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MORPHOMETRIC CHARACTERIZATION OF NEW ZEALAND WHITE RABBIT RAISED AT DIFFERENT AREAS

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ABSTRACT: The study aimed to morphometric characterization the New Zealand White (NZW) doe at three different areas. The materials used were 295 heads of NZW doe rabbits from 29 farms located at different areas. Twelve morphometric characteristics consist of body weight, eight body measurements, and three-body indices. Data analysis was performed by Mixed model, Pearson's correlation, Principal component, and Canonical discriminant procedures. The most of parameters showed significant differences among areas. The heaviest body weight (4.71 kg) was observed in low-land and the lightest in medium land (3.54 kg). Most of the morphometric characters showed positive correlations with each other. Results of principal component show that the body indices of NZW doe raised in three different areas were similar. Canonical discriminant analysis showed that low-land was more favorable than high-land and medium land. In conclusion, The variation in size difference for morphometric characters of female New Zealand white rabbit could be explained by body index and thoracic index. The morphometric characteristics of New Zealand white doe raised in low-land area were superior to those raised in high-land and medium land areas.

Keywords: Body index, Eigenvalues, Least-square means, Phenotypic correlation, Thoracic index.

INTRODUCTION

New Zealand white (NZW) rabbit, the commercial breed has been imported from the American rabbit breeding association (Setiaji et al., 2022). The rabbits are raised by smallholders with the purpose of meat production, pet, and show. The important traits for meat production are average daily gain (ADG), slaughter weight (SW), carcass weight (CW) of bucks, and litter size (LS), liveability (LA), kidding interval (KI) of Doe. The average of ADG, SW, CW, LS, LA and KI reported in NZW rabbit are 20.40 g, 1.900 kg, 1.499 kg, 6.23, 90%, 109 days (Marai et al., 2008; Ghosh et al., 2008). Most buck is slaughtered, while the doe is used for breeding purposes. The population of doe is 80% of the total population of rabbits. Most of the breeding farm for New Zealand white rabbits in Indonesia is located in Central Java Province, and covers low-land to high-land areas (Blasco et al., 2017; Ume et al., 2018).

Morphometric characterizes are at times favored in light of the fact that measurements of body weight can be biased due to gut fullness (Obike et al., 2010). The quantitative characters have been used to perform morphometric were: chest circumference, chest depth, chest width, body length, head length, head width, tibia length, femoral length, humerus length, radius-ulna length, hip width, ear length, ear width. Multivariate analysis generally used for these trait to estimate phylogeny three (Brahmantiyo et al., 2006).

Theoretically, rabbits are well adapted and grew optimum in the high-land areas due to low air temperature and humidity. Rabbits are sensitive to high temperatures (>26°C) and relative humidity (>70%) (Silva et al., 2021). High temperature can significantly decrease growth and reproductive performance (Szendrö et al., 2018). This condition represents a problem in rabbit farming in the low-land areas. Closed-house system that can control temperature and humidity might solve the problem. No characterization of NZW rabbit at different areas have been published recently. The study can be carried out based on morphometric characteristics. The morphometric characteristics of the same breed from different populations have been reported in goats (Ouchene-Kelifi et al., 2018; Depison et al., 2020) and sheep (Dekhili, 2014; Markovic et al., 2019).

The characterization based on morphometric of rabbits is essential for any purpose, such as strategies of breeding or conservation, genetic improvement, and sustainable utilization of a breed. The aim of this study was to characterize the NZW doe at three different areas.

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MATERIALS AND METHODS

Ethical approval

The protocol was based on the standard rule of animal treating as appointed in the Republic of Indonesia's law, that is, number 41, 2014. This research was funded by Hibah Dana Penelitian Universitas Diponegoro Semarang with Contract No. 41/UN7.5.5.2/HK/2022.

Material

The number of NZW doe used in the study was 295 heads. The age of doe was grouped to be: 6 - <12 months (n=146); 12 - <18 months (n=79), and ≥18 months (n=70) for preliminary analysis. The doe was obtained from 29 farms located at different areas. The doe measured were not pregnant or lactating. The location of farm was classified based on the areas above sea level (a.s.l.) as follows: low-land, medium land, and highland. The detailed information of the data is presented in Table 1. The body measurement consist of body weight (BW); head length (HL); head width (HW); ear length (EL); thoracic circumference (TC); thoracic depth (TD); thoracic width (CW); hip-width (HP); and body length (BL). Body indices were calculated from body weight and body measurements as follow: index of body weight (IBW) = [BW/TD] x 100; body index (BI) = [BL/TC] x 100; and thoracic index (TI) = [TW/TD] x 100.

Table 1 - General Information of study areas.

