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PRINCIPAL COMPONENT ANALYSIS (PCA) OF BODY MEASUREMENTS AND BODY INDICES IN THE PASUNDAN COWS

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Abstract

Principal component analysis (PCA) is important for describing the body conformation in livestock. Total of seven body measurements and thirteen body indices parameters from 144 heads of Pasundan cow (average 3 years age) at West Java Province of Indonesia were used in this study for PCA analysis. The body measurements in this study consisted of withers height (WH), body length (BL), chest girth (CG), chest width (CW), rump height (RH), rump width (RW) and rump length (RL). Therefore the body indices in this study consisted of height slope (HS), width slope (WS), body index (BI), area index (AI), rump length index (RLI), conformation index (CI), length index (LI), body ratio (BR), proportionality (Pr), thoracic development (TD), pelvic index (PI), transverse pelvic (TP) and longitudinal pelvic (LP). The highest of Pearson's coefficient of correlations (r) value in body measurements was showed between WH and RH (0.93). Hence, the highest r value in body indices was showed between WS and TP (0.86). The PCA for body measurements and body measurements was revealed two factors of PC1 (WH, BL, RH) and PC2 (CG, CW, RW, RL) that explained about 73.36% of the total variation. Meanwhile, the PCA for body indices was revealed four factors of PC1 (BI, AI, RLI, LI, Pr, LP), PC2 (CI, TD), PC3 (WS, PI, TP) and PC4 (HS, BR) that explained about 89.38% of the total variation. It was concluded that the seven body measurements is important for describing body conformation of Pasundan cows such as body size (PC1) and body shape (PC2).

Keywords: Body measurements, Body indices, Body conformation, Pasundan cows, PCA

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1. Introduction

Pasundan cattle is one of indigenous beef cattle in Indonesia that adapt well at West Java province. The Pasundan cattle was decided as one of Indonesian native cattle through the decision of Ministry of Agriculture of Republic Indonesia Number: 1051/Ktsp/SR.120/10/2014. According to Cytochrome B (Cyt-b) gene and microsatellite analysis, the Pasundan cattle was included of *Bos indicus* cattle (Hartatik et al., 2019; Agung et al., 2019). The total number of Pasundan population in West Java at year 2018 was 7,616 heads and consisted of 6,708 females and 908 males (Setiawati

et al., 2018). Said et al. (2017) reported that Pasundan cattle had various exterior characteristics but the commonly the coat colors in this breed is solid reddish brown with black colours in hoof, switch of tail, muzzle and horn. In addition, the light brown colour was found in legs (stocking) and rump patch. In addition, most of the Pasundan cattle had hump, backline and small dewlap size.

As the native cattle of Indonesia, genetic improvement program for Pasundan cattle is important to increase the economic value in this breed. Genetic improvement in Pasundan cattle can be obtained with molecular and traditional selections. Most of Pasundan cattle was kept by smallholders with extensive management system (Arifin et al., 2015). Limited number of animals weighing scale in the livestock farmer groups is the common problem in the cattle selection program in Indonesia. Presently, the body conformation of animal can be identified through principal component analysis (PCA) method (Mishra et al., 2017). Previous studies reported principal component analysis (PCA) of body measurements can be used to explain the body conformation of ruminant livestocks such as cattle (Yakubu et al., 2009; Pundir et al., 2011; Tolenkhomba et al., 2012; Pares-Casanova et al., 2013; Peres-Casanova and Mwaanga, 2013; Verma et al., 2015; Shah et al., 2018; Heryani et al., 2018), buffaloe (Vohra et al., 2015; Vohra et al., 2017; Saroji et al., 2010; Sembiring et al., 2013; Nafiu et al., 2015), goat (Ferreira et al., 2013; Khargharia et al., 2015; Birteeb and Lomo, 2015; Pares-Casanova, 2015; Boujenane et al., 2016) and sheep (Osaiyuwu et al., 2010; Legaz et al., 2011; Mavule et al., 2013; Birteeb et al., 2014; Khan et al., 2014).

