www.abiosci.com

RESEARCH ARTICLE

Annals of Biological Sciences
2014, 2 (1):1-6

ISSN: 2348-1927

Prediction of bodyweight from body measurements in rabbits using principal component analysis

O.M.Akinsola[1], B.I.Nwagu[2], M.Orunmuyi[1], G.T.Iyeghe-Erakpotobor[2], E.D.Eze[3] O.T.F.Abanikannda[4], O.Onaadepo[5], E.U.Okuda[1]and U.Louis[6]

[1]Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria
[2] National Animal Production Reseach Institute, Shika, Kaduna State, Nigeria
[4] Department of Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Bingham University, Karu, Nasarawa State, Nigeria
[4]Department of Zoology, Faculty of Science, Lagos State University, Ojo Lagos, Nigeria
[5]Department of Physiology, Faculty of Basic Medical Sciences, College of Health Sciences University of Abuja, Abuja, Nigeria
[6]Department of Biology, School of Sciences, Federal College of Education, Katsina, Katsina State, Nigeria

---

ABSTRACT

The study aimed at describing objectively the interdependence among the biometric traits and to predict body weight from their orthogonal body shape characters using principal component factor analysis. Body weight and ten biometric variables namely body length, height at wither, thigh circumference, shoulder to tail drop, ear length, heart girth, tail length, length of front and back leg and nose to shoulder were measured on eight week old 104 F_1 progeny Hyla rabbits of two genetic groups (NZWXNZW purebred and NZWXCAL crossbred rabbits). General linear model and principal component analysis procedure of statistical analysis system (S.A.S 9.0) was used to compute the variations between the two breeds. Pair wise correlations between bodyweight and biometric traits were positive and highly associated ($r = 0.60$-0.90, 0.62–0.94; $P<0.01$) for Hyla purebred and crossbred rabbits. In the factor solution of the principal component analysis, with varimax rotation of the transformation, two factors were identified for the first genetic group and three factors for the second genetic group (ratio of variance = 83.97 and 89.88% for NZWXCAL crossbred and NZWXNZW purebred rabbits respectively). The first factor in each case accounted for the greatest percentage of the total variation, and was termed general size. The subsequent factors (indices of body shape) presented patterns of variation independent of general size. The principal component based regression models, which are preferable for selecting animals for optimal balance, accounted for 88% of the variation in the body weight for both Hyla purebred and crossbred rabbits respectively.

Keywords: Biometric traits, principal component analysis, multivariate analysis, statistical methods

---

INTRODUCTION

Rabbits can be considered as one of the several species quite suitable for meat production. They are characterized by quality protein (20 - 21%) with high biological value amino acids, meat low in calories and fat, prolificacy, short gestation length, initial capital outlay is minimal, great genetic flexibility, lipids are highly unsaturated (60% of the total fatty acids), valuable animal model for biomedical research, low sodium and cholesterol level and it is considered a delicacy for health food products [1].

Breed characterization of livestock is the first approach to a sustainable use of its animal genetic resource [2]. The first knowledge of the characterization of local genetic resources falls on the knowledge of the variation of morphological traits [3]. Morphometric measurements have been found useful in contrasting size and shape of animals [4]. However, correlations between linear body measurements are modeled as bivariates rather than multivariates. This is because of the interrelatedness or lack of orthogonality (collinearity) of the independent variables which increase the noise of the variables. To address this instability, multivariate analysis of data sets such as the use of principal component factor technique becomes imperative.

Principal components are a weighted linear combination of correlated variables, explaining a maximal amount of variance of the variables [5].This aids in data reduction, and breaks multicollinearity which may lead to a wrong inference. In spite of the rich genetic resource base on imported Hyla rabbits, there is dearth of information on its characterization using multivariate analysis. Therefore, the present study aimed at describing objectively body shape of imported Hyla rabbits using principal component factor analysis.

Hypothesis

H_o = Relationships involving body measurements and body weight may be different when orthogonal conformation traits derived from the factor analysis are used instead of the inter-correlated original traits.