Description	Low-land	Medium-land	High-land
Altitude (m.a.s.l)	<250	250-750	≥750
Number of farms	1	18	20
Number of doe	52	172	71
Type of house	Closed house	Open house	Open house
Type of cage	Individual cage	Individual cage	Individual cage
Feed	Complete feed	Complete feed + forage	Complete feed + forage

m.a.s.l: meters above the sea level.

Data analysis

All of the data analysis was performed using Statistical Analysis System (SAS) University Edition V.6 p.2. software (SAS, 2014). One-Way ANOVA procedure was used to estimate least-square means and analyze the effect of age on body measurement and body indices. A mixed procedure was used for analyzing the effect of areas on morphometric characteristics with the farm as a random effect. The Tukey-Kramer multiple comparisons was tested at 5% of probability. Pearson's correlation was used to estimate the phenotypic correlation among morphometric characteristics. Multivariate analysis was performed to determine principal components, canonical structure, and distribution mapping by using Principal component and Canonical discriminant methods.

RESULTS AND DISCUSSION

The least square means of morphometric characteristics are presented in Table 2. Preliminary analysis showed that age class only affected significantly BW, HL, and BL whereas; most morphometric characteristics were not significant differences among age classes. This result indicated that after six months of age, bones were growing slower or almost stopped. Masoud et al. (1986) reported that whole bone longitudinal growth of NZW doe was inclining after six months. According to the results, further analysis for morphometric characteristics was not separated into different classes of age.

Table 2 - Least-square means for morphometric characteristics of NZW doe

Parameters \ Age of doe		6 - <12 months		12 - <18 months		≥18 months		Pr > F
		Mean ± SE	CV (%)	Mean ± SE	CV (%)	Mean ± SE	CV (%)	
BW (kg)		3.64 ± 0.06	21.23	3.91 ± 0.08	18.82	4.00 ± 0.09	18.98	0.0178
Body measurement (cm)	HL	10.28 ± 0.11	13.09	10.84 ± 0.18	14.83	10.75 ± 0.13	10.21	0.0052
	HW	4.94 ± 0.05	11.13	4.93 ± 0.05	8.73	5.00 ± 0.06	9.59	0.7839
	EL	11.14 ± 0.08	8.68	11.39 ± 0.12	9.13	11.29 ± 0.11	7.99	0.3157
	TC	35.84 ± 0.30	10.04	36.27 ± 0.36	8.76	36.15 ± 0.36	8.38	0.1879
	TD	9.30 ± 0.10	13.64	9.40 ± 0.12	11.65	9.61 ± 0.11	9.94	0.7287
	TW	8.91 ± 0.09	12.18	8.95 ± 0.19	18.65	9.13 ± 0.15	13.85	0.2854
	HP	10.29 ± 0.10	11.42	10.34 ± 0.15	12.48	10.33 ± 0.14	11.44	0.0644
	BL	35.75 ± 0.24	8.03	37.00 ± 0.28	6.80	37.35 ± 0.25	5.71	0.0379
Body indices	IBW	39.51 ± 0.73	22.38	41.80 ± 0.90	19.04	41.81 ± 0.93	18.78	0.3323
	BI	100.47 ± 0.90	10.80	102.61 ± 1.09	9.44	103.89 ± 1.11	8.94	0.2617
	TI	97.41 ± 1.63	20.20	96.07 ± 2.25	20.77	95.51 ± 1.57	13.78	0.6848

BW: Body weight; HL: Head Length; HW: Head Width; EL: Ear Length; TC: Thoracic Circumference; TD: Thoracic Depth; TW: Thoracic width; HP: Hip Width; BL: Body Length; IBW: Index of body weight; BI: Body index; TI: Thoracic index; SE: Standard error; CV: Coefficient of variation.

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Table 3 presents the morphometric characteristics of NZW doe from different areas. All parameters showed significant different among areas, except HL, BL, and BI. The heaviest BW observed in NZW doe raised in low-land and the lightest one by NZW doe raised in medium land. Body measurement of NZW doe (TW and HP) raised in low-land showed superiority over that for NZW doe raised in medium and high-land. Whereas, HW, TC, and TD were similar between low-land and high-land. BI was not different between areas, while IBW and TI of low-land were similar to that of high-land but higher than medium land. These results indicated that environment manipulation could increase the performance of NZW doe. Agreed with Elamin et al. (2012) and Arandas et al. (2017) that morphometric characteristics are affected by management techniques environment, and feed quality.

A total of 66 phenotypic correlations were computed among morphometric characteristics, of which 39, 8, 3, 2 were positively significant (P<0.01); negatively significant (P<0.01); positively significant (P<0.05); and negatively significant (p<0.05), respectively as presented in Table 4. Meanwhile, a high phenotypic correlation (>0.60) was shown between BW and TC (0.69), TW (0.66), IBW (0.72); between TW and TC (0.65), HP (0.63), and between IBW and TI (0.68). High and positive correlations among morphometric characteristics can be indicated that they are pleiotropic (Luo et al., 2017).

