Original Research Article

Examination of sexual dimorphism in New-Zealand White × Californian rabbits by morphological traits

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Abstract

Rabbits provide a cheap source of high quality animal protein and thus have the potential to bridge the shortage of animal protein in developing countries. Data were collected on 174 New Zealand × California cross-bred rabbits (87 males and 87 females) for this study, to quantify the morphological characteristics and to determine the morphological parameters that contribute to body conformation using Principal Component Analysis (PCA). Data were collected on live body weight (LBW), body length (BDL), ear length (EAL), tail length (TAL), rump length (RUL), heart girth (HAG) and abdominal circumference (ADC). Data collected were analysed using the procedures of the PAST® 3.21 statistical package. Mean live body weight (± SE) for the females (0.980 ± 0.02 kg) and males (0.790 ± 0.02 kg) was recorded. There were positive and highly significant ($p < 0.01$) correlation coefficients between live body weight and the linear body measurements. One principal component was extracted, accounting for 64.8% of the total variances in morphological indicators measured in the New Zealand × California rabbits. The extracted principal component in this study could be used as aid in selection programme. The results obtained revealed the occurrence of sexual dimorphism, where female rabbits recorded significantly ($p < 0.05$) higher values than males in all the traits measured. This information suggests that use of rabbit for meat production should skew towards raising female rabbits.

Keywords: Morphology; body weight; body length; ear length; tail length; rump length; heart girth; abdominal circumference

INTRODUCTION

Rabbits provide a cheap source of protein for human consumption in Nigeria. Rabbit production is also an important source of employment and income generation in Nigeria. The New Zealand White and Californian rabbit breeds are the commonest commercial rabbit breeds around the world and in Nigeria, too. They are popular for fast growth and meat production (Ozimba and Lukefahr, 1991; Shemeis and Abdallah, 1998). Crossbreeding is one of the fast tools to improve many traits in farm animals (Nofal et al., 1997; Oseni et al., 1997).

Due to the morphological variations among different breeds and populations of rabbits, detailed characterisation and inventories are important in the conservation of rabbit genetic resources (Ajayi and Oseni, 2012). The first step towards the characterisation of local genetic resources falls on the identification of populations based on morphological descriptions (Delgado et al., 2001). Morphometric measurements have been used in describing the size and shape of animals (Ajayi et al., 2008). Our previous study revealed the manifestations of sexual dimorphism in the morphological traits of the rabbits (Rotimi and Ati, 2020). Principal components are a weighted linear combination of correlated variables, explaining a maximal amount of variance of the variables (Truxillo, 2003). Multicollinearity occurs because two or more variables measure essentially the same thing and this leads to unreliable results (Shahin and Hassan, 2002). Multicollinearity is eliminated using multivariate procedures of principal component analysis.

The principal component analysis is used to reduce data set with many independent variables to a smaller set of derived variables in such a way that the first component has a maximum variance, followed by second, third, and so on (Udeh, 2013).

Principal Component Analysis (PCA) has been used to analyse morphological data in guinea pigs (Anye et al., 2010), in New Zealand white × Chinchilla rabbits (Yakubu and Ayoade, 2009) and Nigerian chickens (Yakubu and Ayoade, 2009). Reports on quantifying body measurements of the New Zealand × California rabbits using PCA are scanty. This study, therefore, was carried out to quantify the morphological characteristics and to determine the morphological indicators that contribute to body conformation using Principal Component Analysis (PCA) in the cross-bred rabbits.

MATERIALS AND METHODS

Experimental location

This study was conducted at the Livestock Teaching and Research Farm, Federal University Dutsin-Ma, Katsina State, Nigeria. Dutsin-Ma lies on latitude 12°26’ N and longitude 07°29’ E (Abaje et al., 2014).

Management of the experimental animals

The study was conducted using crossbred rabbits (New Zealand White × Californian), comprising 87 male and 87 female, aged 12 weeks. Rabbits used for this study were weaned at 28 days and were kept individually in separate cages in a well-ventilated rabbit building. The dimension of each hutch used in the experiment was 70×60×50 cm (length, breadth and height, respectively) and raised with a wooden stand 90 cm high from the concrete floor. Standard management practices and animal welfare were observed throughout the experiment. Rabbits were fed with a ration containing 16% CP (Crude Protein) *ad libitum*. Fresh, cool, and clean drinking water was provided *ad libitum* throughout the study.