H_a = Relationships involving body measurements and body weight may not be different when orthogonal conformation traits derived from the factor analysis are used instead of the inter-correlated original traits.

MATERIALS AND METHODS

Location of Study and Animals

The study was carried out at the Rabbitry of National Animal Production Research Institute (NAPRI) Shika, Zaria, Kaduna State. The rabbitry lies between $11^o 12' 42''$ N and $7^o 33' 14''$ E at an altitude of 691m above sea level [6].

Experimental Animals

One hundred and four (104) Hyla F_1 progeny were used comprising of 54 purebred and 50 crossbred rabbits.

Measured Traits

Body weight and ten (10) biometric traits were measured on each animal. The anatomical reference points were as described by standard zoometric procedure of Gueye *et al*. [7] and Teguia *et al*. [8]. The parts measured were body length (BL), diagonal distance from the point of the shoulder to the pin bone (Tuber ischi), and heart girth (HG), measured as circumference of the thoracic cavity just behind the fore limbs; thigh circumference (TC): circumference at the knee-cap (patella); Tail length (TL): measured from the base of the tail to the tip (coccygeal vertebrae). Head to shoulder (HS): Is the distance from nose to the point of the shoulder. Shoulder to tail-drop (STT): This is the distance from the point of the shoulder to the tip (coccygeal vertebrae). Length of front and back leg (LFL and LBL): This is the length of front and back legs measured in centimeter and ear length (EL): distance from the base of the ear to its tip. The height measurements were obtained using a graduated measuring stick. All measurements were taken by the same person to avoid between-individual variations.

Statistical Methodology

Least squares means and standard errors of body weight and biometric variables were estimated. General linear model (GLM) was used to analyze genetic group differences. Pearson's correlation coefficients (r) body weight and various biometric traits were also estimated. From the correlation matrix, data for the principal component factor analysis were generated. According to Everitt *et al.* [9], principal component analysis is a method for transforming the variables in a multivariate data set x_1, x_2, ---, xp, into new variables, y_1, y_2,---, yp which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$y_1 = a_{11}\,x_1 + a_{12}\,x_2 + \text{------------------} + a_{1p}\,x_p$$
$$y_2 = a_2\,x_1 + a_{22}\,x_2 + \text{-------------------} + a_{2p}\,x_p$$
$$y_p = a_{p1}\,x_1 + a_{p2}\,x_2 + \text{------------------} + a_{pp}\,x_p$$

with the coefficients being chosen so that y_1, y_2, ------, y_p account for decreasing proportions of the total variance of the original variables, x_1, x_2, ------, x_p. During the evaluation, factors were rotated with varimax rotation of Kaiser. The aim of the Varimax rotation is to maximize the sum of variances of a_{ij}^2 quadratic weight. The stepwise variable selection multiple regression procedure was used to obtain models for predicting body weight from body measurements (a) and from established principal components (b).

BW = a + B_i x $_i$ + --------- Bk x k ----------- (a)
BW= a + B_iPC_i + -------- BkPCk ---------- (b)

where; BW is the body weight, a is the regression intercept, B_1 is the i-th partial regression coefficient of the i-th linear body measurement, X_i or the i-th principal component. Anti-image correlations, Kaiser–Meyer Olkin measures of sampling adequacy and Barlett's Test of Sphericity were computed to test the validity of the factor analysis of the data sets. The appropriateness of the factor analysis was further tested using communualities and ratio of cases to variables. Components are extracted until some stopping criteria is encountered or until p components are formed. The weights used to create the principal components are the eigenvectors of the characteristics equation:

$(R- \lambda_1 I)\ a = 0$

Where R is the correlation matrix, the λ_1 are the eigenvalues, the variances of the components. The eigenvalues are obtained by solving $(R- \lambda_1 I)a = 0$ for λ_1. Cumulative proportion variance was employed in determining the number of principal components to extract. The overall reliability of the factor solution was tested using Chronbach's Alpha. The factor programme of SAS 9.0 statistical package was used for the principal component analysis.

