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Genetic estimates studies of morphometric, physiological and blood traits of mixed breed of rabbits

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Abstract

This study was conducted to determine the genetic estimates and blood traits of mixed breed of rabbits at different stages of growth. Three hundred and sixty rabbits comprising crosses of New Zealand White and Chinchilla breeds were used. Morphometric traits such as body weight, shoulder to tail length, head to shoulder length, trunk length, height at withers, ear length, heart girth, forelimb length, hind limb length and nose to shoulder length were recorded weekly. Blood samples were taken at 32 and 48 weeks to assess haematological and serum biochemical indices while physiological parameters such as rectal temperature, pulse rate and respiratory rate were determined as well. The data collected were analyzed using SAS (2008) to determine the phenotypic correlations among blood and physiological traits of mixed breed of rabbits; to estimate realized heritability and repeatability of morphometric and physiological traits. Results obtained are low to high heritability (0.13 to 0.99) and repeatability (0.07 to 0.90) estimates of morphometric and physiological parameters from mixed breeds of rabbits at different ages were obtained in this study. The high heritability estimates could be as a result of additive gene effect that gave rise to high genetic variability. The implication of this is that individual selection will lead to high genetic gain, while the repeatability of these traits being high, suggests that the likelihood to repeat these records is high. Further studies should be conducted involving larger datasets, which would yield more precise estimates of heritability and repeatability.

Key words: Heritability, repeatability, correlation and linear body traits

Estimations génétiques études des caractères morphométriques, physiologiques et sanguins de race mixte de lapin

Résumé

Cette étude a été menée pour déterminer les estimations génétiques et les traits sanguins de races mixtes de lapins à différents stades de croissance. Trois cent soixante lapins issus de croisements de races néo-zélandaises blanches et chinchillas ont été utilisés. Les caractéristiques morphométriques telles que le poids corporel, la longueur de l'épaule à la queue, la longueur de la tête à l'épaule, la longueur du tronc, la hauteur au garrot, la longueur des oreilles, la circonférence du cœur, la longueur des membres antérieurs, la longueur des membres postérieurs et la longueur du nez à l'épaule ont été enregistrées chaque semaine. Des échantillons de sang ont été prélevés à 32 et 48 semaines pour évaluer les indices hématologiques et biochimiques sériques, tandis que les paramètres *physiologiques tels que la température rectale, le pouls et la fréquence respiratoire ont également été déterminés. Les données collectées ont été analysées à l'aide de SAS (2008) pour déterminer les corrélations phénotypiques entre les traits sanguins et physiologiques des races mixtes de lapins ; pour estimer l'héritabilité et la répétabilité réalisées des traits morphométriques et physiologiques. Les résultats obtenus sont des estimations d'héritabilité faible à élevée (0,13 à 0,99) et de répétabilité (0,07 à 0,90) des paramètres morphométriques et physiologiques de races mixtes de lapins à différents âges ont été obtenues dans cette étude. Les estimations élevées de l'héritabilité pourraient résulter d'un effet génétique additif qui a donné lieu à une forte variabilité génétique. Cela implique que la sélection individuelle entraînera un gain génétique élevé, tandis que la répétabilité de ces caractères étant élevée, cela suggère que la probabilité de répéter ces enregistrements est élevée. D'autres études devraient être menées sur des ensembles de données plus vastes, ce qui permettrait d'obtenir des estimations plus précises de l'héritabilité et de la répétabilité.*

