ESTIMATES OF CORRELATION AND REGRESSION OF MORPHOMETRIC TRAITS IN CROSS BRED RABBIT USING DIFFERENT FUNCTIONS

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ABSTRACT

This study was conducted to determine the correlation and regression estimates of linear body traits in mixed breed of rabbits. One hundred and sixty growing rabbits comprising New Zealand White and Chinchilla crossbreed were used. Body morphometric data, such as; body weight, shoulder to tail length, head to shoulder length, trunk length, height at withers, ear length, heart girth, fore-limb length, hind limb length and nose to shoulder length, were collected and recorded appropriately per week. Data generated were analyzed using SAS (2008) to establish the existing phenotypic relationship among morphometric traits of mixed breed of rabbits and to predict the performance traits of the rabbits using linear and non-linear functions. The results showed that there were low to high correlation coefficients between body weight and linear body parameters. The strong and positive relationships were found existing between the following: ear length-shoulder to tail length; body weight-shoulder to tail length; body weight-heart girth; body weight-ear length; heart girth-height at withers; and shoulder to tail length-heart girth. However, trunk length-body weight, height at withers-trunk length, ear length-trunk length, were negatively correlated and were not significant ($p>0.05$). The predictive functions were mostly positive and significant ($p<0.05$) except for ear length. Allometric function had the highest coefficient of determination (R^2) of 96% for height at withers. It therefore recommended that allometric function be used to predict the linear body traits of rabbit breed.

Key words: Relationship, Rabbits, Breed, Prediction functions and Coefficient of determination

INTRODUCTION

The growing population has given rise to the need to increase livestock production to satisfy the requirement for animal protein. In order to increase food production and meet protein requirements in Nigeria, feasible options need to be explored and evaluated (Owen *et al.*, 2008). Among such options is the use of livestock species that are yet to play a major role in animal production within these countries. Fast-growing livestock species such as rabbits possess a number of features that might be of advantage in the small holder subsistence – type of integrated farming in developing countries.

Improvement of rabbits is important in order to increase their contribution to the much-needed animal protein in this part of the world. One of the pre-requisites for genetic improvement is the knowledge of genetic parameters for important economic traits (Akanno and Ibe, 2006). Rabbit producers are interested in the relationship that exists between bodyweight and physical characteristics, since this information would reflect in their feed efficiency and performance.

Relating body weight to linear body measurements is one way of predicting body weight of rabbits. This is relevant especially in rural communities where there is evidence for absence of conventional weighing scales. The relationships among quantitative traits such as body weight, body length, ear length, tail length and limb lengths etc. have been examined among domestic rabbits (Chineke *et al.,* 2002; Abdullahi *et al.,* 2003; Atansuyi *et al.,* 2011; Isaac *et al.,* 2011). Based on the foregoing, this study was designed to establish the existing phenotypic correlations among morphometric traits of mixed breed of rabbits and to predict the performance traits of rabbits using linear, cubic, quadratic, allometry and exponential functions.

MATERIALS AND METHODS

Experimental Site This research work was carried out at the Rabbitry Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria. The study location lies in the humid rain forest zone of Western Nigeria which is characterized by two rainfall peaks and high humidity during the raining season. The mean annual rainfall is about 1,500mm which last for nine months between March and November. The relative humidity is over 75% and that of temperature is about 27ºC (Climate data, 2018).

Experimental Animals

One hundred and sixty (160) growing rabbits comprising of cross breed of New Zealand White and Chinchilla breeds were used for this experiment.

Data Collection

Studies of morphometry via the linear body measurements of each rabbit were recorded by careful and humane handling of the animals. The linear body measurements were taken using centimeter graduated measuring tape after restraining the animal. These body measurements were used as predictors of body weight (g). All measurements (cm) were taken at the reference points according to the method of Egena *et al.* (2012).

Statistical Analyses

All data generated were analyzed using SAS 2008 (Version 9.2) software package. For correlation and regression analysis, the degree of association between all pairs of traits was computed for the mixed breeds of rabbits using linear correlation of SASCORR and SAS REG procedure of the same statistical package.

