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Research article

SOURCES OF SHARED VARIABILITY IN BODY WEIGHT AND LINEAR BODY MEASUREMENT TRAITS OF TWO BREEDS OF RABBIT

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ABSTRACT: Records obtained from two breeds of rabbit; New Zealand White and Chinchilla were used in the study. Body weight, nose to shoulder length, shoulder to tail length, heart girth, trunk length and length of ear were the parameters measured. The objective of the study was to assess variability among body weight and linear body measurement traits of the rabbit breeds and hence, deduce the components that best describe body weight using factor analysis.Correlation coefficient between body weight and linear body measurements in the New Zealand White rabbit ranged from 0.723 to 0.931and 0.713 to 0.938 in the Chinchilla rabbit, respectively. The shares of total variance of the first two principal factors were55.6% and 32.7% for New Zealand White rabbit, and 50.8% and 35.3% in the Chinchilla rabbit respectively. Together the first two factors accounted for 88.2% and 86.1% of the total variability in the New Zealand White and Chinchilla rabbits, leaving 11.8% and 13.9% as unique factors respectively. The first factor in all the breeds accounted for the greatest percentage of the total variability and hence, was representative of body weight.
Keywords: Factor analysis, Body weight, Linear body measurements, New Zealand White, Chinchilla.

INTRODUCTION

The relationship between live body weight and body dimensions is very useful in the prediction of live body weight of animals. According to Ozoje and Mgbere [1] the final body weight of animals is really a reflection of the sum total of the weight of all its component parts. This means that a change in any one of the component parts could impart positively or negatively on the final body weight depending on the direction of the change. Olutogun *et al.*[2] posited that, body dimension traits tend to increase as body weight increases. Data obtained from such relationships are therefore useful tools for breeders in selecting animals destined for use as breeding stock [3], and also in predicting body weight without resulting to animal slaughter.

Most studies on relationships between body dimensions and live body weight use univariate and bivariate analyses. This is however limiting because body traits are interrelated both phenotypically and genetically [4, 5, 6]. Multivariate analysis for such traits is the way forward since it considers not only their linear relationship, but also their interdependence on each other. One way of carrying out multivariate analysis involves the use of factor analysis (FA) which basically, is a means of extracting or finding a smaller number of factors, or unobservable variables, that best explain most of the data variability and yet, makes a contextual sense.

Many workers have used independent factor scores derived from multivariate technique of factor analysis in body morphological data analysis [7, 8, 9] and as a selection criterion for the improvement of body size [10]. However, this has not been widely exploited in Nigeria. The objective of this study therefore was to evaluate the sources of shared variability in New Zealand White (NZW) and Chinchilla (CH) rabbit breeds, and to deduce factors that best describe their body conformation traits.

MATERIALS AND METHODS

Source of data

Records obtained from NZW and CH rabbits were used for this study. The kits used were born over a nine month period and represented progenies of 6 and 18 NZW and CH sires and dams (3 sires and 9 dams per breed). The animals were from the experimental farm of the Department of Animal Production of the Federal University of Technology Minna, Niger State, Nigeria.Minna is located between latitude 9^{o}37' north and longitude 6^{o}32' east of the equator. The altitude is 853 feet (260 m) above sea level. Annual precipitation averages 1312mm with a mean temperature of between 19^{o}C and 37^{o}C. The mean relative humidity is between 21 – 73% [11].

Management of experimental rabbits

Records were collected from the kits as from 21-d when they started coming out of the kindling boxes. The kits were tattooed using indelible marker and housed in groups (i.e according to breed) in well ventilated and shaded hutches. The dimension of each hutch was 75 (length) x 75 (width) x 50 cm (height). The hutches were raised on wooden legs about 60cm above the ground level.The kits received feed and water *ad libitum* from 21-d to 49-d,the diet containing approximately 16% crude protein and metabolizable energy of 2775kcal kg^{-1}. *Tridax procumbens and* legume hay were given as fibre supplement. The kits were maintained under similar management conditions as the experiments occurred concurrently.