Data collection

Data were collected on the individual rabbits at the end of the experiment. Live body weights were taken in kilograms using a top loader weighing scale. Six linear measurements were taken using a simple Tailors’ flexible ruler graduated in centimetres. These included:

- Body length (BDL). The diagonal distance from the point of the shoulder to the pin bone;
- Ear length (EAL). This was the distance from the base of the ear to its tip;
- Tail length (TAL). This was the distance from the pin bone to the tip of the tail;
- Rump length (RUL). This was measured between the outermost points of shoulder blades;
- Heart girth (HAG). This was the circumference of the thoracic cavity just behind the forelimbs;
- Abdominal circumference (ADC). This was measured as the circumference of the thigh muscles.

Measurements were taken according to the procedures of Chineke et al. (2006). Measurements of morphological variables were taken on the experimental animals early in the morning before feeding.

Experimental design

The design was a completely randomized design with sex as the factor of interest.
The statistical model is:

$$Y_{ij} = \mu + S_i + e_{ij}$$

Where,
Y_{ij} .... individual observation,
μ ...... general mean,
S_i ...... effect of i^{th} sex (i = M, F)
e_{ij} ..... residual error

Statistical analysis

All data obtained were subjected to statistical analysis using the PAST® statistical package (Hammer et al., 2008).

Least square mean of live body weight and linear body measurements were evaluated for significant effects of sex. Kaiser Meyer-Olkin (KMO) measure of sample adequacy and Bartlett’s test of sphericity were used to test the suitability of the data set for principal component analysis. The appropriateness of the factor analysis was further tested using communalities and ratio of cases to variables. The varimax criterion of the orthogonal rotation method was employed in the rotation of the factor matrix to enhance the interpretability of the principal components. The factor analysis procedures of the PAST® statistical package (Hammer et al., 2008) was used for the principal component analysis.

Table 1. Least square (means ± SE) showing sex effects on body weight and linear measurements New Zealand × California rabbits

Parameters	Mean (+SE)		
	Male	Female	Overall
Live body weight (kg)	0.79 ± 0.02[b]	0.98 ± 0.02[a]	0.89 ± 0.01
Body length (cm)	25.17 ± 0.24[b]	27.26 ± 0.35[a]	26.22 ± 0.22
Ear length (cm)	8.92 ± 0.07[b]	9.40 ± 0.07[a]	9.16 ± 0.05
Tail length (cm)	9.79 ± 0.09[b]	10.26 ± 0.10[a]	10.02 ± 0.07
Rump length (cm)	10.33 ± 0.17[b]	11.51 ± 0.19[a]	10.92 ± 0.13
Heart girth (cm)	18.68 ± 0.15[b]	20.04 ± 0.14[a]	19.36 ± 0.11
Abdominal circumference (cm)	20.01 ± 0.19[b]	21.82 ± 0.18[a]	20.91 ± 0.14

a, b, c = Means with different superscripts in the same column differ significantly ($p < 0.05$).

Table 2. Correlation coefficient matrix of body weight and linear body measurements of New Zealand × California rabbits

	LBW	BDL	EAL	TAL	RUL	HAG	ADC
LBW	1	0.620**	0.438**	0.580**	0.569**	0.786**	0.753**
BDL		1	0.427**	0.617**	0.702**	0.542**	0.653**
EAL			1	0.580**	0.403**	0.405**	0.440**
TAL				1	0.647**	0.494**	0.582**
RUL					1	0.530**	0.720**
HAG						1	0.845**
ADC							1

**. Correlation is significant at the 0.01 level (2-tailed), LBW = live body weight, BDL = body length, EAL = ear length, TAL = tail length, RUL = rump length, HAG = heart girth, ADC = abdominal circumference.