Model functions:

$Y = a+ bx$ ………….. Simple linear function

$Y= a+ bx + cx^2$ ……….. Quadratic function

$Y= a+ bx +cx^2+ dx^3$ ……... Cubic function

$Y= ax^b$ ……………………. Allometry function

$Y= ab^x$ or ae^{bx} …………… Exponential function

Where: Y is the dependent variable (body weight)

x represents the independent variables (STL, TKL, HGT, HAW, ELT, HTS, FLM and HLM) while "a" is the intercept on the Y-axis; b = regression coefficients, allometric exponent or growth factor, e = exponential.

RESULTS AND DISCUSSIONS

Table 1 showed the correlations among morphometric traits of mixed breed of rabbits. It was observed from the table that there were very low to very high correlation estimates between the body weight and linear body measurements. The strongest relationships existed between ear length and shoulder to tail length, body weight and shoulder to tail length, body weight and heart girth, body weight and ear length, hearth girth and height at withers; and shoulder to tail length and heart girth. The positive and strong nature of correlation estimates between body weight and body measurements in mixed breed of rabbits means that body weight could be easily estimated from body measurements. This is because growth in animals could be evaluated from the component parts of the animal's body (Wolanski *et al.,* 2006). This means that an improvement in the body measurements will invariably lead to a corresponding improvement in the body weight of the rabbits especially if the correlation is positive and high as observed in some traits for the present study. High correlation estimates recorded in this study agreed with that of Okoro *et al*. (2010) whose result indicated positive correlation coefficient between the linear body measurements and the body weight in Chinchilla breed of rabbits. The present estimates are comparable to the range of values recorded for rabbits in earlier study (Yakubu, 2009). The strong relationship existing between body weight and body measurements suggests that either or a combination of these morphometric traits could be used to estimate live weight in mixed breed of rabbits fairly well in the situation where scales are not available. The association may also be useful as selection criterion since positive correlations of traits suggest that the traits may be under the same genetic influences which could be caused by pleiotropy or gene linkage.

Table 1: Phenotypic correlations among morphometric traits of mixed breed of rabbits

Parameter	BDG	STL	HSL	TKL	HTW	EL	HGT	FLL	HLL
STL	0.77***								
HSL	0.34*	0.47**							
TKL	0.27	-0.16	-0.19						
HTW	0.40**	0.57**	0.42**	-0.11					

EL	0.63***	0.78***	0.54**	-0.17	0.49**				
HGT	0.66***	0.62***	0.33*	-0.18	0.63***	0.57**			
FLL	0.31	0.28	0.34*	-0.03	0.50**	0.32*	0.19		
HLL	0.11	0.10	0.13	-0.02	0.37*	0.06	-0.01	0.32*	
NTS	0.11	-0.08	-0.10	-0.05	-0.15	-0.03	-0.13	0.35*	-0.07

******Correlation is significant at the 0.001 level; ** Correlation is significant at the 0.01 level and * Correlation is significant at the 0.05 level, BDG=Bodyweight, STL=Shoulder to tail length, HSL=Head to shoulder length, TKL=Trunk length, HTW=Height at withers, EL=Ear length, HGT=Heart girth, FLL=Forelimb length, HLL=Hind limb length and NTS=Nose to shoulder length.***

Estimate of parameters in simple linear, quadratic, cubic, allometry and exponential functions fitted for body weight and linear body measurements of the mixed breed of rabbits were presented in Tables 2 and 3.

Result obtained from simple linear, quadratic and cubic functions in Table 2 revealed that the equations for the three functions were positive and very highly significant (p>0.001) for all parameters. Description of the relationships using these functions indicated TKL, HGT and HTW as the best morphometric traits to predict the performance of the mixed breeds of rabbits with high and better coefficients of determination (R^2). The values of the coefficient of determination obtained in this study agreed with literature reports on rabbit breed (Atansuyi *et al*., 2011); Akinsola (2012) reported similar findings in Hyla rabbits. This author concluded that regression analyses showed that easily measurable body parts such as chest girth and body length; can help in the determination of body weight. The higher association of body weight with heart girth was possibly due to relatively large contribution to body weight by heart girth consisting of bones, muscles and viscera.