Traits measured

Body weight (g) and body dimensions (cm) were recorded for each kit at 21, 35 and 49-d of age. The following measurements were considered: nose to shoulder length (NTS, distance from the nose to the point of the shoulder);shoulder to tail length (STL,distance from the point of the shoulder to the pin bone or the end of coccygeal vertebrate); heart girth (HG, body circumference just behind the fore limbs);trunk length (TL,measured as the longitudinal distance from the point of the shoulder to the tuberosity of the ischium)and length of ear (LE, distance from the point of attachment of the ear to the tip of the ear).

Statistical analysis

Data collected from the experiment were analyzed using the multivariate analysis procedure of MINITAB statistical package [12]. The multivariate technique involved the use of factor analysis on body weight and the original five linear body measurements of the rabbits. Pearson coefficient of correlation (r) among body weight and linear body traits were estimated. For each breed, the data was subjected to factor analysis. The purpose of carrying out factor analysis was to reduce a set of *p* variables to a set of *m* underlying super ordinate dimensions. These underlying factors were inferred from the correlations among the *p* variables and each factor is estimated as a weighted sum of the *p* variables [13]. The $_i{}^{th}$ factor is thus;

$$F_i = W_{i1}X_1 + W_{i2}X_2 + \dots W_{ip}X_p$$

The *p* variables may also be expressed as a linear combination of *m* factors.

$$X_j = A_{1j}F_1 + A_{2j}F_2 + \dots A_{mj}F_m + U_j$$

Where U_j= variance that is unique to variables (that is, variance that cannot be explained by any of the common factors).

The first factor in the result contained the greatest portion of the original variation while the second factor normally has those traits that showed close variability not shown in the first factor. Subsequent factors were mutually orthogonal to those preceding and to one another and contained less variation.The total variance of a variable is equal to unity and can be written in the form of common variance "communalities" and unique variance" uniqueness". The communality represent the portion of the variable variance accounted for by all common factors and the uniqueness represent the portion of the variable variance not ascribable to its correlation with other variables [14] and hence attributed to that particular variable.

RESULTS AND DISCUSSION

The means, standard deviations and coefficient of variability for live weight and body dimensions at 7 weeks of age for the breed groups is presented in Table I. In NZW, the average body weight at 7 weeks was 424.92g and 323.43g in the CH. Values for the other parameters NZW versus CH were: 11.10 versus 10.49cm (NTS), 22.18 versus 19.46cm (STL), 15.45 versus 14.16cm (HG), 18.32 versus 16.08cm (TL) and 7.95 versus 7.10cm (LE). The mean values for body weight and body dimensions at 49-d compare favourably with earlier reports for rabbits in Nigeria [15, 16, 17].In the NZW, body weight varied more (CV of 42.44%) while HG had the least variation (CV of 9.15%). Shank length varied more in the CH (CV of 29.89%) compared to the other measurements. Variations in NTS and SL in NZW were lower than the corresponding variations in the CH, while CH had lower values in STL, HG and TL compared to the NZW. Shahin and Hassan [14] reported more variation in the body weight of New Zealand White rabbit compared to Red Baladi and Black Baladi rabbits, respectively in Egypt. The skeletal dimensions (NTS, STL, TL and LE) were more variable (CV ranged from 13.19% to 26.96%) than the flesh dimension (HG with a CV range of 4.99% to 9.15%).The higher variability reported for LE contradicts the report of Yakubu and Ayoade [8] from their work with crossbred rabbits.

The correlation coefficients among the original interdependent variables of the two breeds of rabbit are presented in Table 2. Positive and significant ($p<0.01$) correlations were observed between body weight and the five body dimension traits measured. Shoulder to tail length (r = 0.931 for NZW and r = 0.938 for CH) were found to have the highest correlation with body weight. The lowest correlation were those observed between NTS and HG (r = 0.723 for NZW) and, TL and LE (r = 0.713 for CH). Generally, correlation between body weight and the five original interdependent variables were observed to be high in the two breeds of rabbit. This is in agreement with earlier findings [4, 18, 14]. Lukefahr and Ozimba [18] reported a correlation of 0.57 between body weight and body length which is much lower than the values recorded for all body length attributes in this study (r = 0.812 to 0.938).