Body measurements of the cattle represented by different body conformation that important for selection criteria. Body conformation are used to indicate breed, origin, body indices and body dimensions of shape and size (Heryani et al., 2018; Sembiring et al., 2013; Nafiu et al., 2015). Furthermore, different body measurements, which represent the size of the animal is important criteria for selection of elite animals. However, the PCA transforms an original group of variables into another group, principal components, which are a linear combination of the original variables. In animal breeding, this technique can be used for selection and conservation purpose. The objective of this study was to provide the information about morphological structure of Pasundan cows reared in West Java for the purposes of breed characterization using PCA analysis.

2. Material and Method

2.1. Research Site and Animals

This research was conducted at West Java province, Indonesia. This area is situated at 5°54' to 7°45' S and longitude 106°22' to 108°50 E. The humidity 65% to 90% with temperature 16°C to 28°C and rainfall occurring 2000 - 5000 mm/year. Body measurements data on 144 Pasundan cows (average 3 years age) was collected from seven Villager Breeding Centre (VBC) in West Java Province of Indonesia (Figure 1).

Figure 1. The location of the breeding tract of Pasundan cattle in Indonesia.

2.2. Body Measurements and Body Indices

Seven different body measurements were taken based on Boujenane (2014) and consisted of withers height (WH), body length (BL), chest girth (CG), chest width (CW), rump height (RH), rump width (RW) and rump length (RL). WH was measured with a stick-ruler as the distance from the surface of the platform to the dorsal point (*os vertebrae thoracalis III*) of the withers. BL was measured with stick mesure as the distance between the point of the shoulder (*tuber humerus* on *os humerus*) and the pinbone (*tuber ischiadicum* on *os coxa*). CG was measured with a tape measure as circumference of the chest just behind the foreleg (*os costa V*). CW was measured with caliper as a distance from left to right upper arm or the distance between *tuberositas humerisinister* and *dexter*. RH was measured with stick measure as the distance from rump (*tuber coxae*) to the surface of the platform on which the animal stands. RW was measured with caliper as the distance between both of the hip bones (*tuber ischii*). RL was measured with caliper from hips to pins. All the measurements were recorded once in upright animal standing on a level ground (Figure 2). Therefore, thirteen of body indices parameters were calculated using formula according to Khargaria et al. (2015) and Alderson (1999) as presented in Table 1.

Table 1. The formula for body indices analysis in cattle*

No	Body indices	Symbol	Formula
1	Height slope	HS	RH - WH
2	Width slope	WS	RW / CW
3	Body index	BI	BL × CG
4	Area index	AI	WH × BL
5	Rump length index	RLI	RL / BL
6	Conformation index	CI	$(CG)^2$ / WH
7	Length index	LI	BL / WH
8	Body ratio	BR	WH / RH
9	Proportionality	Pr	WH / BL
10	Thoracic development	TD	CG / WH
11	Pelvic index	PI	RW / RL
12	Transverse pelvic	TP	RW / RH
13	Longitudinal pelvic	LP	RL / RH

*Khargaria et al. (2012); Alderson (1999)

2.3. Statistical Analysis

Means, standard deviation and coefficients of variation of the body measurements were calculated through SPSS 16.0 software. Pearson's coefficient of correlation (r) among the various morphometric traits were calculated. From the correlation matrix, data were generated for the principal component factor analysis. Anti-image correlations, Kaiser Meyer Olkin (KMO) measures of sampling adequacy and Bartlett's Test of Sphericity were computed to test the validity of the factor analysis of the data sets (Vohra et al., 2015). According to Johnson and Wichern (2002), the PCA are linear combination of the original variables and are estimated in such a way that the first principal component (PC1) explains the largest percentage of the total phenotypic variance. The varimax criterion of the orthogonal rotation method was employed for the rotation of factor matrix. The choice of varimax rotation is informed by its ability to maximize sum of the variances of the squared loadings within each column of the loading matrix. This tends to produce some higher loadings and some loadings near zero which is one of the aspects of simple structure that enhance the interpretability of the principal components. The mathematical model of PCA according to Karacaoren and Kadarmideen (2008) as follows:

$$Y_{ij} = \sum_{k=1}^{q} a_{ik} c_{kj} + e_{ij}$$

Where Y_{ij} is the value of the i^{th} observation on the j^{th} measure; q is the number of common factor; a_{ik} is the value of the ith observation on the k^{th} common factor (factor loadings); C_{kj} is the regression coefficient of the k^{th} common factor for predicting the j^{th} measure and e_{ij} is the value of the i^{th} observation on the j^{th} communality value.

