0.577	-0.195			
HSA	0.327	0.329	0.741	-0.190		0.425	0.132
HBA	0.230	0.252	0.277			-0.884	0.121
HFA			0.115	0.185	-0.949		-0.201
FUA	0.798	-0.587					-0.109

RBA: rib angle; RMA :rump angle ; TLA :thurl angle ;HSA :hock side-view angle; HBA; hock back-view angle HFA : hoof angle; FUA fore udder angle ;PC_{1-7}: principal component 1 to7

Table (6): Eigenvalue of the dairy cattle body angular principal component.

Level	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7
Standard deviation	16.9430	12.2268	8.5477	7.2446	6.2094	5.2243	4.2915
Proportion of Variance	0.4441	0.2313	0.1130	0.0812	0.0597	0.0422	0.0285
Cumulative Proportion	0.4441	0.6754	0.7884	0.8696	0.9293	0.9715	1.0000

PC_{1-7}: Principal component 1 to7



(a) (b)

Fig. (2): Dairy cattle body angular. (a) PCA Scree-plot, and (b) PC_1/PC_2-plot

Table (7): Phenotypic correlation matrix between dairy cattle body angular and milk yield.

Corr.	RBA	RMA	TLA	HSA	HBA	HFA	FUA	MYT	MYS	MYM
RBA	1.00									
RMA	0.03	1.00								
TLA	0.25**	-0.05	1.00							
HAS	0.17	0.14	0.38**	1.00						
HBA	0.24**	0.09	0.44**	0.55**	1.00					
HFA	0.11	-0.10	0.09	0.15	0.12	1.00				
FUA	0.06	-0.25	0.24**	0.28**	0.26**	0.01	1.00			
MYT	0.02	-0.12	0.07	0.01	0.14	0.03	-0.01	1.00		
MYS	0.04	-0.04	0.09	-0.02	0.21*	-0.02	-0.04	0.90**	1.00	
MYM	0.03	-0.01	0.11	0.09	0.23*	0.02	0.03	0.73**	0.85**	1.00

RBA :rib angle ;RMA :rump angle ;TLA :thurl angle ;HSA :hock side-view angle ;HBA :hock back-view angle ; HFA :hoof angle; FUA fore udder angle, MYT :milk yield test-day ; MYS :milk yield standardized-305 d ;MYM : milk yield mature equivalent

**Correlation is significant at the 0.01 level (2-tailed) and * Correlation is significant at the 0.05 level (2-tailed).

The output of the linear model strengthened it to predict milk yields from the regression analysis stepwise method. Correspondent to table (8), the linear regression model to predict the milk yield potency was delivered as

$$\text{MYT} = 1475.302 + 6.488(x_5)$$

while to estimate the total milk yield standardized 305-d could follow the formula next

$$\text{MYS} = 1062.035 + 8.528(x_5)$$

Finally, to compute the total milk yield of mature equivalent could follow the model below

$$\text{MYM} = 897.035 + 11.484(x_5)$$

The MYT is the equation of milk yield test day; MYS is the formula of milk yield standardized 305-d; MYM is the model of milk yield of mature equivalent; and x_5: HBA. Merely HBA trait was selected by the regression analysis stepwise method; meanwhile, the other characteristics were eliminated.

Table (8): The regression coefficient of body angular to milk yields.

Model		Milk yield-tim (MYT)		Milk yield-standardized 305d (MYS)		Milk yield-mature equivalent (MYM)	
		β	Adjusted R square	β	Adjusted R square	β	Adjusted R square
1	Intercept HBA	1475.302 6.488	0.012	1062.035 8.528	0.035*	897.035 11.484	0.042*

HBA :hock back-view angle

*p-value < 0.05

It began with the RBA feature to elaborate deeply. A shred of evidence discovered that the ribs angularity has a strong association with the body condition score (BCS) negatively, then the BCS has a moderate negative relationship to milk yield (Battagin *et al*., 2013). Therefore, this property is categorized as a milk trait (Trukhachev *et al.*, 2021) or dairy form (Bewley

& Schutz, 2008), and it has a heritability score of 0.17 with longevity (Kern *et al.*, 2015). Adversely, the current study findings showed an insignificant correlation to milk yield of this property, and it was removed as a factor to establish the first principal component model. However, the RBA has a significant association with the TLA trait