Table 3 present the result of the factor analysis in the two breeds of rabbit. Two common factors (varimax rotated independent factors) were identified in all the breeds which corresponded to 88.2% and 86.1% of the total variability of the original six variables in the NZW and CHrabbits, respectively. This left 11.8%and 13.9% to the unique factors. The first factor (F1) ('general size') was characterized by high positive loadings on all body traits other than HG in the NZW (0.494) and TL in the CH (0.454), respectively. The first factor 'general size' accounted for 55.5% of the variance in NZW rabbit and for 50.8% in CH rabbit. The coefficient associated with STL dominated the first factor in the NZW while BW dominated the first factor in CH rabbits, respectively. These are good estimators of body size. The second factor in the NZW (HG) was also characterized by high positive loadings on all body traits other than NTS (0.401) which was lower. In the CH, the second factor (TL) was characterized by negative loadings on all body dimensions with LE (-0.402) having the highest loadings. The result obtained here are similar to those reported by Shahin and Hassan [14] except that negative second factor loadings were observed for CH rabbit.

Table 1.Means, standard deviations (SD) and coefficients of variation (CV %) for body weights and linear body measurements of two rabbit breeds at 7 weeks

	New Zealand White			Chinchilla		
Parameter	Mean	SD	CV	Mean	SD	CV
BW	424.92	180.31	42.44	323.43	80.39	27.33
NTS	11.10	2.12	19.11	10.49	2.83	26.96
STL	22.18	4.24	19.13	19.46	3.54	18.17
HG	15.45	1.41	9.15	14.16	0.71	4.99
TL	18.32	3.54	33.28	16.08	2.12	13.19
LE	7.95	1.41	17.79	7.10	2.12	29.89

BW = body weight; NTS = nose to shoulder; STL = shoulder to tail; HG = heart girth;
TL = trunk length; LE = length of ear.

Table 2.Correlation coefficients between live body weight and body dimensions of the New Zealand White rabbit

New Zealand White						
Body weight (BW)	**1**					
Nose to shoulder (NTS)	0.812	**1**				
Shoulder to tail (STL)	0.931	0.837	**1**			
Heart girth (HG)	0.880	0.723	0.841	**1**		
Trunk length (TL)	0.899	0.832	0.923	0.829	**1**	
Length of ear (LE)	0.846	0.756	0.881	0.782	0.802	**1**
Chinchilla						
Body weight (BW)	**1**					
Nose to shoulder (NTS)	0.818	**1**				
Shoulder to tail (STL)	0.938	0.811	**1**			
Heart girth (HG)	0.837	0.773	0.812	**1**		
Trunk length (TL)	0.812	0.856	0.833	0.749	**1**	
Length of ear (LE)	0.856	0.728	0.840	0.766	0.713	**1**

All correlation coefficients were highly significant ($p<0.01$).

The communalities for the various traits are presented in Table 3. The variance of each trait was partitioned into a common portion shared with some or all of the other traits, and a uniqueness portion, that is unique to that particular trait and therefore, is not shared with any of the other traits. Variation in the traits was brought about by 74% to 100% of the common factors in the two rabbit breeds while, 0% to 16% of the variation could be attributed to unique factors specific to each of the traits. The communality for the traits in the NZW ranged from 0.735 (NTS) to 1.000 (HG), while it was 0.738 (HG) to 1.000 (TL) in the CH. Heart girth (NZW) and trunk length (CH) had the highest communality with no uniqueness of their own in the rabbits. About 100% of the variation in heart girth and trunk length was brought about by common factors whereas 0% of their variations were contributed by the unique factors specific for these traits in the rabbits. The relatively low proportion of the unique variance for heart girth and trunk length in the rabbits could therefore not be totally related to any differential functional needs placed on them. The values of communality observed for the traits are similar to those reported by Shahin and Hassan [14] and Ogah [19].

The results of the predictive equations relating body weight in the two rabbit breeds to the five interdependent body dimension variables are presented in Table 4. It showed that, 65.9% of the variability in live weight was accounted for by NTS alone in the NZW rabbit.