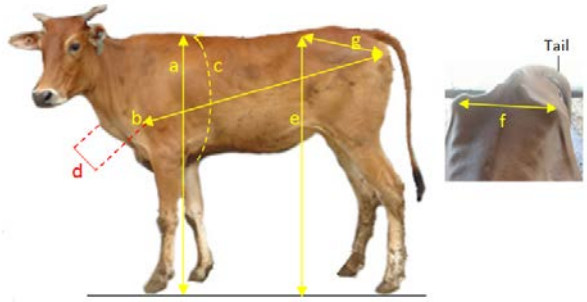

Figure 2. Scheme of the body measurements in Pasundan cow consisted of withers height (a), body length (b), chest girth (c), chest width (d), rump height (e), rump width (f) and rump length (g).

3. Results

Results show that the moderate of coefficient of variation (CV) values (0.10<CV<0.20) in body measurements were found in BL, CW, RW, RL and the other measurements had low CV values (CV<0.10) as presented in Table 2.

Table 2. Descriptive statistic of body measurements and body indices in Pasundan cows

Parameter	Mean	SD	CV (%)	Min.	Max.
Body measurements (cm)					
Withers height	119.55	8.37	7.00	101.10	145.00
Body length	120.82	14.79	12.24	90.10	160.50
Chest girth	136.67	10.76	7.87	119.00	175.50
Chest width	29.26	3.67	12.53	22.00	41.00
Rump height	122.72	7.16	5.83	109.50	147.50
Rump width	32.95	4.44	13.48	14.00	43.00
Rump length	31.26	4.99	15.97	18.50	46.05
Body indices					
Height slope	3.79	2.48	65.60	0.00	11.10
Width slope	1.15	0.22	19.22	0.50	3.13
Body index	0.89	0.11	12.13	0.54	1.16
Area index	14546.10	2704.21	18.59	9720.48	23352.75
Rump length index	0.26	0.06	23.84	0.15	0.44
Conformation index	157.26	22.76	14.47	120.01	230.47
Length index	1.01	0.08	7.57	0.74	1.13
Body ratio	0.97	0.03	2.68	0.90	1.07
Proportionality	1.00	0.08	8.21	0.89	1.35
Thoracic development	1.15	0.09	8.04	0.95	1.44
Pelvic index	1.08	0.20	18.88	0.56	2.59
Transverse pelvic	0.27	0.06	21.24	0.12	0.82
Longitudinal pelvic	0.26	0.05	17.82	0.15	0.38

SD= standard deviation; CV= coefficient of variation; Min= minimum value; Max= maximum value

Therefore, the low of CV values in body indices were found in LI, BR, Pr, and TD. The body indices of WS, BI, AI, CI, PI and LP had moderate of CV value (0.10<CV<0.20). In addition, body indices of HS, RLI and TP had high of CV values (CV>0.20). Pearson's coefficient of correlation (r) among all body measurements show that WH-BL and WH-RH were positive and very high (0.80<r<1.00) as presented in Table 3. Meanwhile, the correlations among

all body indices shows that HS-BR; LI-Pr and BI-TD were negative and very high as presented in Table 4. Thus, the correlation of CI-TD; WS-TP and RLI-LP were positive and very high.

The PCA analysis of body measurements in this study was obtained two principal components as presented in Table 5. According to Figure 3, the first component (PC1) consisted of WH, BL and RH. The second component (PC2) consisted of CG, CW, RW and RL. Both principal components in the body measurements were explained 73.36% of total variance (Table 5). In addition, each principal component in the present study were explained of total variance of 47.89% (PC1) and 25.47% (PC2).

