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Morphological Structure of Rabbits Based on Body Types

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Abstract

The study was carried out to characterize different body types of rabbits based on the phenotypic relationship between body weight and body measurements. The materials used were 135 of New Zealand Grade, 115 heads of Rex, and 60 heads of Flamish Giant. Rabbits were categorized into three groups: semi-commercial, commercial, and semi-arc body types. Pearson correlation was used to estimate the correlation coefficients between body weight and body measurements with 1% and 5% significant level. Principal component analysis (PCA) representing a linear combination of the body measurement into a factor or component was determined separately for each body type of rabbit. BW showed a significant correlation with all of the variables measured on semi-commercial and semi-arc body types. The result of PCA showed a lower factors of PC1 (-0.04 - 0.41). The highest component loaded were CD in PC3 for all body types and TB in PC2 for semi-arc body type. Chest circumference, chest depth, and chest width (chest shape) are more appropriate in predicting body weight in rabbits than body length. Body length is highly correlated with body weight, but shows low factors in the principal component analysis.

KEYWORDS
Eigenvalues, Pearson correlation, Principal component analysis, Total variance, Sexual dimorphism

INTRODUCTION

Rabbits are potential livestock with special traits, including small body size, short intervals of generations, excellent reproductive performance, wide genetic diversity, efficient feed conversion, and rapid growth rates (Sakr *et al.*, 2020). Recently, numerous standard breeds of rabbits (New Zealand White, Californian, Rex, Hayla, Flemish Giants, and Hycole have been imported to Indonesia (Setiaji *et al.*, 2022). The current trend in the improvement of rabbits relies on the variations (within and between breeds) of body weight. It is a great opportunity for the breeding program. The imported have been crossed with each other or with Local breeds to produce highly prolific and adaptable for tropical conditions. The main purpose of crossing among breeds of rabbits was to increase body weight and meat production. One of the hybrid rabbits popularly raised by the farmer is New Zealand Grade. The hypothesis of New Zealand Grade was the result of a cross between three breeds: New Zealand White, Flemish Giant, and Local breed.

Body size and shape are substantial traits in meat rabbits. Whereas the former has largely been estimated for scale weight, the latter has generally been described visually, giving rise to subjective scores. Body measurements in rabbits have been used to contrast variations in size and shape (Shahin and Hassan, 2000; Zhan-fu *et al.*, 2008; Yakubu and Ayoade, 2009; Petrescu-Mag *et al.*, 2014). The relationship between body weight and body measurement may be differrent among different body types, since body measurements are phenotypically and genetically correlated each other (Akanno and Ibe, 2005). However, if these body measurements are treated as bivariates rather than multivariates, the phenotypical correlation between them may be different (Mavule *et al.*, 2013). Therefore, when morphological traits in a body's size and shape are associated, principal a multivariate technique, can be employed with great effectiveness.

Several studies have employed principal component to extract body measurements contributing on predicted body weight and characterized in several breeds: rabbits (Yakubu and Ayoade, 2009), Goat (Okpeku *et al.*, 2011; Kurnianto *et al.*, 2013; Silva *et al.*, 2013), Sheep (Mavule *et al.*, 2013; Mishra *et al.*, 2017; Marković *et al.*, 2019). They came to the conclusion that the factor score coefficients produced may predict body weight more precisely than the initial interdependent variables. The phenotypic diversity of rabbits is yet to be investigated in detail. Hence, the present work was carried out to characterize different body types of rabbits based on the phenotypic relationship between body weight and body measurements.