The magnitude of the variation increased from 87.0% to 90.4% when the other independent traits (STL, HG, TL and LE) were added. In the CH, 67.0% of the variability in live weight was accounted for by NTS alone. The magnitude of the variation also increased, from 89.0% to 90.8% when the other independent traits (STL, HG, TL and LE) were added in the equation. These results indicate that body weight can be predicted accurately from NTS, STL, HG, TL and LE which when combined, accounted for as much as 90.4% and 90.8% of the variation in live body weight in the NZW and CH rabbits. This is similar to the findings of Yakubu *et al.* [20] and Ajayi *et al.* [21] who obtained the best predictive equation based on R^2 value when they used five variables in their equation models. The final regression equation for estimating live body weight from the original body dimensions are:
New Zealand White (g) = -644.2 + 6.4NTS + 23.7STL + 22.3HG + 7.0TL
Chinchilla (g) =-440.8 + 7.3NTS + 22.7STL + 10.0HG + 0.2TL + 14.3LE

Table 3.Explained variations associated with rotated factor analysis along with communalities and unique factors for each trait in rabbit

	Common factor		Communality	Unique factor
Trait	1	2		
New Zealand White				
Body weight (BW)	0.761	0.580	0.915	0.085
Nose to shoulder (NTS)	0.758	0.401	0.735	0.265
Shoulder to tail (STL)	0.860	0.479	0.968	0.032
Heart girth (HG)	0.494	0.870	1.000	0.000
Trunk length (TL)	0.793	0.503	0.883	0.117
Length of ear (LE)	0.753	0.472	0.789	0.211
Variance	3.3317	1.9597	5.2914	
% of total variance	0.555	0.327	0.882	
Description	General size	HG		
Chinchilla				
Body weight (BW)	0.856	-0.476	0.958	0.042
Nose to shoulder (NTS)	0.590	-0.660	0.784	0.216
Shoulder to tail (STL)	0.802	-0.526	0.919	0.081
Heart girth (HG)	0.715	-0.477	0.738	0.262
Trunk length (TL)	0.454	-0.891	1.000	0.000
Length of ear (LE)	0.781	-0.402	0.771	0.229
Variance	3.0492	2.1208	5.1701	
% of total variance	0.508	0.353	0.862	
Description	General size	TL		

Table 4.Predictive multiple regression (stepwise) equations relating live body weight to original body dimensions in rabbit

Step	Independent variable (predictor)	Intercept	Regression coefficient	SE	R^2	Independent variable (predictor)	Intercept	Regression coefficient	SE	R^2
	New Zealand White					**Chinchilla**				
1.	Nose to shoulder	-467.7	80.4	90.3	0.659	Nose to shoulder	-335.1	62.8	63.2	0.670
2.	Nose to shoulder	-575.7	10.9	56.2	0.870	Nose to shoulder	-411.2	13.1	36.9	0.889
	Shoulder to tail		39.7			Shoulder to tail		30.7		
3.	Nose to shoulder	-652.6	8.8	49.4	0.901	Nose to shoulder	-466.1	8.3	35.5	0.899
	Shoulder to tail		27.5			Shoulder to tail		26.9		
	Heart girth		23.9			Heart girth		12.7		
4.	Nose to shoulder	-644.2	6.4	49.3	0.904	Nose to shoulder	-466.1	8.5	35.8	0.899
	Shoulder to tail		23.7			Shoulder to tail		26.9		
	Heart girth		22.3			Heart girth		12.7		
	Trunk length		7.0			Trunk length		-0.3		
5.	Nose to shoulder	-641.2	5.8	49.6	0.904	Nose to shoulder	-440.8	7.3	34.6	0.908
	Shoulder to tail		21.3			Shoulder to tail		22.7		
	Heart girth		21.6			Heart girth		10.0		
	Trunk length		7.6			Trunk length		0.2		
	Length of ear		7.0			Length of ear		14.3		

SE = standard error; R^2 = coefficient of determination

CONCLUSION

In conclusion, factor analysis explored the interdependence of the variables by analysing them together rather than independently. Results from the study indicated that body weight could be predicted accurately from linear body measurements which when combined, accounted for most of the variation in body weight.

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