Mots-clés: Héritabilité, répétabilité, corrélation et traits corporels linéaires

Introduction

Rabbit farming in Nigeria is faced with myriad of problems, which have resulted in gross shortage of meat and therefore unable to meet up the demand of an increasing population of Nigeria (Nworgu, 2007). The genetic potential for improvement of rabbits is dependent largely on the heritability of the trait measured and its relationship with other traits of economic importance. Among the pre-requisites for genetic improvement for important economic traits in animal breeding is knowledge of genetic parameters such as heritability (Akanno and Ibe, 2005). Realized heritability (h^2) is a key concept in quantitative genetics. Heritability is technically defined as the ratio of additive genetic variance (the variance of breeding values) to the total phenotypic variance ($h^2=\sigma a^2/\sigma p^2$), and represents the fraction of the phenotypic variation of a quantitative trait that is transmissible from one generation to the next. Heritability determines the degree of resemblance between relatives, and the rate of response to artificial and natural selection; therefore, estimating h^2 is often the first step in applied plant and animal breeding programs as well as evolutionary genetics studies. Heritability is also the upper limit for the accuracy of predicting phenotypes from molecular marker data (genomic prediction), and, hence, is required knowledge for common diseases in humans in the context of precision medicine (Yang *et al.,* 2010).

Information on heritability h^2 estimates is very useful in animal breeding as a means of predicting potential response to or progress from selection. Since production traits are inter-related, considerations of such relationships are very relevant to choosing appropriate selection method (Kabir *et al*., 2012). Knowledge of realized heritability h^2 and repeatability R of traits of interest is very crucial to the use of artificial selection which will culminate in genetic improvement using appropriate breeding plans (Kabir *et al*., 2006).

Repeatability (*R*) is the fraction of the phenotypic variance that is due to permanent effects (genetic and permanent environmental effects). It is a measure of the propensity for an animal to repeat the present performance in future (Fayeye, 2014). It is the average proportion of differences in the present records that is likely to be repeated in later records. It is important in prediction of breeding values from multiple records on the same animals as well as being very important in making culling decisions: When R is high we can

cull animals of poor performance on the basis of the first record When R is low, one should wait for more records before making a culling decision on the animal.
The magnitude of a genetic estimate gives an indication of the extent to which selection applied at any stage will affect subsequent flock performance (Ibe, 1995). Therefore, this study is to estimate realized heritability of morphometric and physiological traits of the rabbits at different ages.

Materials and Methods

Experimental Site

The experiment was carried out at the Rabbitry Unit, 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 9 months between March and November. The relative humidity is over 75% and that of temperature is about 27°C, latitude 7°15' North of the Greenwich meridian in the humid tropical rainforest region. It has an average annual rainfall of about 1500mm with temperature ranging between 28°C – 30°C and a relative humidity of about 80% (Climate data, 2018).

Experimental Animals

Three hundred and sixty rabbits obtained from a cross breeding experiment involving thirty rabbits (15 New Zealand white and 15 Chinchilla breeds) conducted at Rabbit Unit of Teaching and Research Farm, Federal University of Technology, Akure were used in the study. The does were randomly assigned to bucks for mating early in the morning. The kits were sexed at 21days. Litters were weaned at 35days when each kit was individually ear-tagged and weighed. Litter mates were kept together in the same cage unit they kits were 56 days of age. Thereafter, the rabbits were separated into individually cages. Concrete drinking and feeding troughs were provided in each cage. The rabbits were given *ad libitum* access to commercial diet of 15% crude protein and 2300 kcal kg^{-1} metabolizable energy in the morning, supplemented with green fodder (sweet potato leaves and *Aspillia africana*) in the evening. The incidence of diarrhoea was combated with antibiotics such as embassin forteR. To ensure absence of internal and external parasites, the animals were treated with IVOMEC injection.

Data Collection

Physiological Parameters

Rectal temperature (^{0}C), pulse rate (bpm) and respiration rate (bpm) were collected on each animal as described by Abdalla and Instar (2009). Measurement were taken early in the morning before feeding. Rectal Temperature (RT) were measured with a digital thermometer. Respiratory Rate (RR) was measured by visually counting the flank movement for one minute. Pulse Rate was measured using a stethoscope.

Haematological and Serum Studies

All haematological parameters were obtained from the blood samples collected in EDTA sample bottles and determined as described by Lamb (1981). Serum biochemical parameters were obtained using the blood collected in lithium heparin sample bottles. The blood was centrifuged to separate the serum from the whole blood. The sera were harvested (using a pipette) into cryopreservation containers and then stored in the freezer at -20°C prior to use.