MATERIALS AND METHODS

Data collection

The total number of rabbits used in the study was 310 heads

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consisting of three different breeds, 135 of New Zealand Grade, 115 heads of Rex, and 60 heads of Flamish Giant (Figure 1). Rabbits were categorized into three groups: semi-commercial, commercial, and semi-arc body types, the illustrations of the three body types of rabbits were presented in Figure 2. New Zealand Grade, Rex, and Flamish Giant were belonging to semi-commercial, commercial, and semi-arc body types, respectively. The criteria of rabbits chosen were more than 12 months of age. The parameters observed were body weight (BW) as the dependent variable and body measurements as the independent variable. Body measurements consist of chest circumference (CC), chest depth (CD), chest width (CW), radius-ulna length (RU), femoris length (FM), tibia length (TB), humerus length (HM), hip width (HP), and body length (BL).

Statistical analysis

t-Test was used for preliminary analysis to distinguish the body weight and body measurements of female and male rabbits in each breed. Pearson correlation was used to estimate the correlation coefficients between body weight and body measurements. Significant level was used at 1% and 5% of probability. Principal component analysis (PCA) representing a linear combination of the body measurement into a factor or component was determined separately for each body type of rabbit. Kaiser-Meyer-Olkin measures of sampling adequacy and Bartlett's sphericity test were tested for factor analysis validity for each data set. Data analysis was performed using Statistical Analysis System (SAS) OnDemand for Academics (SAS, 2021).

RESULTS

Preliminary analysis has been conducted to test the sexual dimorphism among male and female rabbits. Female semi-commercial type showed lower all body measurements and body weight than which male ones. Female commercial type showed higher CD and BL and female FG showed higher CC and CD than their opposite. Further, the significant difference between males and female have found only on HP for semi-commercial type and HP and BL for commercial type. There was no variable difference between males and females FG (Table 1). Table 2, present the coefficient correlation between body measurement and body

Fig. 1. Three breeds of rabbit used in the study: A, New Zealand Grade; B, Rex; C, Flamish Giant.

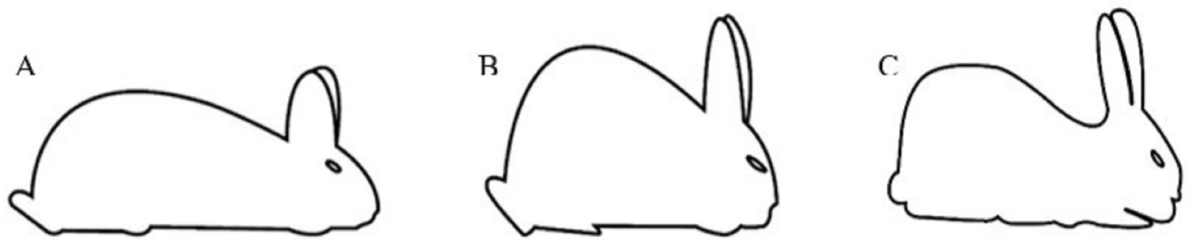

Fig. 2. Classifications of body type: A, Semi-commercial; B, Commercial; C, Semi-arc.

Table 1. Sexual dimorphism in three different body types of rabbits.

	Semi-commercial			Commercial			Semi-arc		
Traits[1]	Female	Male	Pr > F	Female	Male	Pr > F	Female	Male	Pr > F
CC (cm)	35.03±0.33	35.98±4.57	0.197	32.72±0.33	33.87±0.64	0.789	36.27±0.49	35.98±0.87	0.721
CD (cm)	8.96±0.11	9.34±0.19	0.051	9.10±0.11	8.97±0.19	0.407	9.49±0.17	9.37±0.19	0.066
CW (cm)	8.55±0.13	9.33±0.36	0.785	7.84±0.11	8.20±0.19	0.591	8.92±0.13	9.19±0.21	0.908
RU (cm)	8.94±0.11	9.89±0.28	0.483	8.41±0.09	8.56±0.15	0.192	10.08±0.17	10.22±0.28	0.921
FM (cm)	13.49±0.12	14.79±0.32	0.512	12.81±0.15	13.54±0.24	0.191	14.79±0.22	15.53±0.45	0.312
TB (cm)	13.82±0.17	15.06±0.32	0.058	12.99±0.13	13.74±0.22	0.172	15.31±0.25	15.42±0.34	0.369
HM (cm)	10.44±0.10	11.46±0.26	0.443	9.63±0.13	10.12±0.24	0.681	11.17±0.21	11.75±0.33	0.857
HP (cm)	9.97±0.08	10.19±0.57	<0.001	9.63±0.10	9.70±0.29	0.043	10.68±0.12	10.89±0.18	0.736
BL (cm)	36.23±0.28	39.43±0.79	0.798	35.17±0.49	26.13±0.42	0.000	43.1±0.62	43.25±1.18	0.486
BW (kg)	3.55±0.07	4.05±0.17	0.465	0.29±0.06	3.09±0.10	0.315	5.32±0.13	5.43±0.21	0.836