Table 3 - Morphometric characteristics of NZW doe from different areas

Parameters	Areas	Low-land	Medium-land	High-land
BW (kg)		4.71 ± 0.34[a]	3.54 ± 0.08[c]	3.91 ± 0.11[b]
Body measurement (cm)	HL	10.81 ± 0.55	10.58 ± 0.16	10.72 ± 0.23
	HW	5.34 ± 0.22[a]	4.86 ± 0.06[b]	4.97 ± 0.08[ab]
	EL	11.07 ± 0.61	11.32 ± 0.14	11.05 ± 0.19
	TC	38.92 ± 1.73[a]	35.19 ± 0.42[b]	36.17 ± 0.56[ab]
	TD	10.26 ± 0.53[a]	9.15 ± 0.14[b]	9.53 ± 0.19[ab]
	TW	10.21 ± 0.43[a]	8.48 ± 0.12[c]	9.26 ± 0.18[b]
	HP	11.96 ± 0.21[a]	9.75 ± 0.08[c]	10.39 ± 0.12[b]
	BL	37.66 ± 1.57	36.22 ± 0.38	36.74 ± 0.50
Body indices	IBW	46.18 ± 3.25[a]	38.69 ± 0.90[b]	42.06 ± 1.29[a]
	BI	97.02 ± 4.91	103.60 ± 1.27	102.15 ± 1.77
	TI	99.95 ± 5.78[a]	93.15 ± 1.84[b]	99.67 ± 2.76[a]

BW: Body weight; HL: Head Length; HW: Head Width; EL: Ear Length; TC: Thoracic Circumference; TD: Thoracic Depth; TW: Thoracic width; HP: Hip Width; BL: Body Length; IBW: Index of body weight; BI: Body index; TI: Thoracic index; SE: Standard error; CV: Coefficient of variation.

Table 4 - Phenotypic correlation among morphometric characteristics of NZW doe

	BW	HL	HW	EL	TC	TD	TW	HP	BL	IBW	BI
HL	0.19**										
HW	0.52**	0.10									
EL	0.01	0.14*	0.04								
TC	0.69**	0.19**	0.46**	0.04							
TD	0.42**	0.14*	0.32**	-0.14*	0.41**						
TW	0.66**	0.17**	0.55**	-0.02	0.65**	0.39**					
HP	0.58**	0.19**	0.55**	-0.08	0.54**	0.39**	0.63**				
BL	0.59**	0.17**	0.29**	0.13*	0.35**	0.31**	0.34**	0.28**			
IBW	0.72**	0.11	0.30**	0.07	0.44**	-0.27**	0.43**	0.34**	0.37**		
BI	-0.21**	-0.04	-0.22**	0.08	-0.69**	-0.17**	-0.36**	-0.29**	0.42**	-0.13*	
TI	0.21**	0.03	0.17**	0.05	0.21**	-0.49**	0.52**	0.23**	0.01	0.68**	-0.19**

BW: Body weight; HL: Head Length; HW: Head Width; EL: Ear Length; TC: Thoracic Circumference; TD: Thoracic Depth; TW: Thoracic width; HP: Hip Width; BL: Body Length; IBW: Index of body weight; BI: Body index; TI: Thoracic index; *: significant at 0.05 levels; **: significant at 0.01 levels.

Table 5 shows the summary of the principal component analysis including eigenvalues and percent of the variance. The results explained 62.22%, 52.20%, and 88.87% of the total phenotypic variance in low-land, medium-land, and high-land, respectively. Ajayi and Oseni (2012) extracted two principal components from twelve body measurements of Nigerian rabbits which explained 55.55% of the total phenotypic variance. PC1 loaded heavily on TI in NZW doe raised in all over areas, PC2 loaded heavily on BI in low-land and high-land, then BI and TI in medium-land. The characteristics strongly correlated with each PC same among three areas implying that their morphometric characteristics were not differed genetically. This study shows that the body indices of NZW doe raised in three different areas were similar.

Squared distances of canonical discriminant between areas and their probability are presented in Table 6. The result indicates that despite the doe belonging to the same breed, there are differences among areas. The distance between

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land-land and medium-land was longer than that between low-land and high-land. As shown in Figure 1, low-land was more favorable than high-land and medium-land. Meanwhile, medium-land was near to low-land. The result was not in accordance with Depison et al. (2020) studied Kacang goats with the same management but raised at two different locations (low-land and high-land). They reported that morphometric characteristics cannot characterize the goats from low-land and high-land. The results of a recent study could be due to intensive management done in the low-land areas. It leads morphometric characteristics of NZW doe raised in low-land similar even exceed to their raised in high-land.