Morphometric Study

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 tape rule after restraining the animal and these body measurements were used as predictors of body weight (kg). All measurements (cm) were taken at the reference points:

Shoulder length: measured as the distance from the base of the neck to the tip of the tail or end of the coccygeal vertebrae.

Head length: measured as the distance from the nose to the point of the shoulder (that is, base of the neck).

Trunk length: measured as the longitudinal distance from the point of the shoulder to the tuberosity of the ischium.

Height at withers: measured as the dorsal midline at the highest point on the withers.

Ear length: measured as the distance from the base of the attachment of the ear to the head to the tip of the ear.

Heart girth: measured as the chest circumference posterior to the fore legs at right angles to the body axis.

Fore-limb length: measured as the distance from the shoulder blade to the base of the claw.

Hind-limb length: measured as the distance from the iliac wing to the base of the claw.
All measurements were taken in the morning before feeding the animals according to the method of Egena *et al.* (2012).

Statistical Analyses
All data collected were analyzed using SAS 2008 (Version 9.2) software package. For correlation and regression analysis, the degree of association between all pairs of traits were computed for the mixed breeds of rabbits using linear correlation of SASCORR and SAS REG procedure. The heritability and repeatability were estimated using the standard expression by SAS (2008).

Heritability estimates:

$$h^2 = \frac{4\sigma^2 d}{\sigma^2 s + \sigma^2 d + \sigma^2 e}$$

While, repeatability estimates were computed as

$$r = \frac{\sigma^2 d}{\sigma^2 d + \sigma^2 s + \sigma^2 e}$$

The appropriate standard errors of the estimated heritabilities and repeatabilities were also computed.

Results and Discussion

Table 1: Heritability and Repeatability Estimates for Mixed Breed of Rabbits at Different Ages

TRAITS	4 weeks		8 weeks		12 weeks		32 weeks		48 weeks	
	h^2	r	h^2	r	h^2	r	h^2	r	h^2	r
BDG	0.27±0.10	0.12±0.002	0.29±0.15	0.18±0.002	0.46±0.31	0.29±0.003	0.53±0.16	0.31±0.002	1.32±0.46	0.90±0.003
STL	0.38±0.16	0.19±0.003	0.26±0.60	0.15±0.003	0.19±0.11	0.11±0.002	0.47±0.39	0.23±0.003	0.51±0.29	0.22±0.003
HSL	0.34±0.25	0.29±0.002	0.28±0.24	0.21±0.002	0.20±0.15	0.14±0.003	0.33±0.21	0.29±0.002	0.29±0.28	0.11±0.002
TKL	0.32±0.13	0.18±0.002	0.19±0.54	0.11±0.002	0.23±0.10	0.17±0.002	0.41±0.08	0.20±0.003	0.25±0.14	0.18±0.003
HTW	0.48±0.29	0.23±0.003	0.51±0.27	0.33±0.003	0.29±0.12	0.14±0.002	0.60±0.31	0.39±0.003	0.66±0.38	0.34±0.002
EL	0.36±0.58	0.11±0.002	0.29±0.53	0.16±0.002	0.30±0.14	0.21±0.003	0.41±0.39	0.32±0.003	0.38±0.29	0.21±0.002
HGT	0.13± 0.10	0.07±0.002	0.32±0.18	0.21±0.003	0.36±0.29	0.32±0.002	0.46±0.21	0.28±0.003	0.41±0.33	0.19±0.003
FLL	0.46±0.37	0.13±0.002	0.36±0.33	0.29±0.002	0.44±0.26	0.28±0.002	0.39±0.10	0.20±0.002	0.25±0.21	0.20±0.002
HLL	0.32±0.16	0.25±0.003	0.18±0.17	0.08±0.002	0.21±0.20	0.18±0.003	0.38±0.12	0.19±0.003	0.39±0.17	0.28±0.002
NTS	0.32±0.22	0.11±0.003	0.26±0.84	0.18±0.003	0.31±0.18	0.28±0.003	0.35±0.03	0.23±0.003	0.26±0.14	0.19±0.003
RT	0.40±0.14	0.36±0.005	0.38±0.22	0.24±0.003	0.43±0.23	0.39±0.003	0.38±0.19	0.21±0.002	0.32±0.28	0.27±0.002
PR	0.46±0.12	0.21±0.002	0.21±0.19	0.18±0.002	0.38±0.26	0.21±0.002	0.88±0.37	0.46±0.003	0.64±0.35	0.33±0.003
RRT	0.41±0.98	0.29±0.002	0.33±0.31	0.25±0.003	0.21±0.18	0.17±0.002	0.99±0.43	0.48±0.002	0.77±0.43	0.41±0.002

