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ORIGINAL RESEARCH ARTICLE

Principal Components as a Measure of Live Weight and Morphometric correlates in Pre-Pubertal Heterogeneous Rabbit Population

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ABSTRACT
An experiment was conducted to elucidate the interdependence of conformation traits and to predict body weight from their independent factor scores using principal component extraction method. Body weight and eight morphometric variables namely body length, chest girth, thigh circumference, thigh length, hind leg length, fore leg length, ear length, and head length of 47 pre pubertal heterogeneous rabbit crosses were measured. Mean body weight were 993.31±40.66 and 1110.50±63.61 for male and female rabbits, respectively. Phenotypic variations between body weight and other morphometric variables were highly significant (r = 0.37 – 0.86 at P<0.01). Pairwise correlations ranged from moderate to high for most of the measured variables. However there were no significant correlations between head length and ear length; fore leg length and ear length; thigh circumference and ear length. Cumulative contribution ratio from the first principal component (PC1) to the fourth principal component (PC4) was 85.50%. The PC1 accounted for 34.98% of the total variance with loadings for body length, chest girth, thigh circumference, hind leg length and fore leg length and described the general size. PC2 was determined by thigh length and accounted for 22.15% of the total variance, while PC3 had loading for head length and accounted for 14.77% of the generalized variance. The PC4 loaded for ear length, accounting for 13.60% of the generalized variance. The stepwise regression for orthogonal variables derived from factor scores accounted for about 84% of the variation observed in body weight of rabbits whereas the original morphometric variables accounted for 89.7% of the observed variation in body weight.

Keywords: Factor Loadings, Generalized variance, Morphology, Orthogonal, Regression

NTRODUCTION

The use of mini-livestock species as alternatives or additional sources of animal protein has been advocated (Mailafia, *et al*., 2010) for developing countries such as Nigeria. This is because, though population growth in the developed countries of the world is stabilizing, that of the developing countries is still generally increasing rapidly. Economic indices indicate that as this population trends continues, there will be more people to feed necessitating increased Agricultural output rather than food importation (Allen, 1993). It has been estimated that the daily minimum crude protein requirement of an adult in Nigeria varies from 65g to 85g per person (Adetunji, 2011) and it has also been said that of this minimum requirement, 35g ought to be crude protein of animal origin (Oloyede, 2005). Hence the need for viable options to meet the food production and protein needs of the Nigerian populace (Owen, *et al.*, 2008).

Fast growing livestock such as rabbits possess a number of unique attributes that might be of advantage to the small holder integrated farming in the developing countries. Meat from rabbit is highly nutritional with low fat, sodium and cholesterol levels. It is rich in protein reaching about 20.8% and its consumption is bereft of cultural and religious biases (Biobaku, 1997). They can survive on large amounts of fibrous feeds due to the presence of caeca microbes (Taiwo, *et al.*, 1999). It can be fed high forage, low grain diets that are non – competitive with human food supply. The rabbits are suited to both small scale production (backyard) type and large scale commercial production (intensive) type farming (Cheeke, 1987).

Rabbit production is a veritable way to improving animal protein availability in Nigeria (Ajala and Balogun, 2004). However, to achieve this and maintain its use sustainably, there is the need to have an understanding of the breed characteristics to guide decision making in animal development and breeding programs (FAO, 2007). Characterisation of animal genetic resource for food and agriculture involves three levels of information: phenotypic, genetic and historical information (FAO, 2007). Phenotypic characterization of Animal Genetic Resources for food and agriculture (AnGR) is the process of identifying distinct breed populations and describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors that affect them (FAO, 2012). The information provided by characterization studies is essential for planning the management of Animal genetic resources for food and agriculture at local, national, regional and global levels (FAO, 2007). The first step of the characterization of local genetic resources falls on the knowledge of the variation of morphological traits (Delgado *et al*., 2001). Morphometric measurements have been found useful in contrasting size and shape of animals (Mckracken *et al*., 2000; 2006 and Ajayi *et al*., 2008). However, correlations between body dimensions may be different if the dimensions are treated as bivariates rather than multivariates. This is because of the interrelatedness or lack of orthogonality (collinearity) of the explanatory variables. To address this limitation, multivariate analysis of data sets such as the use of principal component factor technique becomes imperative. Principal component analysis (PCA), a multivariate procedure could be a leeway to solving problems associated with univariate analysis of growth and related traits. This is due to its ability to reduce related variables into lesser number of uncorrelated variables called principal components. Jolliffe (2002) stated that the components will be arranged in such a way that the first few components will retain most of the variations existing in the original variables. Therefore, the objective of this study was to characterize heterogeneous rabbits via the estimation of growth indices as revealed by the measurements of growth parameters and to provide information on the quantitative variability of these rabbits by multivariate analysis of the morphometric variables measured in the study.