It can be seen from Table 3 of this study that all the predictive equations from allometry and exponential functions were highly significant (p>0.001) for STL, HSL, TKL, HTW, EL, HGT, FLL, HLL and NTS. Allometric coefficients, exponents and their respective coefficient of determinations (R^2) were positive in the regression equations for all the morphometric traits on body weight. This result was similar to that of Unah *et al.* (2012). These authors reported that prediction equation using allometric function had positive correlation between live weight and linear body measurements (New Zealand White rabbits) with R^2 values ranging from 0.90 to 0.99 for all the measurements. However, the use of allometric equation appeared to be more reliable in predicting live weight and this was closely followed by the exponential, cubic, quadratic and least with linear models respectively. This result was also supported by Randriamandratondrakotonirina *et al.* (2016) who studied the growth allometry among the rabbit of Amoroni Mania in Madagascar.

Table 2: Estimate of parameters in simple linear, quadratic and cubic functions fitted for body weight and linear body measurements of the mixed breed of rabbits

Traits	Predictive Equations	RMSE	R^2 (%)	LS
STL	Y_1=-1.27+0.10STL	0.58	45.10	0.001^{***}
	Y_2=-1.85+0.14 STL -0.07STL^2	0.58	45.12	0.001^{***}
	Y_3=14.87-1.54STL +0.05STL^2-0.01STL^3	0.58	45.14	0.001^{***}
HSL	Y_1=-2.09+0.31HSL	0.68	23.00	0.001^{***}
	Y_2=-14.86+2.42HSL- 0.09HSL^2	0.67	27.10	0.001^{***}
	Y_3=-226.00+54.12HSL- 4.27HSL^2- 0.11HSL^3	0.62	38.00	0.001^{***}
TKL	Y_1=1.48+0.01TKL	0.75	70.82	0.001^{***}
	Y_2=-1.07+0.11TKL -0.03TKL^2	0.36	79.71	0.001^{***}
	Y_3=-6.64+0.53TKL -0.01TKL^2+ 0.01TKL^3	0.28	87.00	0.001^{***}
HTW	Y_1=0.08+0.09HTW	0.37	78.12	0.001^{***}
	Y_2=-1.65+0.32-0.01HTW^2	0.32	83.00	0.001^{***}
	Y_3=-3.00+0.57-0.02 HTW^2 + 0.01HTW^3	0.32	83.00	0.001^{***}
EL	Y_1=0.98+0.07EL	0.77	2.00	0.06^{NS}
	Y_2=-1.82+0.61-0.03EL^2	0.77	4.00	0.04^{*}
	Y_3=40.69-11.52+1.10EL^2-0.03EL^3	0.71	17.98	0.001^{***}
HGT	Y_1=-1.47+0.15HGT	0.45	66.74	0.001^{***}
	Y_2=-9.45+0.88-0.02 HGT^2	0.38	77.03	0.001^{***}

	Y_3=-21.34+2.47-0.059 EL^2 +0.01 HGT^3	0.37	78.36	0.001^{***}
FLL	Y_1=-2.57+0.30FLL	0.56	48.60	0.001^{***}
	Y_2=-9.92+1.37-0.04 FLL^2	0.54	52.14	0.001^{***}
	Y_3=-31.72+5.95-0.35 FLL^2+0.01 FLL^3	0.54	53.83	0.001^{***}
HLL	Y_1=1.79+0.21HLL	0.68	24.08	0.001^{***}
	Y_2=-6.33+0.72-0.01 HLL^2	0.68	25.00	0.001^{***}
	Y_3=51.91-9.56+0.58 HLL^2-0.01 HLL^3	0.65	31.50	0.001^{***}
NTS	Y_1=-4.96+0.47NTS	0.61	39.43	0.001^{***}
	Y_2=-26.10+3.48+0.11 NTS^2	0.57	48.00	0.001^{***}
	Y_3=-132.50+25.12-1.56 NTS^2 +0.03 NTS^3	0.56	50.12	0.001^{***}

Y_1 = Body weight (Linear function), Y_2 = Body weight (Quadratic function), Y_3 = Body weight (Cubic function), RMSE = Root mean standard error, R^2 = Coefficient of determination, LS = Level of Significance, *** = Highly significant (p<0.001), * = Significant (p<0.05), NS = Not significant (p>0.05). STL = Shoulder to tail length, HSL = Head to shoulder length, TKL = Trunk length, HTW = Height at withers, HGT = Heart girth, FLL = Fore limb length, HLL = Hind limb length, NTS = Nose to shoulder length and EL = Ear length.