r=Repeatability, h^2= Heritability, 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, NTS=Nose to shoulder length, RT=Rectal Temperate, PR=Pulse rate and RRT=Respiratory rate.

Table 1 showed the realized heritability (h^2) and repeatability (r) estimates for morphometric parameters of the mixed breed of rabbits at different ages. Reported estimates of h^2 and r for various maternal and/or production traits in rabbits varied significantly. Low to moderate heritability estimates (h^2) were obtained in mixed breed of rabbits at 4, 8 and 12 weeks of age. The implication of low to moderate h^2 values obtained in this work is that selection based on individual alone will not yield substantial genetic gain and that offspring will perform less than parent. Moderate to high heritability estimates were obtained at 32 weeks of age, low to high heritability estimates were obtained at 48 weeks of age. The high h^2 estimates could be as a result of additive gene effect that gave rise to high genetic variability. The implication of this is that individual selection will lead to high genetic gain. The lowest h^2 value was recorded at 4 weeks while the highest (1.32) value was recorded at 48 weeks. The result agreed with that of Akinsola (2012) and Sorhue *et al*. (2013), the differences obtained in the heritability of the morphometric traits could be attributed to genetic and or environmental influence.

The repeatability estimates ranged from low to high across ages. Estimates at 48 weeks of age showed the highest (0.90) value, while the least (0.13) value was obtained at 4 weeks of age. This result is in line with the result of Kabir *et al.* (2014) who reported similar estimates of heritability and repeatability for production traits in pure and mixed breed of rabbit does in Nigeria. The differences obtained in this study could be as a result of breed or line differences and environmental effect (Kabir *et al*., 2006). Low r estimate obtained implies that high number of records were required to estimate the potentials of these mixed breed and to realize high response from selection.

Table 2: Phenotypic Correlations among Haematological Parameters of Mixed Breed of Rabbits

	ESR	PCV	RBC	WBC	Hb	LYM	NEU	MON	EOS	BAS	MCV	MCHC	MCH
ESR													
PCV	-0.96***												
RBC	-0.12	0.25											
WBC	-0.76***	0.73***	-0.02										
Hb	0.10	-0.10	-0.17	-0.10									
LYM	0.03	-0.11	-0.03	0.00	-0.07								
NEU	-0.01	0.08	-0.04	0.01	0.21	-0.91***							
MON	0.13	-0.11	-0.03	-0.15	-0.20	-0.31	-0.02						
EOS	-0.13	0.15	0.19	0.13	0.11	-0.04	-0.05	-0.32					
BAS	-0.35*	0.41*	0.36*	0.14	-0.65***	-0.21	0.04	0.25	-0.12				
MCV	0.24	-0.32	-0.92***	-0.07	0.08	-0.06	0.17	-0.05	-0.19	-0.37*			
MCHC	0.25	-0.25	-0.21	-0.21	0.99***	-0.05	0.19	-0.17	0.08	-0.70***	0.13		
MCH	0.27	-0.29	-0.32	-0.21	0.97***	-0.06	0.21	-0.18	0.06	-0.73***	0.26	0.99***	

**** Correlation is significant at the 0.001 level (2tailed)*
*** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*

Erythrocyte Sedimentation Rate (ESR), Packed cell volume (PCV), Red Blood Cell (RBC), Mean Cell Heamoglobin Concentration (MCHC), Mean Cell Volume (MCV), Haemoglobin concentration (HB), White Blood Cell (WBC), Lymphocyte (LYMP), Neutrophils (NEU), monocytes (MONO), eosinophil (EOS), Mean Cell Haemoglobin (MCH) and Basophils (BAS).