RESULTS AND DISCUSSION

Phenotypic Correlations

Pearson's coefficients of correlation of body weight and body measurements of the two genetic groups are shown in Table 1. Highly significant ($P < 0.01$) association existed among body weight and biometrical traits. The coefficients ranged from 0.60-0.90 and 0.62–0.94 for purebred and crossbred rabbits respectively. Among the body shape characters, the highest correlation was found between shoulder to tail drop and body length (r = 0.96 and 0.94)) for purebred and crossbred rabbits. The estimates of correlation in the present study are comparable to those reported by earlier workers [10]. The strong relationship existing between body weight and body measurements may be useful as selection criterion, since positive correlations of traits suggest that the traits are under the same gene action (Pleiotropy). The positive correlations between BW and morphological traits obtained in the present study indicate that an increase in any one body measurement would result in a corresponding increase in live body weight. The strong relationship existing between body weight and body measurements suggests that the combination of these morphological traits could be used to estimate live weight in rabbits fairly well in the situation where scales are not available. This, therefore, provides a basis for the genetic manipulation and improvement of rabbits in the tropical conditions of Nigeria.

Principal Component Matrix

The principal component matrix for New Zealand White purebred and New Zeal and White X California crossbred rabbits are presented in Tables 2 and 3. The determinants of the correlation matrix were 1.77E0.06 versus 6.45E0.07 for purebred and crossbred rabbits. The anti–image correlations computed showed that partial correlations were low, indicating that true factors existed in the data of both breeds. This was supported by Kaiser-Meyer- Olkin measure of sampling adequacy studied from the diagonal of partial correlation, revealing the proportion of the variance in the body measurements caused by the underlying factor. This was found to be sufficiently high for all the morphometric traits in both breeds (0.951 and 0.950) respectively. The overall significance of correlation matrix was tested with Barlett's Test of sphericity for body dimensions of the purebred versus crossbred rabbits (Chi square = 4103.19; $P < 0.001$) and crossbred (chi square = 2848.29; $P < 0.001$) which provided enough support for the validity of the factor analysis of the data set. The communalities, which represent the proportion of the variance in the original variables that is accounted for by the factor solution, ranged from 0.73 – 0.94 for purebred and ranged from 0.83 – 0.94 crossbred Hyla rabbits. These further lend credence to the appropriateness of the factor analysis. After varimax rotation, two factors were extracted for purebred rabbits which accounted for 83.97% of the total variance, while three factors were extracted for crossbred rabbits which accounted for 89.88% of the total variance. The factor pattern coefficients were used to assess the relative contributions of the various body measurements in determining the numerical value of the corresponding factor (principal component). In the purebreds, BL, HG and STT were highly associated with the first PC (this explained 78.70% of generalized variance of Hyla purebred), and could be termed "body factor" while PC2 was primary determined by LFL and LBL, which accounted for 5.27% of the variation and could be regarded as length factor. PC1 had its highest loadings on BL, HG and STT (81.48%), also could be termed as generalized or body factor. PC2 was solely related to LFL (5.22%) and PC3 had its highest loadings for LBL (3.18%), both could be termed as front leg and back leg factor, respectively. The principal components obtained in the present study could be used with other economic indices in evaluating adaptability of rabbits for management purposes. Similar findings have earlier been reported [11].