[1]CC: Chest Circumference; CD: Chest Depth; CW: Chest Width; RU: Radius-ulna Length; FM: Femoris Length; TB: Tibia Length; HM: Humerus Length; HP: Hip Width; BL: Body Length; BW: Body weight.

weight for three body types of rabbits. A total of 43 correlations were positively significant (P<0.05, 0.01).

Principal components extracted, eigenvalues, percentage of the total variance, and communalities of body measurements observed in three different body types of rabbits are presented in Table 3. The PCA showed three principal components extracted from factors analyzed by varimax rotation. PCA assesses overall variance and identifies variables with greater discriminatory power between body types. Kaiser's Measure of sampling adequacy estimated for semi-commercial, commercial and semi-arc body types was found to be 0.83, 0.73, and 0.85, respectively. The significance of the correlation matrices tested for sphericity using Bartlett's test for all body measurements in semi-commercial (Chi-Square=374.49; P<0.001), commercial (Chi-Square=189.28; P<0.001), and semi-arc (Chi-Square=190.95; P<0.001) body types of rabbit provided support for the validity of the factor analysis of the data sets.

DISCUSSION

The CC, CD, and CW of New Zealand Grade in this study were shorter, whereas, HP was longer compared with that of purebred New Zealand White. Whereas, the other variables were in range with the reported by Setiaji *et al.* (2022). Compared with the previous study by Brahmantiyo *et al.* (2006), the body measurements of semi-arc in the present study were longer than that of the same breeds. Furthermore, CC, CW, and BL of commercial type were shorter and the other body measurements were longer than that of the same breed in their study.

Table 2. Pearson correlation between body measurement and body weight observed in three different body types of rabbits.

Trait[1]	CC	CD	CW	RU	FM	TB	HM	HP	BL	BW
Semi-commercial										
CC	1									
CD	0.36**	1								
CW	0.22*	0.68**	1							
RU	0.34**	0.20*	0.25**	1						
FM	0.44**	0.15	0.35**	0.42**	1					
TB	0.42**	0.16*	0.32**	0.30**	0.32**	1				
HM	0.39**	0.20*	0.30**	0.49**	0.51**	0.36**	1			
HP	0.54**	0.18*	0.53**	0.27**	0.29**	0.22*	0.23**	1		
BL	0.39**	0.39**	0.32**	0.35**	0.38**	0.38**	0.45**	0.17	1	
BW	0.72**	0.32**	0.67**	0.44**	0.56**	0.35**	0.47**	0.43**	0.65**	1
Commercial										
CC	1									
CD	0.13	1								
CW	0.40**	-0.16	1							
RU	0.29**	-0.01	0.26**	1						
FM	0.32**	-0.1	0.27**	0.35**	1					
TB	0.27**	0.07	0.22*	0.31**	0.44**	1				
HM	0.42**	-0.03	0.13	0.35**	0.39**	0.31**	1			
HP	0.35**	-0.14	0.48**	0.21*	0.24**	0.23*	0.15	1		
BL	0.27**	-0.03	0.17	0.20*	0.21*	0.12	0.11	0.14	1	
BW	0.41**	0.06	0.31**	0.12	0.12	0.21*	0.19*	0.16	0.48**	1
Semi-arc										
CC	1									
CD	0.42**	1								
CW	0.56**	0.21	1							
RU	0.59**	0.35**	0.36**	1						
FM	0.61**	0.38**	0.44**	0.57**	1					
TB	0.18	0.2	0.11	0.09	0.23	1				
HM	0.46**	0.28*	0.41**	0.63**	0.59**	0.18	1			
HP	0.47**	0.25	0.37**	0.49**	0.42**	0.14	0.37**	1		
BL	0.52**	0.24	0.49**	0.39**	0.53**	0.39**	0.48**	0.28*	1	
BW	0.73**	0.31*	0.55**	0.52**	0.66**	0.36**	0.49**	0.42**	0.73**	1