Successively discussed is the rump angle (RMA) type trait. The rump angle (RMA) with thurl position (TLA) has a high (0.65) phenotypic correlation (Špehar *et al.*, 2012). At the moment, connected with several reproductive characteristics, this trait has an insignificant expression with the first service days, nonreturn rate (Wall *et al*., 2005), days open, and times bred (Shapiro & Swanson, 1991). However, compared with the rump width, the RMA has a greater association with calving easiness (Sawa *et al*., 2013). Besides that, the more slope RMA, the longer the calving interval (Makgahlela *et al*., 2009). Afterward, either with herd life or length of productive life, this trait has a very weak correlation negatively (Vacek *et al*., 2006). From a different angle, this trait's heritability with a lifespan from all total lactation is as high as 0.31, and the average score from different breeds of cattle is 0.27 for this feature, with 0.24 from the Ireland Holstein Friesian (Gengler *et al*., 1999; Berry *et al*., 2004; Kern *et al*., 2015). Therefore, cows with a moderate score in this area are preferred (Wathes, 2022). Surprisingly, the RMA trait in the present study served a mark that was unclassified as a factor composing the first principal component of body angularities. It was also eliminated when linked to milk yield. The SNPs BTA 5 and 9 are connected to this trait (Cole *et al*., 2011).

It is continued by the thurl angle (TLA) feature. Thurl position or thurl angle is recently used to examine the dairy form and be fathomed correlated with the calving course (Lawlor et al., 2005). Thurl placement (TLA) is highly negatively correlated with the rump angle (RMA) (Junior *et al.*, 2021). After that, the TLA relates to locomotion and flexibility (Giess *et al*., 2021) because thurl placement backward dominantly is related to the defective leg structure (Godara et al., 2015). In addition, this trait has a negative genetic correlation with the reproductive tract size (Martin *et al*., 2022). Then, the TLA has a heritability score for Holstein as big as 0.22 (Junior *et al*., 2021), but another finding was merely 0.06 in Holstein (Short *et al*., 1991). Even in the Brown Swiss cattle is lower, only 0.03; this signifies the adversity when applied this trait is a selection criterion (Špehar *et al*., 2012). However, in the current findings, this trait was included as a loading factor and positioned secondly as the strongest relationship to milk yield merits. So, the TLA is classified as an important body angular trait in dairy cattle.

The next trait is encompassed in the feet and legs classification and breakdowns such as hock side view angle (HSA) or rear leg side view, hock back view angle (HBA) or rear leg rearview, and hoof angle (HFA) or foot angle (Van der Waaij *et al*., 2005). The vigorous level of the feet and legs traits is linear with age (Tapkı *et al*., 2020). Generally, feet and leg-type traits have low heritability scores (Roveglia *et al*., 2019). For instance, the rear leg set or hock side view angle (HSA) has a heritability score of as much as 0.17 in Holstein (Short *et al*., 1991), 0.12 (Chapinal *et al*., 2013), 0.075 (Toghiani, 2011), 0.16 with longevity (Kern *et al*., 2015), in Brown Swiss only 0.13 (Špehar *et al*., 2012), meanwhile in Red Angus 0.29-0.31(Giess *et al*., 2021). Afterward, the repeatability score of this trait is 0.45 (Vinson *et al*., 1982). However, the quintessential structure of the rear leg set, especially related to longevity characteristics, is recommended in the moderate score (Vacek et al., 2006). Concerning studying this trait with a genomic approach is advocated to emphasize the *ADIPOR2, INPP4A, DNMT4A, ALD1A2,* and *PCDH7* genes, respectively (Abdalla *et al*., 2021). Linearly, the current investigation has classified this trait as a factor in compiling the first principal component, even though it was disqualified in the stepwise regression analysis of milk yield.