MATERIALS AND METHODS

Location of the Study: The study was conducted at the Rabbit Unit of the Department of Animal Science, University of Ibadan Teaching and Research Farm, Ibadan, Nigeria which lies within 7° 26′ 30″ North and 3° 54′ 00″ East (Wikipedia, 2017) within the tropical rain forest zone.

Experimental animals and their management. Forty-seven (47) heterogeneous rabbit kits (crosses of New Zealand White, Californian White and American Chinchilla) aged 13 to 15 weeks were used for the study. The animals were housed in hutches (3-5 animals per unit; 78 x 68 x 48cm, raised 90cm above the ground) in a well-ventilated rabbit building. Each cage was fitted with 2 feeders and 1 drinker. The animals were fed concentrate feed containing 17.6% crude protein and fresh clean water was available *ad libtum*. Each kit was ear tagged for easy identification.

Data collection: Data were collected on live weight and 8 morphometric variables. On the day of data collection, feed was withdrawn 2 – 3hrs before data was collected between 6.00 am and 9.00 am. The following data were collected relative to specific anatomical reference points:

Live Body Weight (BW) measured as the total weight of the live animal in grams; Body length (BL) measures as horizontal distance from the front point of the withers to the pin bone; Chest (heart) girth (CG) measured as body circumference just behind the fore leg; Ear Length (EL) was measured as the distance from the base of attachment of the ear to the head to the tip of the ear; Head Length (HL) was measured as the distance from the knob of the occipital to the top of the nose; Thigh Circumference (TC) measured as the circumference at the knee cap (patella); Thigh Length (TL) was measured as the distance from the pelvic girdle to the patella; Fore Leg

Length (FLL) was measured as the distance from the proximal extremity of the olecranon process to the mid lateral point of the coronet; Hind Leg Length (HLL) measured as the distance from the proximal end of the femur to the distal end of the fibula.

Statistical Analysis: Means and standard deviation, Pearson's correlation between the measured variables and factor analysis - Principal Component Analysis were performed using the factor programme of SPSS version 20.0 (IBM Corp., 2011). After the correlation matrix which served as the primary data for the PCA was generated, it was inspected for sampling adequacy (Kaiser-Meyer-Okin Test) and sphericity (Battlet's Test).

RESULTS AND DISCUSSIONS

Body weight and Morphometric Variables. Table 1 presents the descriptive statistics of body weight and morphometric variables of heterogeneous rabbit crosses. Coefficients of variation ranged from 7.80 for hind leg length to 23.34 for body weight. Body weight, thigh length, rabbits while body weight associated with all body measurements in male rabbits. The highest association was observed between body weight and thigh circumference (0.96) and between body weight and chest girth (0.84) in female and male rabbits, respectively. Similar results have been reported by Udeh (2013) for Chinchilla rabbits, Yakubu and Ayoade (2009) for New Zealand White X Chinchilla crossbreds, and Abdullah *et al*, (2003) for New Zealand White X Dutch belted crossbred rabbits. However, body weight had highly significant associations with all measured variable when the population was pooled. The highest correlation coefficient for the pooled data was observed between body weight and chest girth. There were however no significant associations between ear length and thigh circumference (0.18), ear length and fore leg length (0.27) ear length and head length (0.14). According to Oliveira *et al.* (2004) the thigh is the part of the body where there is highest meat deposition in the rabbit body and as a result it is expected to be highly positively correlated with thigh circumference, body length and chest girth were more variable than fore leg length, ear length, head length and hind leg length. The observed difference in coefficients of variation may be attributable to breed homogeneity, the rate of development of different body parts, condition of individual animals and environmental factors such as feed and management practices. This variation observed will be of importance in designing selection programs for heterogeneous rabbits since the larger the variation the more unique individuals will be with respect to the trait of interest. Shahin and Hassan (2002) reported that body weight was more variable than any other body measurement. Similarly, Hassan *et al.*, (2012) reported high coefficient of variation for body weight and moderate value for heart girth.