[1]CC: Chest Circumference; CD: Chest Depth; CW: Chest Width; RU: Radius-ulna Length; FM: Femoris Length; TB: Tibia Length; HM: Humerus Length; HP: Hip Width; BL: Body Length; BW: Body weight. *, Correlated on 0.05 significant level; **, Correlated on 0.01 significant level.

Based on the results of the t-Test, concluded that there was no sexual dimorphism based on body measurement for all three breeds of rabbits. The result agreed with Ajayi and Oseni (2012) and Ferreira *et al.* (2015) that reported no sexual dimorphism in adult Nigerian rabbits and European rabbits, respectively. Sexual dimorphism has been reported in wild European wild rabbits. The differential between sexes has been marked by the humerus (distal transverse diameter and width of the trochlea) and mandible (diastema depth and length) (Jones, 2006). Based on the results that no sexual dimorphism of all breeds in the study, the following analysis was not separated by sex.

BW showed a significant correlation with all of the variables measured on semi-commercial type. The highest coefficient correlation was with CC (0.72), whereas the lowest was with CD (0.32). A significant correlation was also shown among body measurements, except for CD with FM, HP, and BL. The correlation between BW and all the body measurements could be due to the correlations among body measurements of semi-commercial type. There were 20 correlations positively significant (P<0.01), and 7 positively significant (P<0.05) of commercial type. BW showed a significant correlation with CC, CW, TB, HM, and BL, coefficients ranging from 0.16 to 0.48. CD has no significant correlation with all of the variables measured. There were 32 correlations positively significant (P<0.01), and 3 positively significant (P<0.05) of semi-arc. BW showed a significant correlation will all of the body measurements. The highest and lowest coefficient correlation was BW with CC and BL (0.73) and CD (0.31), respectively. The results of semi-arc were the same case with that of semi-commercial type. Generally, the highest correlation in the study was BW and BL. The results agreed with the previous studies reported a high correlation between BW and BL on New Zealand White x Chinchilla crossbred (0.74) by Yakubu and Ayoade (2009), and on Transsilvanian Giant rabbit (0.86) by Petrescu-Mag *et al.* (2014). The positively significant correlation

Table 3. Principal components extracted, eigenvalues, percentage of total variance, and communalities of body measurement observed in three different body types of rabbits.