Subsequently, the hock back-view angle (HBA) or rear leg rear view (RLRV) type trait is discussed. The HBA has the highest association with locomotion traits (Ring *et al.*, 2018). Consequently, this trait has an association with the lameness incident and somatic cell count (SCC) level in dairy cattle (Singh *et al*., 2018; Boettcher *et al.*, 1998; Chapinal *et al*., 2013). After effect, when HBA works together with the HSA traits, is given impacts longevity significantly (Török *et al*., 2021). Another disadvantage of this trait is the low phenotypic correlation with the calving interval (Gaviria & Zuluaga, 2014). However, based on pedigree, the HBA has the greatest heritability score in the feet and leg class (Xue *et al*., 2022). Genetic point of view, this trait has a heritability score of 0.09 (Short *et al*., 1991), 0.041 (Chapinal *et al*., 2013), and 0.14-0.15 in Red Angus (Giess *et al.*, 2021). However, the HBA has the greatest heritability score in the feet and leg class based on pedigree (Xu *et al*., 2022). Strangely, most farmers prefer the HSA trait to the HBA trait nowadays (Trukhachev *et al.*, 2021). Afterward, this trait's relative breeding value (RBVs) is -2.58±5.41 (Alcantara et al., 2022). The gene of *BARHL2, FBXL7*, and *LOC107132214* is applicable for the marker in the exploration of this trait (Abdalla *et al*., 2021) and mainly *MGMT* on *BTA26* SNPs (Cole *et al*., 2011). In tune, this exploration placed this trait as the most important body angular trait related to milk yield.

The hoof angle (HFA) is the next trait elaborated further. In the hoof area, between the lateral and medial section of the claws down the surface, particularly on the hind leg is uneven load distribution among the different structures of foot and leg conformation (Nuss et al., 2020). The HFA correlates with hoof lesions in the low to moderate range (Chapinal *et al*., 2013). This trait also correlates either with herd life or length of productive life but is very weak and negative (Vacek et al., 2006). Thereunto, the HFA is associated likewise with the nonreturn rate of service (Wall *et al*., 2005). The heritability score of this trait varies, like 0.11 (Short *et al*., 1991), 0.17 (Berry *et al*., 2004), 0.07 (Ring *et al*., 2018), and 0.17-0.21 (Giess *et al*., 2021). Meanwhile, in the Simmental breed, 0.11±0.06 (Xu *et al.*, 2022), and in the Red Angus breed, 0.17±0.05 (Giess *et al*., 2018). This trait has a very small heritability score with longevity (Kern *et al*., 2015). Harmonically, the milk yield is unrelated to this trait from the outcome of the current experiment.

Lastly, the fore udder angle (FUA) is taken up. The number of parities is affectless to the condition of this trait (Güler et al., 2019). Cattle originating from tropical areas is less shallow but stronger on fore udder attachment trait than those originating from temperate areas (Dahiya, 2006). Loosen of the umbilical ligament suspensory, and the fore udder attachment contribute to the higher SCC level (Němcová *et al*., 2007). It contributed as well to udder cleft dermatitis (UDC) (Ekman *et al.*, 2018), mastitis prevalence (Sørensen *et al*., 2000), and udder health (Togla *et al*., 2021). Various papers revealed FUA is an important trait related to milk yield (Đedović et al., 2020). Thus, fore udder conformation can be employed as selection criteria for milk yield betterment and minimizing SCC number (Juozaitiene *et al*., 2006). Moreover, the FUA, together with udder depth, served a combination effect on the culling risk level (Török *et al*., 2021). This trait correlates more with the lifetime relative net income (RNI) than some udder traits (Cassell *et al*., 1990). Although, cattle attributed with tenser FUA are prone to lessen pregnancy rate in the first service (Berry *et al*., 2004). Unfortunately, with all the prosperous attributes of this trait, the genetic quality of this trait in Gir dairy cattle has been un elevated from 1993 onward (Fernandes *et al*., 2019). Anterior udder attachment (AUA) significantly correlates with almost entirely udder cleft characteristics, and several SNPs like *DB-340-seq-rs208014256, Hapmap58214-rs29015775, BovineHD270000 5329,* and *BovineHD0900028603* is serviceable as a candidate gene to explore the udder conformation trait (Nazar et al., 2022). Afterward, the fore udder attachment or fore udder angle (FUA) has heritability points 0.21 (Short *et al*., 1991), 0.19 (Boettcher *et al*., 1998), 0.13 (Berry *et al*., 2004), 0.00 (Duru *et al*., 2012), 0.20 with longevity (Kern *et al*., 2015), 0.19-0.29 in Simmental breed (Xu *et al*., 2022), and 0.16 in Jersey breed (Roveglia *et al*., 2019). The FUA has a high phenotypic and genetic association with the udder depth trait (Němcová *et al*., 2011; Špehar *et al*., 2012) but a very low relationship to the milking speed (Boettcher *et al*., 1998). Ultimately, the results of a study showed considerable effects of the non-genetic factors on linear type traits (Güler *et al*., 2018). Although many papers claimed that this feature correlates with the milk yield, the current study was given evidence oppositely to other findings. However, the FUA was classified as an essential factor of body angular by principal component analysis.