Phenotypic correlations among morphometric variables. Person's correlations coefficients for body weight and morphometric variables is as presented in Tables 2 and 3. Results in Table 2 reveal that there were no significant correlations between body weight and head length (0.30), ear length (-0.14) and hind leg length (0.54) in female body weight. Since thigh circumference and chest girth correlated significantly with body weight, it therefore follows that as the any of these increases, the live weight of the rabbit will increase thereby making it possible to select for heavier live weight indirectly by selecting for thigh circumference or chest girth.

Principal Component Matrix. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (0.782) indicating the amount of variations caused by the underlying factor; the Bartlett's test of sphericity (Chi-square 198.891; p<0.0001); the communalities (0.638 – 0.989) representing the explained portion of the variance and the determinant (0.009) obtained from the correlation matrix indicates that the sample size was adequate and permitted all body measurements into reasonable factor analysis – PCA. Four principal components (PC1 – PC4) were extracted by the factor solution after varimax rotation amounting to 85.50% of the total variance explained (Table 4)

Table 1. Live body weight (kg) and linear body measurements (cm) of rabbits

	Male Rabbits (N= 35)				Female Rabbits (N= 12)				Overall (N= 47)			
Parameters	Mean	S.D	SE	CV	Mean	S.D	SE	CV	Mean	S.D	SE	CV
Body Weight	993.31	240.55	40.66	24.22	1110.50	220.37	63.61	19.84	1023.23	238.85	34.84	23.34
Body length	22.89	2.48	0.42	10.83	24.47	2.23	0.64	9.09	23.30	2.49	0.36	10.70
Chest Girth	20.35	1.99	0.34	9.76	21.62	2.17	0.63	10.04	20.68	2.09	0.30	10.09
Ear Length	10.06	1.05	0.18	10.44	10.39	0.76	0.22	7.27	10.15	0.99	0.14	9.72
Head Length	8.47	0.78	0.13	9.18	8.50	0.59	0.17	6.95	8.48	0.85	0.11	8.59
Thigh Circumference	11.90	1.25	0.21	10.47	12.82	1.46	0.42	11.36	12.13	1.35	0.20	11.11
Thigh Length	9.00	1.31	0.22	14.52	9.31	0.41	0.12	4.36	9.08	1.15	0.17	12.66
Fore Leg Length	8.45	0.84	0.14	9.88	9.14	0.70	0.20	7.70	8.63	0.85	0.12	9.89
Hind Leg Length	9.95	0.80	0.14	8.08	10.36	0.66	0.19	6.38	10.05	0.78	0.11	7.80

S.D = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation

Table 2. Correlations coefficients of body weight and linear body measurements of Male and Female rabbits

	BW	BL	CG	ThC	ThL	HLL	FLL	EL	HL
BW		0.75^{**}	0.90^{***}	0.96^{***}	0.71^{**}	0.54^{ns}	0.66^{*}	-0.14^{ns}	0.30^{ns}
BL	0.61^{***}		0.68^{*}	0.66^{*}	0.74^{**}	0.69^{**}	0.74^{**}	0.23^{ns}	0.22^{ns}
CG	0.84^{***}	0.62^{***}		0.93^{***}	0.61^{*}	0.46^{ns}	0.60^{*}	-0.22^{ns}	0.44^{ns}
ThC	0.72^{***}	0.40^{*}	0.53^{***}		0.56^{ns}	0.39^{ns}	0.55^{ns}	-0.22^{ns}	0.28^{ns}
ThL	0.75^{***}	0.45^{**}	0.75^{***}	0.26^{ns}		0.77^{**}	0.83^{***}	-0.03^{ns}	0.22^{ns}
HLL	0.82^{***}	0.54^{***}	0.70^{***}	0.69^{***}	0.68^{***}		0.81^{***}	-0.06^{ns}	0.34^{ns}
FLL	0.72^{***}	0.49^{**}	0.65^{***}	0.71^{***}	0.52^{***}	0.71^{***}		-0.25^{ns}	0.40^{ns}
EL	0.45^{**}	0.31^{ns}	0.42^{**}	0.25^{ns}	0.33^{ns}	0.39^{*}	0.34^{ns}		-0.68^{*}
HL	0.53^{***}	0.32^{ns}	0.37^{*}	0.34^{*}	0.35^{*}	0.56^{***}	0.41^{*}	0.29^{ns}	