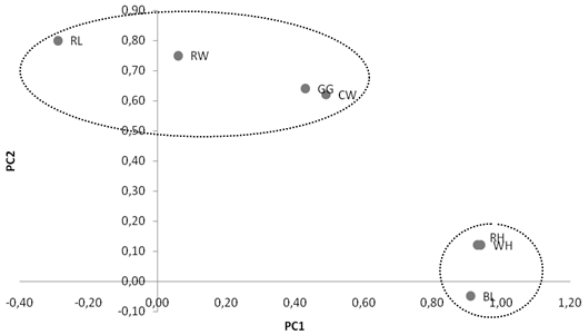

Figure 3. Projections on principal component analysis (PCA) of the factors and associations between body measurements in Pasundan cows based on rotated component matrix. WH: withers height; BL: body length; CG: chest girth; CD: chest width; RL: rump height; RW: rump width.

The PCA analysis of body indices in the present study was obtained four principal components as presented in Table 6. The first component (PC1) consisted of BI, AI, RLI, LI, Pr and LP. The second component (PC2) consisted of CI and TD. The third component (PC3) consisted of WS, PI and TP. The fourth component (PC4) consisted of HS and BR. Four principal components in body indices could explained 89.38% of total variance (Table 6). In addition, each principal components in the present study were explained of total variance of 43.67% (PC1); 20.10% (PC2); 13.01% (PC3) and 12.60% (PC4).

4. Discussion

The moderate CV value of Pasundan cows in this study was found in BL, CW, RW, RL and similar to the Jabres (*Bos indicus*) cows at Central Java (Adinata et al., 2016). Hence, the positive and very high correlation was reached in WH-BL (0.83) and WH-RH (0.93) and higher than in Jabres cattle i.e. 0.44 (WH-BL) and 0.70 (WH-RH). Correlation of WH-BL was positive and high ($0.60<r<0.79$) was observed in Kankrej (0.69) and Cholistani (0.79) cows (Pundir et al., 2011; Shah et al., 2018). In addition, the correlation of WH-BL in White Fulani cows was 0.81 (Yakubu et al., 2009) and similar to this study.

Moreover, the correlation of WH-RH in Pallaresa was 0.89 (Pares-Casanova et al., 2013) and similar to this study. Gunawan et al. (2016) reported that Bali cows (*Bos javanicus*) had body indices of HS (2.03±4.44); WS (2.94±4.60) and LI (0.89±0.25). Therefore, Peranakan Ongole (PO) cows (*Bos indicus*) had body indices of HS (2.25±1.27); WS (4.16±0.69) and LI (0.94±0.12). According to the Gunawan et al. (2016), HS and LI in Pasundan cows was highest than PO and Bali cows. Despite, WS in Pasundan was lowest than PO and Bali cows. Unfortunately, study to explain the correlation among all body indices in cattle so far is not reported. In Katjang does, the correlation of CI-TD and LI-Pr were 0.88 and -0.98 respectively (Putra et al., 2019) and similar to this study. Moreover, study to compare the body indices of cattle based on sex so far is not reported.

Seven body measurements in the present study were revealed two principal components. The similar result was reported by Sembiring et al. (2013) in buffaloes that two principal components were obtained based on seven body measurements. Moreover, PC1 and PC2 of body measurements as the specific measurements for body size and body size (Heryani et al., 2018; Sembiring et al., 2013; Nafiu et al., 2015). Heryani et al. (2018) reported that body measurements of WH, BL, CG, CW, RH and RW in the White Taro cows were included of PC1. Hence, Ndumu et al. (2008) obtained three principal components of body measurements in Ankole cattle that explain body size, body shape and head shape. In this study, the PC1 (WH, BL and RH) was explained body size and PC2 (CG, CW, RW and RL) was explained body shape of Pasundan cows.