Table 3: Phenotypic Correlations among Serum Biochemical indices of Mixed Breed of Rabbits

	ASP	AST	ALP	CHOL	TRG	HDL	LDL	Urea	CREAT	TP	ALB	GLOB
ASP												
AST	0.89***											
ALP	0.19	0.12										
CHOL	-0.08	-0.10	0.33									
TRG	0.31	0.21	0.19	0.20								
HDL	0.11	-0.08	0.17	0.38*	0.25							
LDL	-0.07	-0.15	0.26	0.54**	-0.04	0.49**						
Urea	0.08	-0.05	0.29	0.39*	0.02	0.47**	0.94***					
CREAT	0.09	0.12	-0.04	-0.21	0.04	-0.51**	-0.72***	-0.56**				
TP	-0.02	0.06	-0.02	-0.06	0.18	-0.30	0.01	0.02	-0.13			
ALB	0.11	0.12	-0.35*	-0.39*	0.03	0.03	-0.06	-0.04	-0.18	0.05		
GLOB	0.06	0.19	-0.25	-0.04	0.05	-0.40*	-0.21	-0.17	0.25	0.54**	0.17	

**** Correlation is significant at the 0.001 level (2tailed)*
*** Correlation is significant at the 0.01 level (2-tailed).*
** Correlation is significant at the 0.05 level (2-tailed).*
Aspartate amino transferase (AST), alanine amino transferase (ALT), alkaline phosphate (ALP), cholesterol (CHOL), triglycerid e (TRG), High density lipoprotein (HDL), Low density lipoprotein (LDL), Creatinine (CREAT), Total protein (TP), Urea, creatinine and globulin (GLOB)

From this study (Table 2 and 3) The result obtained from phenotypic correlation among haematological parameters of mixed breed of rabbits showed that Erythrocyte Sedimentation Rate (ESR); and Packed cell volume (PCV), Red Blood Cell (RBC) and Mean Cell Haemoglobin Concentration (MCHC), Mean Cell Volume (MCV) and Haemoglobin concentration (HB), White Blood Cell (WBC), ESR and PCV, Neutrophils (NEU) and LYM , BAS and ESR, PCV, RBC and HB, MCV, RBC BAS and WBC, MCHC HB and BAS and MCH, HB and MCHC of mixed breeds of rabbits were significant.

The correlation that existed among the blood traits of the mixed breed of rabbits were low to high correlation. The phenotypic correlation between PCV and ESR was negative and with high correlation coefficient. High relationship existed between WBC and ESR with negative correlation coefficient while WBC and PCV had positive correlation coefficient. Strong relationship existed between NEU and LYM but correlation was negative. High correlation with a very strong relationship existed between MCV and RBC but negatively correlated. The strongest relationship existed between MCHC and Hb, MCH and Hb; and MCH and MCHC while MCHC and BAS; with MCH and BAS were negatively correlated. This is the phenomenon of correlated response, however the negative correlations observed in some cases indicated that selection for one of the traits could lead to the improvement in the other if a reduction of the second trait is desired. This result is in concord with that of Khalil *et al.* (2015). These workers or investigators reported low to high correlation in the blood traits for bucks of New Zealand white and Baladi red rabbits. This result also agreed with that of Elamin (2013) who reported negative phenotypic correlations among blood traits of rabbits.