BW= Body weight; BL= Body length; CG= Chest girth; ThC= Thigh circumference; ThL= Thigh length; HLL= Hind leg length; FLL= Fore leg length; EL= Ear length; HL= Head length. *** *Significant at 0.001;* ** *Significant at 0.01;* * *Significant at 0.05*

Table 3. Correlations coefficients of body weight and linear body measurements of rabbits (Male + Female)

	BW	BL	CG	ThC	ThL	HLL	FLL	EL	HL
BW		0.66^{***}	0.86^{***}	0.79^{***}	0.72^{***}	0.77^{***}	0.72^{***}	0.37^{**}	0.48^{***}
BL			0.66^{***}	0.51^{***}	0.47^{***}	0.60^{***}	0.58^{***}	0.33^{*}	0.29^{*}
CG				0.67^{***}	0.69^{***}	0.67^{***}	0.67^{***}	0.31^{*}	0.37^{**}
ThC					0.29^{*}	0.64^{***}	0.70^{***}	0.18^{ns}	0.31^{*}
ThL						0.66^{***}	0.53^{***}	0.31^{*}	0.33^{*}
HLL							0.74^{***}	0.34^{*}	0.52^{***}
FLL								0.27^{ns}	0.38^{**}
EL									0.14^{ns}
HL									

BW= Body weight; BL= Body length; CG= Chest girth; ThC= Thigh circumference; ThL= Thigh length; HLL= Hind leg length; FLL= Fore leg length; EL= Ear length; HL= Head length

*** *Significant at 0.001;* ** *Significant at 0.01;* * *Significant at 0.05*

PC1 comprising five measurements (BL, CG, ThC, HLL and FLL) explained 34.98% of the generalized variance observed and represents the 'general size'. The present findings are in line with the reports of Yakubu and Ayoade (2009), and Udeh (2013) that the PC1 is a general size estimator and explains the highest percentage of total variance. However, the size of the percentage of variance explained by PC1 in the present study was lower than the values obtained by these two sets of researchers. Thigh length had the highest loading followed by chest girth. The observed difference in the size of the percentage variance explained by the PC1 in this current study and other reports may be attributable to the number, age and breed of rabbits used in the different studies. In this current study pre-pubertal rabbits were studied. Salako (2006) also reported that the first principal component explained 67.7% of the generalized variance and can be considered the generalized size factor. Similarly, Osaiyuwu *et al.* (2010) reported that the first principal component explained 63.20% of the generalized variance observed. PC2 loaded thigh length and explained 22.15% of the generalized variance and can be referred to as thigh length factor. PC 3 explaining 14.77% of the generalized variance only had Head length while PC4 had just ear length with 13.60% of the generalized variance being explained. PC3 and PC4 may be termed head length and ear length factors, respectively. Each principal component may be useful for the purpose of selection or to compare among animals.

Prediction of Body weight of Rabbit. The results of the stepwise multiple regression for predicting body weight from original body measurements and their principal component factor score is as presented in Table 5. Chest girth alone explained about 73% of the observed variation in body weight. With the addition of thigh circumference, the amount of variation explained increased to 81% of the total variation in body weight. When the model included CG, ThC and ThL, the proportion of explained variance increased to 89%. The combination of CG, ThC, ThL and HL raised the amount of variance accounted for to about 90%. This result indicates that body weight can be predicted to a reasonable degree of accuracy from any of the body dimensions. However, the use of body measurements in predicting weight must be treated with caution due to multicollinearity, which is associated with unstable regression estimates (Ibe, 1989). Malau-Aduli *et al.* (2004) suggested the use of principal component analysis to overcome the problem of multicollinearity in multiple regression models. The PC1 alone predicted body weight with an accuracy of about 50%, when PC2 was added the coefficient of determination increased to 74%. When all four principal components were added the prediction accuracy increased to 84% indicating that body weight can be predicted reliably from the combination of the four principal components.

Table 4. Principal component matrix, Eigenvalue and its contribution in each principal component for body dimensions of Rabbits.