Previous studies reported that the PCA of body measurements in several cattle breeds were explain of 86.47% with 4 PC in White Fullani (Yakubu et al., 2009); 66.02% with 3 PC in Kankrej (Pundir et al., 2011); 64.31% with 7 PC in local Manipur (Tolenkhomba et al., 2012); 65.84% with 2 PC in Pallaresa (Pares-Casanova et al., 2013); 54,40% with 2 PC in Tonga (Pares-Casanova and Mwaanga, 2013); 65,95% with 5 PC in local Himalayan (Verma et al., 2015); 83.62% with 4 PC in Cholistani (Shah et al., 2018); 91.08% with 2 PC in Taro (Heryani et al., 2018); 65.16% with 3 PC in Oulmes-Zaer and 54.70% with 3 PC in Tidili (Boujenane et al., 2016) from the total variance. Meanwhile, the PCA of body indices in the present study is first reported and not found in the other previous studies. Seven body measurements in this study had communality value more than 0.50 and indicated that all measurements were explained of body conformation in Pasundan cows.

The communality value in 13 body indices were more than 0.50 and indicates that all body indices were explained of body conformation in Pasundan cows. Previous studies reported that low communality value (less than 0.50) of body measurements were showed in distance between horns, horn diameter and neck diameter of Kankrej (Pundir et al., 2011); elbow length and thigh length of local Manipur (Tolenkhomba et al., 2012); ear length, rump height, body length, dorsosternal

distance, head width, facial width and cranial length of Tonga (Pares-Casanova and Mwaanga, 2013); shoulder width and head length of Pallaresa (Pares-Casanova et al., 2013); head length, cannon circumference and tail length of Tidili and head length and horn length of Oulmes-Zaer (Boujenane et al., 2016).

Table 3. Phenotypic correlation among body measurements in Pasundan cows

Variables	WH	BL	CG	CW	RH	RW	RL
Withers height (WH)	1.00	0.83**	0.40**	0.43**	0.93**	0.20*	-0.11
Body length (BL)	-	1.00	0.29**	0.39**	0.76**	0.03	-0.23**
Chest girth (CG)	-	-	1.00	0.56**	0.45**	0.31**	0.29**
Chest width (CW)	-	-	-	1.00	0.46**	0.36**	0.26**
Rump height (RH)	-	-	-	-	1.00	0.17*	-0.15
Rump width (RW)	-	-	-	-	-	1.00	0.43**
Rump length (RL)	-	-	-	-	-	-	1.00

*p<0.05, **p<0.01

Table 4. Phenotypic correlation among body indices in Pasundan cows

BI	HS	WS	BI	AI	RLI	CI	LI	BR	Pr	TD	PI	TP	LP
HS	1.00	-0.10	-0.46**	-0.50**	0.22**	0.20*	-0.26**	-0.99**	0.26**	0.43**	-0.10	-0.09	0.03
WS	-	1.00	-0.13	-0.16	0.35**	0.03	-0.27**	0.10	0.30**	0.03	0.59**	0.86**	0.31**
BI	-	-	1.00	0.74**	-0.74**	-0.64**	0.77**	0.50**	-0.78**	-0.82**	0.21*	-0.25**	-0.50**
AI	-	-	-	1.00	-0.64**	-0.06**	0.71**	0.55**	-0.69**	-0.46**	0.26**	-0.14	-0.44**
RLI	-	-	-	-	1.00	0.36**	-0.68**	-0.27**	0.69**	0.54**	-0.34**	0.46**	0.92**
CI	-	-	-	-	-	1.00	-0.11	-0.22**	0.16	0.90**	-0.03	0.27**	0.32**
LI	-	-	-	-	-	-	1.00	0.28**	-0.99**	-0.28**	0.10	-0.23**	-0.37**
BR	-	-	-	-	-	-	-	1.00	-0.27**	-0.47**	0.15	0.09	-0.08
Pr	-	-	-	-	-	-	-	-	1.00	0.30**	-0.07	0.27**	0.38**
TD	-	-	-	-	-	-	-	-	-	1.00	-0.18*	0.25**	0.46**
PI	-	-	-	-	-	-	-	-	-	-	1.00	0.59**	-0.42**
TP	-	-	-	-	-	-	-	-	-	-	-	1.00	0.45**
LP	-	-	-	-	-	-	-	-	-	-	-	-	1.00