The results from this study also revealed that phenotypic correlation among serum biochemical indices such as Aspartate amino transferase (AST), alanine amino transferase (ALT), alkaline phosphate (ALP), cholesterol (CHOL), triglyceride (TRG), High density lipoprotein (HDL), Low density lipoprotein (LDL), Creatinine (CREAT), Total protein (TP), Urea, creatinine and globulin (GLOB) of mixed breed of rabbits were significant. The phenotypic correlation between AST and ASP was positive with high correlation coefficient. High relationship existed between LDL and CHOL; GLOB and TP and CREAT and HDL. The strongest relationship existed between urea and LDL. For traits with strong positive phenotypic correlation, selection for one trait will lead to improvement in the other. This result disagreed with that of Elamin (2013); this author reported strong but negative phenotypic correlations among blood traits of rabbits.

Table 4: Phenotypic Correlations among Physiological Traits of Mixed Breed of Rabbits

Age (Weeks)	Traits	Rectal Temperature	Pulse Rate
	Rectal Temp		
4	Pulse Rate	0.06	
	Respiratory Rate	0.2	0.43*
	Rectal Temp		
8	Pulse Rate	0.34	
	Respiratory Rate	0.46*	0.07
	Rectal Temp		
12	Pulse Rate	-0.13	
	Respiratory Rate	-0.09	-0.18
	Rectal Temp		
32	Pulse Rate	0.01	
	Respiratory Rate	-0.07	0.22
	Rectal Temp		
48	Pulse Rate	0.19	
	Respiratory Rate	-0.08	0.32*

** Correlation is significant at (p< 0.05) level (2-tailed).*

Phenotypic correlations among physiological traits of mixed breed of rabbits at different ages were presented in Table 4. The phenotypic correlation among rectal temperature, pulse rate and heartbeat of mixed breed of rabbits were significant at different ages. The correlation that existed among the physiological traits of the mixed breed of rabbits was low to moderate correlation. The phenotypic correlation between respiratory rate and pulse rate was positive. Respiratory rate and rectal temperature at 8 weeks had moderate correlation while respiratory rate and pulse rate had low correlation at 48 weeks. This result is similar to the result of Iyeghe-Erakpotobor *et al*. (2013) and Sabah *et al.* (2016), These authors concluded that correlation exist between physiological traits of rabbits and thermal changes have significant effect on their growth and physiological responses.

Conclusion and Recommendation

The estimates of heritability suggest strong contribution of additive genes in the expression of bodyweight, shoulder to tail length, height at withers, pulse rate and respiratory rate at old age. Likewise, low repeatability estimates (R) implies that the mixed breed of rabbits in this study have lower ability to repeat their present performance in the future and also high numbers of records are required to realize high expected response for selection. Phenotypic correlations among blood traits and physiological parameters of mixed breed of rabbits were significant.

Recommendations

From this study, it is hereby recommended that:

i. For traits with strong positive phenotypic correlation, selection for one trait leading to improvement in the other should be employed in breeding programme.
ii. This study revealed that heritability estimates for body weight and morphometric traits can be used in making selection programs targeted towards improvement of rabbits.
iii. Based on this study, it is therefore suggested that further studies be conducted involving larger datasets, which would yield more precise estimates heritability and repeatability.

References

Abudalla, M. A. and Instar, H. S. (2009). Thermoragulation, Heart Rate and Body Weight as Influenced by Thyroid Status and Season in the Domestic Rabbit (Lapus Cunalus) Middle-East *Journal of Scientific Research* 4(4); 310-319.

Akanno, E. C. and Ibe, S. N. (2005). Estimates of Genetic Parameters for Growth traits of Domestic Rabbits in the Humid tropics. *Livestock Res. Rural Dev.,* 17 (7).

Akinsola, O. M. (2012). Genetic and Physiological Evaluation of Hyla Rabbits in Guinea Savannah Zone of Nigeria. Msc. Thesis submitted to the Postgraduate School and Department of Animal Science, Ahmadu Bello University, Zaria Nigeria

Climate Data (2018). Akure Climate Information http://en.climate–data.org/location/385339. Retrieved on: 24/11/2018.