Table 1: Phenotypic Correlations of Bodyweight and Linear Body Measurements of HYLA Rabbits

Traits	BW	HW	BL	HG	TL	TC	LFL	LBL	STT	EL	NTS
BW		0.80	0.90	0.86	0.77	0.74	0.62	0.69	0.91	0.84	0.87
HW	0.86		0.80	0.68	0.66	0.65	0.60	0.61	0.78	0.76	0.73
BL	0.89	0.86		0.87	0.84	0.81	0.72	0.71	0.96	0.89	0.86
HG	0.88	0.76	0.85		0.76	0.71	0.62	0.64	0.89	0.80	0.81
TL	0.79	0.76	0.85	0.82		0.79	0.69	0.74	0.85	0.87	0.78
TC	0.77	0.76	0.86	0.79	0.87		0 .68	0.69	0.79	0.83	0.78
LFL	0.63	0.67	0.72	0.62	0.72	0.71		0.67	0.69	0.78	0.68
LBL	0.71	0.70	0.73	0.66	0.73	0.68	0.71		0.70	0.77	0.69
STT	0.92	0.84	0.94	0.89	0.88	0.85	0.69	0.73		0.87	0.85
EL	0.84	0.83	0.89	0.82	0.88	0.88	0.79	0.79	0.89		0.86
NTS	0.87	0.79	0.86	0.83	0.81	0.79	0.66	0.71	0.86	0.87	

**=* *significant,* *ns = not significant.*

BW-Body weight, EL-Ear length, HS- Head size, HG- Heart girth, TL – Tail length, STT- Shoulder to tail drop, LFL-Length of front leg, LBL-Length of back leg, TC- Thigh circumference, BL- Body length and HW- Height at wither, NTS- Nose to shoulder, LBMs- Linear body measurement. Upper matrix= Breed 1, Lower matrix= Breed 2Significant at P < 0.01 for all correlation coefficients, Breed 1= Hyla purebred, Breed 2= Hyla crossbred.

Table2: Eigenvalues and share of total variance along with factor loadings and communalities of the body measurements of breed 1 and breed 2 of Hyla rabbits

Traits	PC1	PC2	PC3	Communality
Breed 1				
HW	0.779	0.348		0.729
BL	0.833	0.497		0.941
HG	0.845	0.364		0.846
TL	0.638	0.640		0.817
TC	0.593	0.652		0.777
LFL	0.346	0.829		0.807
LBL	0.384	0.802		0.791
STT	0.852	0.462		0.939
EL	0.683	0.668		0.912
NTS	0.761	0.509		0.837
Eigen value	7.870	0.527		
% of total variance	78.70	5.27		
Breed 2				
HW	0.706	0.252	0.512	0.829
BL	0.810	0.372	0.357	0.921
HG	0.859	0.248	0.269	0.872
TL	0.734	0.505	0.280	0.873
TC	0.750	0.543	0.180	0.890
LFL	0.324	0.833	0.374	0.939
LBL	0.372	0.402	0.801	0.942
STT	0.837	0.341	0.345	0.936
EL	0.702	0.522	0.405	0.929
NTS	0.782	0.274	0.413	0.857
Eigen value	8.147	0.522	0.318	
% of total variance	81.48	5.22	3.18	

BW-Body weight, EL-Ear length, HS- Head size, HG- Heart girth, TL – Tail length, STT- Shoulder to tail drop, LFL-Length of front leg, LBL-Length of back leg, TC- Thigh circumference, BL- Body length and , NTS- Nose to shoulder, HW- Height at wither, Breed 1=Hyla purebred and Breed 2= Hyla crossbred rabbits. R^2 - coefficient of determination

Table 3: Stepwise Multiple Regression of Body Weight on Original Body Measurements and on their Principal Components Factor Scores of Breed 1 and 2 Rabbits

