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Prediction of body weight in rabbits using Principal Component Factor Scores in Multiple Linear Regression Model

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Abstract. The aim of this study was to predict body weight from body measurements (body length, heart girth, height at withers and ear length) of 100 mature female rabbit using principal component factor scores and multiple regression analysis. Pearson correlation coefficients among the variables were highly significant (p<0.01) and ranged from 0.65 to 0.84. Only one component with eigenvalue greater than 1 was extracted which accounted for 77.23 % of the total variance. Stepwise multiple regression analysis showed that body length alone predicted body weight of rabbits with accuracy of 71.30 % while in combination with other independent variables, the accuracy of body weight prediction in rabbits increased to 84.20 %. Principal component factor scores explained 83.70 % of the variation in the body weight of rabbits. The principal component based prediction model is more reliable than the interdependent based models because it eliminates multicollinearity which might be present if interdependent variables are combined in a multiple regression model.
Key Words: Body weight, body measurements, orthogonal traits, rabbits, stepwise multiple regression.

Introduction. The domestic rabbits are characterized by fast growth rate, high reproductive rate, early sexual maturity and ability to rebreed shortly after kindling (Orheruata et al 2006). Rabbit meat is nutritious, high in protein, low in fat and cholesterol (Cheeke et al 2000). These qualities make rabbit production the panacea to animal protein deficiency in developing countries (Obike et al 2010). Body weight and body measurements are good indicators of growth performance in domestic animals including rabbits. Body weight and body measurements are used to characterize rabbit breeds, contrast variation in size and shape (Shahin & Hassan 2000) and estimate carcass and body weight (Oliveira et al 2005). Usually size is measured as body weight while shape is described by several body measurements or visual appraisal (Zarneccki et al 1987). Akanno & Ibe (2005) reported genetic and phenotypic correlations among body measurements of rabbits. Chineke (2005) observed positive and significant relationship between body weight and body measurements in rabbit breeds and crosses. Similar findings were reported by Chineke (2000), Tiamiyu et al (2000), and Ebegbulem (2012).

The presence of linear relationships among predictor variables is termed multicollinearity (Shahin & Hassan 2000). Multicollinearity occurs because two or more variables measure essentially the same thing and this leads to unreliable results from multiple regression analysis. Multicollinearity is drastically reduced by adopting ridge regression or principal component analysis. Information on the use of multivariate technique to describe the relationship between body weight and linear measurements in rabbits under Nigerian condition is scanty. However, Yakubu & Ayoade (2009) used PCA to describe the relationship among morphological traits in New Zealand white x Chinchilla rabbits and to predict body weight from principal component scores in multiple regression analysis. The authors concluded that principal component based prediction model was preferable to linear measure based models for predicting body weight of rabbits. The objective of this study was to describe the relationship between body weight and body measurements of chinchilla rabbits using principal components and to predict body weight based on the original and orthogonal traits.

Material and Method

Study location. The study was conducted at the rabbitry unit of teaching and research farm, Department of Animals Science, Delta State University, Asaba Campus. The study area is located between longitude 60^0 45^1 East and latitude 60^0 12^1 North.

Experimental animals and their management. One hundred and twenty Chinchilla rabbits made up of 100 females and 20 males aged 6 months were available for the study. However, only 100 female rabbits were used for data collection. The animals were housed in individual cages in a well ventilated rabbit building. Each cage was fitted with an aluminum feeder and drinker. The animals were fed with pelleted food containing 16% CP (Crude Protein) free choice. *Panicum maximum* and *Centrosema pubescens* were also provided free choice. Fresh clean drinking water was available *ad libitum*.

Traits measured. The following body measurements were taken at 6 months of age according to the methods of Chineke (2005).
Bodyweight: measured with a weighing scale in grams.
Body length: horizontal distance from the front point of the withers to the pin bone.
Heart girth: measured as body circumference just behind the fore leg.
Height at withers: measured on the dorsal midline at the highest point on the withers.
Ear length: the distance from the base of attachment of the ear to the head to the tip of the ear.

All measurements were taken in the morning before feeding of animals by the same person to avoid variations in values (Shawulu & Ajayi 2011).

Statistic analysis. Mean, standard deviation and coefficient of variation of body weight and body measurements were calculated and the correlation matrix obtained. Kaiser Meyer-Olkin (KMO) measure of sample adequacy and Bartletts test of sphericity were computed to test the suitability or appropriateness of the data to principal component analysis. Bartletts test of sphericity tested the null hypothesis that the correlation matrix was an identity matrix. If it is so, it means that PCA is not appropriate. The aim of principal component analysis is to summarize data with many independent variables to a smaller set of derived variables in such a way that the first component has maximum variance, followed by second, third and so on.

Body weight of rabbits was predicted from body measurements and from principal component factor scores using the following stepwise multiple regression models described by Yakubu et al (2009) and Ogah (2011).

$$BWT = a + B_i X_i + \ldots\ldots\ldots\ldots. + B_k X_k \ldots\ldots\ldots\ldots\ldots. (a)$$
$$BWT = a + B_i PC_i + \ldots\ldots\ldots\ldots + B_K PC_K + \ldots\ldots\ldots\ldots (b)$$

Where BWT is the body weight, a is intercept, B_i is the i^{th} partial regression coefficient of the i^{th} linear body measurements, X_i or the i^{th} principal component (PC).

The factor program of SPSS 16 (2007) statistical package was used for the principal component analysis.