Table 3. Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test for Principal Component Analysis

KMO Measure of Sampling Adequacy		0.803
Bartlett's Test of Sphericity	**Approx. Chi-Square**	665.819
	Df	15
	Sig.	0.000

RESULTS AND DISCUSSION

Table 1 shows the least square mean (± SE) of body weights and linear body measurements as affected by sex. Sex had significant ($p < 0.05$) effects on all the body measurements studied. The mean live body weight recorded for the females was 0.98 kg ± 0.02 whereas that of the males was 0.79 kg ± 0.02 with an overall mean value of 0.89 kg ± 0.01 for the two sexes. The LBW values obtained in this study is lower than the values recorded for dwarf rabbits by Dalle Zotte et al. (2012), who reported 1.630 kg and 1.542 kg for females and males, respectively. Values obtained for female rabbits were significantly ($p < 0.05$) higher than those for the males in BDL, EAL, TAL, RUL, HAG and ADC, see Table 1. The results obtained in this study agree with the report of Rotimi and Ati (2020), who also observed that female rabbits were significantly ($p < 0.05$) heavier than the males. However, Abdel-Azeem et al. (2007) reported that sex non-significantly affected body weight at the different ages studied, although females were slightly heavier than males. The differences observed in this study for all the variables between the sexes of the rabbit could be attributed to sexual dimorphism. Sexual dimorphism was also reported in Dutch rabbits (Akpobasa, 2012).

The correlation coefficients between live body weight and linear body measurements are presented in Table 2. There were positive and highly significant ($p < 0.01$) correlation coefficients among the variables. Correlation values ranged from 0.403 (between EAL and RUL) to 0.845 (HAG and ADC). This result aligns with the work of Yakubu and Ayoade (2009) in New Zealand white × Chinchilla rabbits. However, values in this report are lower than those obtained by Chineke (2000) who reported a correlation coefficient range of 0.765–0.948 among traits in rabbits and Tiamiyu et al. (2000) who reported a high positive correlation coefficient range of 0.89–0.98. The results confirm high prediction ability among the variables.

Table 3 presents the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test for PCA analysis Results of Kaiser-Meyer-Olkin (KMO)

Table 4. Eigenvalues, the proportion of the variance, and the communalities for each Principal Component in the New Zealand × California rabbits

Parameters	PC 1	Communality
Body length	**0.698**	0.680
Ear length	0.162	0.833
Tail length	0.473	0.766
Rump length	**0.739**	0.713
Heart girth	**0.864**	0.771
Abdominal circumference	**0.911**	0.894
Eigenvalue	3.891	
% Variance	64.842	
Cumulative %	64.842	

measure of sampling adequacy (0.803) and Bartlett's test of sphericity ($\chi^2 = 665.819$; $p < 0.01$) showed that the sample size is adequate for Principal Component Analysis.

Table 4 shows the Eigenvalues, the proportion of the variance, and the communalities for each Principal Component in the New Zealand × California rabbits. The communality values obtained in this study were high, ranging from 0.680 to 0.894 implying that the variance of each variable was well represented in the extracted components and hence the adequacy of the PCA procedure. Only one principal component with an Eigenvalue greater than 1 was extracted, accounting for 64.84% of the total variation in the original variables. This is similar to the report of Udeh (2013) who also extracted one principal component, accounting for 77.23% of the total variances. However, Yakubu and Ayoade (2009) extracted two principal components in their study, which explained 90.27% of the total variance. They reported that PC1 was highly correlated with body length, heart girth, and thigh circumference. Ajayi and Oseni (2012) reported that four PCs accounted for about 87% of the total variance in the adult rabbit population studied.

The Eigen loadings of each trait for the Principal Component are shown in Table 4. Sufficiently large values, showing a high correlation between the principal component and the original variables are highlighted as shown in Table 4 where the threshold of ± 0.500 was used for this purpose. The trait with the highest loading in the PC1 is ADC (0.911). It can be concluded that PC1 was a good estimator of body size. Most of the traits loaded strongly on PC1 showing a high correlation between the predictor and response variables. The implication of this is that any of these variables could serve as a good predictor of the live body weight of rabbits.

CONCLUSIONS

The study showed that sex had significant ($p < 0.05$) effects on morphometric parameters measured in the rabbits, with females recording higher values than males in all the parameters. This result confirms the occurrence of sexual dimorphism in the rabbits studied. The information obtained from this study suggests that the use of rabbit for meat production should skew towards raising female rabbits.

CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to research, authorship and publication of this article.

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