Table 5 - Eigenvalues, total variences and cumulative of Principal component analysis

Parameters	Low-land		Medium-land		High-land	
	PC1	PC2	PC1	PC2	PC1	PC2
BW	0.0179	0.0072	0.0051	-0.0039	0.0074	0.0042
HL	0.0138	-0.0026	-0.0079	-0.0109	0.0061	-0.0063
HW	0.0111	-0.0092	0.0122	0.0007	-0.0002	0.0038
EL	0.0112	0.0385	0.0099	0.0109	-0.0005	0.0142
TC	0.0603	-0.2025	0.1131	-0.1517	0.0225	-0.1976
TD	-0.0458	-0.0256	-0.0314	-0.0531	-0.0271	-0.0183
TW	0.0473	-0.0254	0.0409	-0.0022	0.0254	-0.0219
HP	0.0087	-0.0495	0.0149	-0.0051	0.0074	-0.0119
BL	0.0291	0.1708	-0.0709	0.1033	0.0015	0.1437
IBW	0.3825	0.0052	0.1999	0.1805	0.3139	0.1582
BI	-0.0735	0.9429	-0.5483	0.8031	-0.0577	0.9560
TI	0.9158	0.0052	0.7989	0.5345	0.9466	0.0105
Eigenvalues	118.59		178.65		1005.08	
Variance (%)	62.22		52.20		88.57	

BW: Body weight; HL: Head Length; HW: Head Width; EL: Ear Length; TC: Thoracic Circumference; TD: Thoracic Depth; TW: Thoracic width; HP: Hip Width; BL: Body Length; IBW: Index of body weight; BI: Body index; TI: Thoracic index; PC1: first principal component; PC2: second principal component.

Table 6 - Result of canonical discriminant: squared distance to areas (above diagonal) probability for squared distance (below diagonal)

	Low-land	Medium-land	High-land
Low-land		9.2652	4.9586
Medium-land	<0.0001		1.3431
High-land	<0.0001	<0.0001	

BW: Body weight; HL: Head Length; HW: Head Width; EL: Ear Length; TC: Thoracic Circumference; TD: Thoracic Depth; TW: Thoracic width; HP: Hip Width; BL: Body Length; IBW: Index of body weight; BI: Body index; TI: Thoracic index; *: significant at 0.05 levels; **: significant at 0.01 levels.

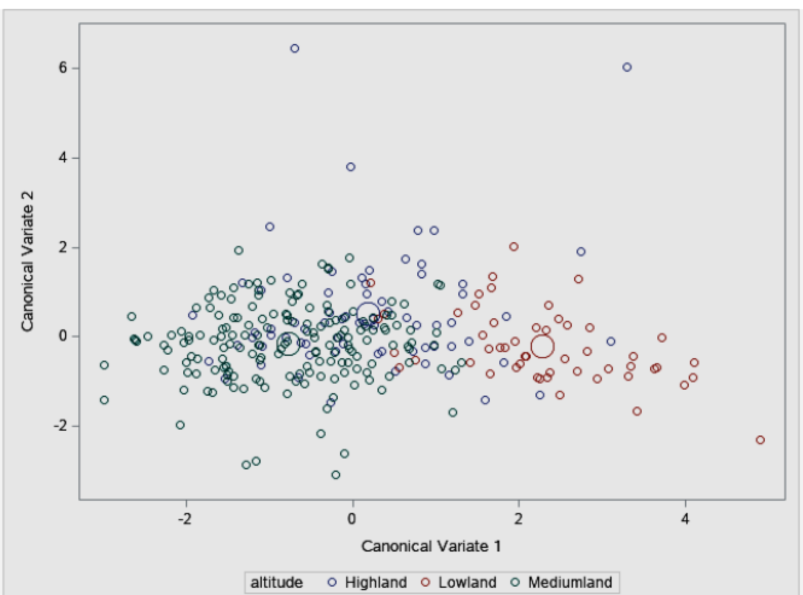

Figure 1 - Distribution mapping from NZW doe from different area based of morphometric characteristics.

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CONCLUSION

The variation in size difference for morphometric characters of female New Zealand white rabbit could be explained by BI and TI. The morphometric character of rabbits raised in low-land was dominant than others. The intensive management done in low-land areas might caused the morphometric characteristics of New Zealand white superior to those raised in high-land and medium-land.

DECLARATIONS

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Authors' contribution

E Kurnianto: Idea and research design; S Sutopo and ME NOVIANTI: Data collection; A Setiaji: Data analysis and Writing the manuscript; DA Lestari: Writing the manuscript.

Conflict of interests

The authors have not declared any conflict of interests.

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