BI= body indices, HS= height slope, WS= width slope, BI= body index, AI= area index, RLI= rump length index, CI= conformation index, LI= length index, BR= body ratio, Pr= proportionality, TD= thoracic development, PI= pelvic index, TP= transverse pelvic, LP= longitudinal pelvic, *p<0.05, **p<0.01

Table 5. Eigenvalues, total variance, cumulative, communalities, Kaiser-Meiyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity for the body measurements of Pasundan cows

Body measurements	PC1	PC2	Communality
Withers height	0.94*	0.12	0.90
Body length	0.91*	-0.05	0.83
Chest girth	0.43	0.64*	0.60
Chest width	0.49	0.62*	0.62
Rump height	0.93*	0.12	0.89
Rump width	0.06	0.75*	0.57
Rump length	-0.29	0.80*	0.72
Eigenvalues	3.35	1.78	-
Variance (%)	47.89	25.47	-
Cumulative (%)	47.89	73.36	-
KMO		0.72	
Bartlett's test		**	

PC= principal component, *main component, **p<0.01

Previous studies reported that the KMO in PCA of body measurements in cattle were 0.81 from 18 body measurements (Pundir et al., 2011); 0.60 from 18 body measurements (Tolenkhomba et al., 2012) and 0.75 from 16 body measurements (Werma et al., 2015). Inter-factor coefficient correlation in body measurements of PC1-PC2 in this study was 0.40 and indicates that high positive correlation between both principal factors. Therefore, the inter-factor correlation in body indices in this study were 0.51 (PC1-PC2); 0.10 (PC1-PC3); -0.33 (PC1-PC4); 0.84 (PC2-PC3); 0.53 (PC2-PC4) and -0.35 (PC3-PC4). Pundir et al. (2011) and Tolenkhomba et al. (2012) reported that the inter-factor correlation of body measurements between PC1 and PC2 were 0.48 and 0.26 respectively. The different result of inter-factor correlation compare to previous studies can be caused by different of breed (genetic) and number of measurements. The KMO value in the present study was 0.72 (body measurements) and 0.67 (body indices). The KMO revealed the proportion of variance in different body measurements caused by

underlying factors. The overall significance of correlation tested with Bartlett's test of sphericity for the body measurements was significant and provided enough support for the validity of factor analysis of data.

Table 6. Eigenvalues, total variance, cumulative, communalities, Kaiser-Meiyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity for the body indices of Pasundan cows

Body indices	PC1	PC2	PC3	PC4	Communality
Height slope	0.18	0.16	-0.07	-0.92*	0.90
Width slope	0.30	0.03	0.88*	0.15	0.88
Body index	-0.69*	-0.56	-0.02	0.37	0.92
Area index	-0.79*	-0.09	0.05	0.41	0.81
Rump length index	0.83*	0.48	0.05	0.09	0.93
Conformation index	-0.02	0.93*	0.09	-0.15	0.90
Length index	-0.91*	0.03	-0.12	0.20	0.86
Body ratio	-0.22	-0.19	0.10	0.90*	0.90
Proportionality	0.90*	0.01	0.16	-0.19	0.86
Thoracic development	0.23	0.89*	-0.00	-0.33	0.96
Pelvic index	-0.31	-0.19	0.89*	-0.12	0.94
Transverse pelvic	0.25	0.31	0.86*	0.18	0.94
Longitudinal pelvic	0.64*	0.55	-0.02	0.33	0.81
Eigenvalues	5.68	2.61	1.69	1.64	-
Variance (%)	43.67	20.10	13.01	12.60	-
Cumulative (%)	43.67	63.77	76.78	89.38	-
KMO			0.67		
Bartlett's test			**		

PC= principal component,*main component, **p<0.01

5. Conclusion

According to the results of this study, three body measurements of WH, BL and RH were the first component to describe the body conformation in Pasundan cows. Therefore, two body indices based on these body measurements (AI and LI) were the first component to describe the body conformation in Pasundan cattle. It was concluded that three body measurements of WH, BL and RH as the main measurements in Pasundan cows and can be used as the selection criteria.

Conflict of interest

The author declare that there is no conflict of interest.

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