Parameters	Component				Communalities
	1	2	3	4	
Body length	0.638	0.409	0.033	0.250	0.638
Chest girth	0.664	0.590	0.116	0.120	0.817
Thigh circumference	0.935	0.018	0.147	0.024	0.896
Thigh length	0.203	0.930	0.165	0.129	0.950
Hind leg length	0.610	0.491	0.400	0.179	0.806
Fore leg length	0.781	0.327	0.218	0.107	0.776
Ear length	0.132	0.140	0.059	0.974	0.989
Head length	0.190	0.152	0.953	0.049	0.969
Eigenvalues	4.447	0.922	0.805	0.667	
Percentage of Variance	34.98	22.15	14.77	13.60	
Description	*GS*	*TL*	*HL*	*EL*	

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.782; Bartlett's Test of Sphericity = 0.000; Determinant = 0.009; GS = General size; TL = Thigh length; HL = Head length; EL = Ear length

Table 5. Stepwise Multiple Regression of body weight on linear measurement and on their principal components.

Variable Entered	Models	R^2	S.E
Original body measurements as independent variables			
CG	BW= 98.03CG – 1003.73	0.733	124.802
CG+ThC	BW= 68.32CG + 68.25ThC – 1217.40	0.806	105.330
CG+ThC+ThL	BW= 25.26CG + 91.87ThC + 86.42ThL – 1398.44	0.888	79.963
CG+ThC+ThL+HL	BW= 23.80CG + 88.29ThC + 81.68ThL + 37.11HL – 1596.48	0.897	76.664
Orthogonal body measurements as independent variables			
PC1	BW= 168.03PC1 + 1023.23	0.495	171.64
PC1+PC2	BW= 168.03PC1 + 121.03PC2 + 1023.23	0.740	121.72
PC1+PC2+PC3	BW= 168.03PC1 + 121.03PC2 + 61.84PC3 + 1023.23	0.806	105.21
PC1+PC2+PC3+PC4	BW= 168.03PC1 + 121.03PC2 + 61.84PC3 + 41.72PC4 + 1023.23	0.835	97.01

BW= Body weight; BL= Body length; CG= Chest girth; ThC= Thigh circumference; ThL= Thigh length; HLL= Hind leg length; FLL= Fore leg length; EL= Ear length; HL= Head length

CONCLUSION

This study revealed the interdependency of the eight original body measurement characters on each other leading to an objective simultaneous analysis of these body measurements rather than on individual basis. The use of independent orthogonal indices (PC1, PC2, PC3 and PC4) was more appropriate than the use of the original interrelated linear type traits for predicting the body weight of rabbits. The principal component factor scores were used to predict body weight with accuracy of 84% in a bit to eliminate the problem of multicollinearity that may occur when the original variables are combined in multiple regression models.

REFERENCES

Abdullah, A. R., Sokunbi, O. A., Omisola, O. O. and Adewumi, M. K. 2003. Interrelationship between body weight and body linear measurements in domestic rabbit (*Oryctolagus cuniculus*). Proceedings of the 28th Annual Conference of Nigerian Society of Animal Production at Institute of Agricultural research and Training, Obafemi Awolowo University, Ibadan, Nigeria. 122 - 4

Adetunji, M. O. and Adepoju, A. A. 2011. Evaluation of Household Pattern in Orire Local Government Area of Oyo State. *Int. J. Agric. Econo. Rural Dev.*, 4:72-82.

Ajala, M. K. and Balogun, J. K. 2004. Economics of rabbit production in Zaria, Kaduna State. *Tropical J. Anim. Sci.*, 7(1): 1-10

Ajayi, F.O., O. Ejiofor and M.O. Ironke. 2008. Estimation of body weight from linear body measurements in two commercial meat-type chicken. *Global J. Agric. Sci. 7: 57-59.*

Allen, C. E. 1993: New horizons in animal agriculture: future challenges for animal scientists. *Journal of Animal Science* 57 supplement. (2): 16, accessed 13 February 2016, http://jas.fass.org/cgi/reprint/57/supplement2/16.pdf.

Biobaku, W. O. and Oguntona, E. B. 1997. The effects of feeding multi nutrient mini blocks and pelleted diet on the growth of rabbits. *Nig. J. Anim. Prod*., 24(2): 147-149.