Conclusions

Wrap-up of the current inquiry registered the thurl angle (TLA), hock side view angle (HSA), hock back view angle (HBA), and fore udder angle (FUA) were tabbed as key factors of dairy cattle body angularities by the PCA. Forthwith, to link with the milk yield by correlation analysis was directed to the hock back view angle (HBA) as the highest score followed by the thurl angle (TLA) as the second, both positive. Based upon that evidence, the milk yield selection program in dairy cattle underlying the body angularities could be emphasized the HBA trait as the initial priority and the TLA as the second priority. Either HBA or TLA trait is felicitous to implement simultaneously in the calf, heifer, and cow period selection program. Finally, executing a selection program with both traits is advocated to execute periodically, mainly in the calf and heifer stages.

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Contributions of authors

S. Prabowo was committed to establish the research design, data collection and analyses, writing the manuscript. Meanwhile, M. Garip was allocated to evaluate the research design, data analyses and data interpretation.

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Conflicts of Interest

The penman stated there are no conflicts of interest. This inquiry is a segment briefly of Sigid PRABOWO's Ph. D. thesis.

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استعمال زوايا الجسم العائدة لنوع السلالة والهامة لإنتاج الحليب كدليل لانتخاب ابقار الحليب

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المستخلص: سبق ان نشرت العديد من الأوراق البحثية حول موضوع زوايا جسم الأبقار خلال العقود القليلة الماضية. وعلى الرغم من ذلك، لم يتم تحديد زوايا الجسم الرئيسية التي تؤثر في إنتاجية الحليب بشكل قاطع. وبالتالي، فان الهدف من الدراسة الحالية هو تحديد زاوية الجسم الاكثر اهمية في أبقار الحليب والتي ترتبط بشكل مباشر بإنتاجية الحليب، وذلك من اجل تحديد الاختيارات المناسبة اثناء عملية الانتخاب. استخدم في هذه الدراسة 121 بقرة حلوب من سلالة الهولشتاين مع سبعة من زوايا الجسم المميزة كمتغيرات بحثية لإجراء التحليل الاحصائي لبيانات الدراسة. استخدم برنامج R الإصدار 4.2.1 بالتزامن مع RStudio ، فيما بعد، تم إجراء تحليل للمكونات الرئيسية PCA ومعاملات الارتباط والانحدار وفقا لهذا السياق. تشير النتائج الى ان الـ PCA الخاصة بزاوية الفخذ–الحوض TLA، وزاوية المنظر الجانبي لمفصل الركبة ، وزاوية المنظر الخلفي لمفصل الركبة HBA، وزاوية الارتباط الامامي للضرع FUA هي المؤشرات الاساسية الهامة لزوايا جسم الأبقار. لذا، حدد تحليل الارتباط كل من HBA و TLA باعتبارهما الصفتان الاكثر تفضيلا من حيث ارتباطهما مع انتاجية الحليب. واشار تحليل الانحدار بشكل حصري الى HBA على انه عامل اساسي يمكن الاعتماد عليه في التنبؤ بقابلية إنتاج الحليب. وبالتالي، فإن نتائج هذا الدراسة تؤكد بان هناك اولوية رئيسية لاختيار الـ HBA في الانتخاب لإنتاجية الحليب، ثم تليها TLA. ويمكن استخدام كلا الصفتين في برامجيات الانتخاب الخاصة بالعجول والاباكير والأبقار، على ان يتم تطبيق هذه البرامج بشكل منتظم.

الكلمات المفتاحية :منحنى الجسم ، قياس الجسم ، الارتباط ، أبقار هولشتاين ، المكون الأساسي.