Trait[1]	PC1[2]	PC2	PC3	Communalities
Semi-commercial				
CC	0.41	-0.33	0.06	0.78
CD	0.23	0.02	**0.8**	0.83
CW	0.36	-0.46	-0.04	0.74
RU	0.32	0.33	-0.24	0.57
FM	0.35	0.21	-0.32	0.61
TB	0.31	0.13	-0.02	0.38
HM	0.35	0.38	-0.2	0.68
HP	0.3	-0.52	-0.18	0.7
BL	0.34	0.31	0.36	0.67
Eigenvalues	3.8	1.19	0.97	
% of total variance	66.23	10.83	13.22	
Commercial				
CC	0.4	0.1	0.42	0.68
CD	-0.04	**0.61**	**0.61**	0.85
CW	0.36	-0.45	0.24	0.7
RU	0.35	0.15	-0.21	0.44
FM	0.4	0.11	-0.35	0.62
TB	0.35	0.27	-0.19	0.49
HM	0.36	0.32	-0.24	0.57
HP	0.34	-0.43	0.21	0.63
BL	0.23	-0.04	0.29	0.25
Eigenvalues	2.97	1.24	1.02	
% of total variance	58.06	11.35	13.74	
Semi-arc				
CC	0.39	-0.09	0.02	0.68
CD	0.25	0.08	**0.79**	0.82
CW	0.32	-0.07	-0.47	0.64
RU	0.37	-0.29	0.13	0.7
FM	0.39	-0.01	0.03	0.65
TB	0.16	**0.83**	0.09	0.86
HM	0.36	-0.09	-0.08	0.58
HP	0.31	-0.24	0.05	0.47
BL	0.35	0.37	-0.33	0.75
Eigenvalues	4.21	1.06	0.87	
% of total variance	68.32	9.66	9.85	

[1]CC: Chest Circumference; CD: Chest Depth; CW: Chest Width; RU: Radius-ulna Length; FM: Femoris Length; TB: Tibia Length; HM: Humerus Length; HP: Hip Width; BL: Body Length; BW: Body weight. [2]PC, Principal component.

was also reported by Okpeku *et al*. (2011) in goats, mavele *et al*. (2012), and Mishra *et al*. (2017) in sheep. The Body measurements on semi-commercial and semi-arc body types seem to serve as a predictor of BW than on commercial type. The few correlations between BW and body measurement for commercial body type might be due to this type having a large body size with solid flesh and small bones (Brahmantiyo *et al*. 2021).

In the semi-commercial body type of rabbit, the principal component accounted were 66.23% of PC1, 10.83% of PC2, and 13.22% of PC3, with eigenvalues of 3.80, 1.19, and 0.97, respectively. The highest principal component loaded on CD of PC3. In the commercial body type, the principal component accounted were 58.06% of PC1, 11.35% of PC2, and 13.74% of PC3, with the eigenvalues of 2.97, 1.24, and 1.02, respectively. PC2 and PC3 had high loading on CD (0.61) each. In the semi-arc body type, the principal component by PCA accounted for 68.32% (PC1), 9.66% (PC2), and 9.85 (PC3) of the total variance measured with eigenvalues 4.21, 1.06, and 0.87, respectively. The communalities representing estimates of the variance in each body measurement observed ranged between 0.38 and 0.83 in semi-commercial, 0.25 and 0.85 in commercial, and 0.47 and 0.82 in semi-arc body types of rabbits.

The result of the recent study showed a lower total variance of PC1 (58.06-68.32) than PC1 in Domestic rabbits (74.98), New Zealand White (75.2), Red Baladi (81.2), and Black Baladi (80.0) (Shahin and Hassan, 2000; Yakubu and Ayoade, 2009). Their study reported body measurement with the highest component of PC1 was BL ranging between 0.68 and 0.94, whereas the results of the recent study showed low components of BL in PC1 (0.23-0.35). The highest component loaded in PC3 findings in the present study was associated with chest shape. The result was in consonance with the observation of Mavule *et al*. (2013) in body measurements of Zulu sheep who showed that the third factor was characterized by high positive loadings of head length and head width. The current study was able to demonstrate that based on the Pearson correlation and PCA analysis the chest shape were appropriate in predicting body weight of rabbits.

CONCLUSION

This study revealed diversity in the predicted body weight of three different body types of rabbits. Semi-commercial and semi-arc body types have more body measurements correlated with body weight than commercial body type. Chest circumference, chest depth, and chest width (chest shape) are more appropriate in predicting body weight in rabbits than body length. Body length is highly correlated with body weight, but shows low factors in the principal component analysis.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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