Table 3: Estimate of parameters in allometry and exponential functions fitted for body weight and linear body measurements of the mixed breed of rabbits

Traits	Predictive Equations	A	B	RMSE	R^2 (%)	LS
STL	$Y_a = 4.78STL^{1.72}$	4.78	1.72	583.14	0.90	0.001^{***}
	$Y_e = 358.90e^{0.05STL}$	358.90	0.05	606.17	0.89	0.001^{***}
HSL	$Y_a = 9HSL^{2.08}$	9.00	2.08	684.72	0.87	0.001^{***}
	$Y_e = 252.2e^{0.15HSL}$	252.20	0.15	686.89	0.86	0.001^{***}
TKL	$Y_a = 442.5TKL^{0.41}$	442.50	0.41	753.86	0.88	0.001^{***}
	$Y_e = 1586.2e^{0.002TKL}$	1586.20	0.002	739.65	0.84	0.001^{***}
HTW	$Y_a = 123HTW^{0.92}$	123.00	0.92	365.60	0.96	0.001^{***}
	$Y_e = 670.8e^{0.05HTW}$	670.80	0.05	375.90	0.95	0.001^{***}
EL	$Y_a = 628.8STL^{0.43}$	628.80	0.43	773.95	0.83	0.001^{***}
	$Y_e = 1296.5e^{0.02EL}$	1296.50	0.02	760.75	0.83	0.001^{***}
HGT	$Y_a = 10.07HGT^{1.67}$	10.07	1.67	452.71	0.94	0.001^{***}
	$Y_e = 371.7e^{0.07HGT}$	371.70	0.07	448.51	0.93	0.001^{***}
FLL	$Y_a = 4.08FLL^{2.27}$	4.08	2.27	563.60	0.90	0.001^{***}
	$Y_e = 209.7e^{0.14FLL}$	209.70	0.14	564.21	0.90	0.001^{***}
HLL	$Y_a = 10.68HLL^{1.81}$	10.68	1.81	683.83	0.87	0.001^{***}
	$Y_e = 275.2e^{0.11HLL}$	275.20	0.11	677.56	0.86	0.001^{***}
NTS	$Y_a = 0.67NTS^{2.96}$	0.67	2.96	612.64	0.88	0.001^{***}
	$Y_e = 127.8e^{0.18NTS}$	127.80	0.18	609.02	0.88	0.001^{***}

Y_a = Body weight (Allometry function), Y_e = Body weight (Exponential function), RMSE = Root mean standard error, R^2 = Coefficient of determination, LS = Level of significance, *** = Highly significant (p<0.001), STL = Shoulder to tail length, HSL = Head to shoulder length, TKL = Trunk length, HTW = Height at withers, HGT = Heart girth, FLL = Fore limb length, HLL = Hind limb length, NTS = Nose to shoulder length and EL = Ear length, a = Allometric coefficient or intercept, b = Exponent or slope or growth factor.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that high correlation coefficients obtained in this study were indications of pleiotropic effect of genes. This reflects the effect of a gene having effect on many growth traits at the same time in animals and rabbits in particular. Body measurements and principal components are good predictors of body weights in rabbits. This could aid selection and breeding programmes for improved productivity in rabbits. The equations and estimates derived from the growth functions used were positive and highly significant especially in allometry function. It is hereby recommended that traits with strong positive correlation should be selected for the improvement of rabbits' growth during breeding programme. Also, the function should be used to predict the performance of rabbits because of its high accuracy of prediction.

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