Results and Discussion. Table 1 presents the descriptive statistics of body weight and linear body measurements of Chinchilla rabbits. The mean body weight of rabbits at 6 months of age was 2.05 kg. Body weight of rabbits had the highest variability, followed by heart girth, and at least by body length. Shahin & Hassan (2002) reported that body weight of rabbits was more variable than any other body measurements while Hassan et al (2012) reported high coefficient of variation for body weight and height at withers and moderate for heart girth. The difference in the coefficient of variability of the body traits is attributable to differences in the environmental conditions the animal experienced.

Table 1

Descriptive statistics of body weight (kg) and linear body measurements (cm) of rabbits

Traits	*Mean*	*SD*	*CV*
Body weight	2.05	0.30	14.80
Body length	43.68	2.17	4.96
Heart girth	24.98	2.00	8.00
Height at withers	14.49	0.80	5.49
Ear length	10.56	0.73	6.90

SD - standard deviation, CV - coefficient of variation %

Pearson coefficients of correlation between body weight and body measurements are shown in Table 2.

Table 2

Pearson correlation coefficients between body weight and linear body measurements in rabbits

Traits	*BW*	*BL*	*EL*	*HG*	*HW*
BW	-	-	-	-	-
BL	0.84**	-	-	-	-
EL	0.80**	0.74**	-	-	-
HG	0.84**	0.76**	0.71**	-	-
HW	0.75**	0.66**	0.65**	0.65**	-

** Correlation is significant at the 0.01 level (2-tailed), BW – body weight, HW - height at withers, BL - body length, EL - ear length, HG - heart girth.

Positive and highly significant ($p<0.01$) coefficients of correlation were obtained among the variables which ranged from 0.65 to 0.84. This implies high predictability among the variables. A similar observation was reported by Yakubu & Ayoade (2009) in New Zealand white x Chinchilla rabbits. The results of Kaiser - Meyer Olkin (KMO) measure of sampling adequacy (0.84) and Bartletts test of sphericity (Chi-square 167.87, $p<0.01$) showed that the sample size is adequate for PCA.

The summary of principal component analysis is presented in Table 3.

Table 3

Summary of principal component analysis

Variables	*Component*	*Communality*	*Component scores*
Body length	0.901	0.813	0.292
Ear length	0.884	0.782	0.286
Heart girth	0.890	0.792	0.288
Height at withers	0.838	0.702	0.271
Eigenvalue	3.089	-	-
% of total variance	77.23	-	-

The communalities ranged from 0.702 to 0.813 implying that each variables variance was well represented in the extracted components and hence PCA adequate. Only one principal component with eigenvalue greater than 1 was extracted after PCA, accounting for 77.23 % of the total variation in the original variables. The component could not be rotated because it defined only one dimensional space. The component represents the body dimension of rabbits. All the variables loaded strongly on the component showing the very high correlation between the two. The implication of this is that any of the body measurements could serve as a good predictor of body weight of rabbits. In a study by Yakubu & Ayoade (2009) two principal components were extracted which explained 90.27 % of the total variance. PC_1 was highly correlated with body length, heart girth and thigh circumference while PC_2 was associated with ear length. The authors concluded that PC_1 was good estimator of general size. Similar finding was reported by Shahin & Hassan

(2000) in New Zealand white rabbits. The component score coefficients used to obtain principal component factor score for the prediction of body weight of rabbits ranged from 0.271 to 0.292 (Table 3).

The results of stepwise multiple regression analysis for predicting body weight from the original body measurements and their principal component factor score is presented in Table 4.

Table 4

Stepwise multiple regression of body weight on the original body measurements and their principal component

Variables	*Models*	R^2 *(%)*	*S.E.*
	Body measurements		
BL	BW = -5.801 + 0.188BL	71.30	0.34
BL, HG	BW = -4.752 + 0.113BL + 0.086HG	79.70	0.29
BL, HG, EL	BW = -4.842 + 0.081BL + 0.066HG + 0.185EL	83.20	0.26
BL, HG, EL, HW	BW = -4.920 + 0.073BL + 0.059HG + 0.159EL + 0.06HW	84.20	0.26
	Orthogonal trait		
PC1	BW = 2.672 + 0.575PC1	83.70	0.26

Body length alone predicted body weight of rabbits with 71.30 % accuracy. Addition of heart girth increased the accuracy of body weight prediction in rabbits to 79.70 %. This implies that body weight of rabbits could be predicted with a high degree of accuracy from body length and heart girth. Similar observation were reported by Obike et al (2010), Oke et al (2011) in rabbits, Taye et al (2012) in sheep, and Okpeku et al (2011) in goats. The combination s of body length, heart girth and ear length in the stepwise multiple regression model predicted body weight of rabbits with accuracy of 83.30 %. The best prediction equation (R2 = 84.20 %) was given by the combinations of body length, heart girth, ear length and height at withers. Principal component factor score predicted body weight of rabbits with accuracy of 83.70 % which is very close to the accuracy of prediction when the four variables were combined in a stepwise multiple regression model. The advantage of using principal component factor score over interdependent variables is that it circumvents multicollinearity which may occur when two or more variables are used as predictors in a multiple regression model. Multicollinearity causes unstable estimates of regression coefficients and unreliable predictions. Malau-Aduli et al (2004) suggested the use of principal component analysis and ridge regression to overcome the problem of multicollinearity in a multiple regression models.

Conclusions. Principal component analysis was used to summarize four interdependent variables into one principal component that describe the body dimension of rabbits. The principal component factor score predicted body weight of rabbits with accuracy of 83.70 % thereby circumventing multicollinearity which might occur when the interdependent variables are combined in a multiple regression model.

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