Cheeke, P. R. 1987. Rabbit feeding and nutrition. Academic press, Orlando, FL. p376

Delgado, J.V., C. Barba, M.E. Camacho, F.T.P.S. Sereno, A. Martinez and J.L. Vega-Pla. 2001. Livestock characterization in Spain. *AGRI 29: 7-18.*

FAO (Food and Agricultural Organization of the United Nations), 2007. A system of integrated agricultural censuses and surveys, volume 1, World Programme for the Census of Agriculture 2010. Statistical Development Series No. 11, accessed 3 December 2013, <http://:fao.org/es/ess/census/default.asp>.

FAO (Food and Agricultural Organization of the United Nations), 2012. Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No.11. Rome, Italy.

Hassan, H. E., Elamin, K. M., Yousif I. A., Musa A. M., Elkhairey, M. A. 2012. Evaluation of body weight and some morphometric traits at various ages in local rabbits of Sudan. *J. Anim. Sci. Adv* 2(4): 407 - 415

Ibe, S. N. 1989. Measures of size and conformation in commercial broilers. *J. Anim. Breed. Genet.* 106: 451 - 459

IBM Corp. 2011. IBM SPSS Statistics for windows, Version 20.0. Armonk, NY: IBM Corp

Jolliffe, I. T. 2002. Principal Component Analysis, Second Edition. Springer , USA. http://cda. Psych.uiuc.edu/statistical_learning_course/Jolliffe%20I.%20Principal%20Component%20Analysis%20(2ed.,%20Springer,%202002)(518s)_MVsa_.pdf accessed 14 February, 2017

Mailafia, S. Onakpa, M. M. and Owoleke, O. E. 2010. Problem and prospects of rabbit production in Nigeria-A review Bayero *Journal of Pure and applied Science*, 3 (2): 20-25.

Malau-Aduli A. E. O., Aziz, M. A., Kojina, T., Niibayashi T., Osima K. and Komatsu M. 2004. Fixing collinearity instability using principal component and ridge regression analysis in relationship between body measurements and body weight in Japanese Black cattle. *Journal of Animal and Veterinary Advances 3(12): 856 – 863*.

McCracken, K.V., D.C. Paton and A.D. Afton. 2000. Sexual size dimorphism of the Musk duck. *Wilson Bull. 112: 457- 466.*

Oliveira, M. C., Moura, C. D., Arantes, U. M., Faria., E. B., Lui, J. F. and Caires, D. R. 2004. Body measurements and its coefficient of correlations with the performance index of sexed rabbits slaughtered at different ages. http://dcam.upv.es/8wrc/docs/Genetics%20and %20Biotechnology/shortpapers/110-111

Oloyede, H. O. B. 2005. All for love of nutrients, the seventy-eight inaugural lecture, library and publications committee, University of Ilorin.

Osaiyuwu, O. H., M. O. Akinyemi and A. E. Salako 2010. Factor analysis of the morphostructure of mature Balami sheep. *Research Journal of Animal Sciences* 4 (2): 63 – 65.

Owen, O. J. Alawa, J. P. Wekhe S. N. Isirimah N. O. Chukuigwe E. C. Aniebo, A. O. Ngodigha, E. M. and Amakiri A. O. 2008 Incorporating poultry litter in Rabbit feed: a solid waste management strategy. *Egyptian Journal of Animal Production 46(1): 63 - 68*.

Salako, A. E. 2006. Principal component factor analysis of the morphostructure of immature Uda sheep. *Int. J. Morphol.*, 24 (4): 571 -4.

Shahin K. A. and Hassan N. S. 2002. Changes in sources of shared variability of body size and shape in Egyptian local and New Zealand White breeds of rabbits during growth. *Arch. Tierz. Dummerstorf, 3:*269-277.

Taiwo, B. B. A. Ogundipe. I. I. and Ogunsiji O. 1999. Reproductive and growth performance of rabbits raised on forage crops. In: Proc. Of the 4th Annual Conference of the Animal Association of Nigeria held in Ibadan, Nigeria, pp 108-109.

Udeh I. 2013. Prediction of body weight in rabbit using Principal Component Factor Scores in Multiple Linear Regression Model. Rabbit Gen 3(1):1-6.

Yakubu, A. and Ayoade, J. A. 2009. Application of principal component and factor analysis in quantifying size and morphological indices of domestic rabbits. *International Journal of Morphology 27*(4):1013-1017.

Wikipedia, 2017. The University of Ibadan. Wilkipedia the Free Encyclopedia. https://en.wikipedia.org/wiki/University_of_ibadan. Accessed 14 February, 2017