Traits	Models	R^2
Breed 1		
Original body measurements as explanatory variables		
STT	BW= -789.63 + 63.32STT	0.84
STT and NTS	BW= -1086.24 + 44.56STT + 74.48NTS	0.86
STT, NTS and HW	BW= -1086.79 + 37.37STT + 63.71NTS + 35.59HW	0.88
STT, NTS, HW and HG	BW= -1186.43 + 27.04STT + 55.14NTS + 38.00HW + 19.41HG	0.88
STT, NTS, HW, HG and LFL	BW= -1122.81 + 29.50STT + 93.16NTS + 40.06HW + 18.97HG – 19.63LFL	0.89
Orthogonal traits as independent Variables		
PC1	BW= 972.06 + 477.64PC1	0.72
PC1 and PC2	BW= 971.88 + 477.45PC1 + 226.45PC2	0.88
Breed 2		
Original body measurements as explanatory variables		
STT	BW= -887.75 + 67.21STT	0.85
STT and NTS	BW= -1177.49 + 48.36STT + 74.48NTS	0.87
STT, NTS and HW	BW= -1172.04 + 38.57STT + 59.10NTS + 48.36HW	0.89
STT, NTS, HW and TL	BW= -1231.29 + 48.84STT + 68.25NTS + 49.91HW – 47.77TL	0.90
STT, NTS, HW, TL and HG	BW= -1333.49 + 37.96STT + 53.82NTS + 51.75HW – 52.16TL + 24.05HG	0.91
STT, NTS, HW, TL, HG and TC	BW= -1300.26 + 39.40STT + 57.22NTS + 54.14HW – 38.67TL + 24.87HG – 32.77TC	0.91
Orthogonal traits as independent Variables		
PC1	BW= 975.58 + 467.01PC1	0.66
PC1 and PC3	BW= 975.58 + 467.01PC1 + 247.37PC3	0.84
PC1, PC3 and PC2	BW= 975.58 + 467.01PC1 + 247.37PC3 + 116.32PC2	0.88

BW-Body weight, EL-Ear length, HS- Head size, HG- Heart girth, TL – Tail length, STT- Shoulder to tail drop, LFL-Length of front leg, LBL-Length of back leg, TC- Thigh circumference, BL- Body length and , NTS- Nose to shoulder, HW- Height at wither, LBMs- Linear body measurement, PC= principal component S.E= standard error; R^2= coefficient of determination, Breed 1=Hyla purebred and Breed 2= Hyla crossbred rabbits

CONCLUSION

In conclusion, the coefficient of determination estimates ($R^{2)}$ obtained for both breeds indicated that principal component analysis is a robust techniques and more efficient in predicting bodyweight compared to the traditional regression analysis.

Acknowledgement
The authors would like to be grateful to the management of National Animal Production Research Institute, Zaria, Nigeria, for their kind assistance in providing facilities for this research.

REFERENCES

[1] A Dalle Zotte, Main factors influencing the rabbit carcass and meat quality. *Proceedings of the 7th World Rabbit Congress*, Valencia, Spain, **2002**, 1-32.
[2] M R Lanari, H Taddeo, E Domingo, MP Centeno, L Gallo, Arch Tierz *Dummerstorf*, **2003**, 46, 347-356.
[3] J V Delgado, C Barba, M E Camacho, FTPS Sereno, A Martinez, JL Vega-Pla , **2001**. *AGRI*, 2001, 29, 7-18.
[4] F O Ajayi, O Ejiofor, M O Ironke, *Global Journal of Agricultural Science*, **2008**,7, 57-59.
[5] C Truxillo, Multivariate Statistical Methods: Practical Research Application Course Notes. Cary, NC: SAS Institute, **2003**.
[6] Ovimaps, Ovi location map; Ovi earth imagery date; April 3rd, **2012**
[7] E F Gueye, A Ndiaye, RDS Branckaert, *Livestock Research for Rural Development 10: http:// www. Cipav.org.co/Irrd 10/3/sene103.htm*, **1998**.
[8] A Teguia, HM Ngandjou, S Defang, T Tchoumboue, *Tropical Animal Health Production*, **2008**, 40,5-10.

[9] B S Everitt, S Landau, M Leese, Cluster Analysis. 4th edition. London, Arnold Publisher, **2001**.
[10] A Yakubu, JA Ayoade, *International Journal of Morphology*,**2009**, Pp 27(4):1013-1017.
[11] M H Sadek, AZ Al-Aboud, A Ashmawy, *Journal of Animal breeding and genetics*. **2006**,123, 369-377.