Egena, S. S. A., Akpa, G. N., Aremu, A. and Alemede, I. C. (2012). Predicting Body Weight of Rabbit from Linear Body Measurements at Various Ages by Genetic Group, Parity and Sex. Proceedings 10th World Rabbit Congress – September 3-6, 2012 - Sharam El – Sheikh - Egypt, 19- 23.

Elamin, K. M (2013). Age and Sex Effects on Blood Biochemical Profile of Local Rabbits in Sudan. *Wayamba Journal of Animal Science, 548-553*, ISSN: 2012-578

Fayeye, T. R. (2014). Genetic Principles and Animal Breeding. Happy Printing Enterprises, Ilorin. Kwara State. 256.

Ibe, S. N. (1995). Repeatability of Growth Trait in Nigerian Local Chickens using Early Records. *Nigerian Journal of Animal Production*, 23(2): 103-106.

Iyeghe-Erakpotobor, G. T., Akinsola, O. M, Samuel, T. T. and Pewar, P. F. (2013). Growth and Physiological Responses of Rabbit Hyla Stock in a Sub-Humid Tropical Environment. *J.Anim. Prod. Res.,* 25: 25-36

Kabir, M., Akpa G. N., Nwagu B. I. and Adeyinka I. A. (2012). Litter Traits in a Diallel Crossing of Three Rabbit Breeds in Northern Guinea Savannah Zone of Nigeria, In: *Proceedings,10th World Rabbit Congress, World Rabbit Science Association*, September 3-6, Sharm El-Sheikh, Egypt. 69–74.

Kabir, M., Oni, O. O., Akpa, G. N. and Adeyinka, I. A. (2006). Heritability Estimates and the Interrelationships of Body Weight and Shank Length in Two Strains of Rhode Island Chickens. *Pakistan Journal of Biological Sciences*, 9 (15): 2892–2896.

Kabir, M., Akpa G. N., Nwagu B.I., Adeyinka I. A. and Ogah, D. M. (2014). Estimates of Heritability and Repeatability for Production Traits in Pure and Mixed Breeds of Rabbit does in Nigeria. *J. Amin. Prod. Res.*, 26:103-112.

Khalil, H. A., Yaseen, M. A. and Hamdy, A. M. (2015). Behavioral Activities, Physiological BodyReactions, Hematological Parameters and Hormonal Profiles for Bucks of New Zealand White and Baladi Red Rabbits Exposed to Short Term of High Temperature. ***AsianJournal of Poultry Science*, 9 (4): 191-202.**

Lamb, G. M. (1981). Manual of Veterinary Laboratory Techniques in Kenya. Ministry of Livestock Development /CIBA GEIGY, Basle, Switzerland. 96-107.

Nworgu, F. C. (2007). Economic Importance and Growth Rate of Broiler Chicken Served Fluted Pumpkin (Telfaria occidentalis) *African Journal of Biotechnology*, **2**:6 34-39

Sabah, A. H., Abd Al-Rahman, A. and Dalal Abd Al-Sattar, A. B. (2016). Effect of the Thermal Changes on Physiological, Biochemical and Histological traits in Pregnant and Embryo of New Zealand White Rabbits. *International Journal of Advanced Biological Research*, 6(2): 313-327.

SAS (2008). Statistical Analysis System Multiple Incorporation. Users' Guide Statistical version Cary, NC. USA

Sorhue, G. U., Akporhuarho, P. O., Udeh, I. and Mmereole, F. U. C. (2013). Estimates of genetic parameters of Litter Size Traits at Birth and Weaning in Domestic Rabbits (*Oryctolagus cuniculus*) raised in Anwai Community, South Nigeria. *Rabbit Genetics*, 3(1):7-14.

Yang, J., Benyanda, B., Mc Evoy, B. P. Gordon, S., Henders, A. K. N. G., Montgomery, G. W., Goddard, M. E., and Visscher, P. M. (2010).Common SNPs Explain a Large Proportion of the Heritability for Human Height. *Nature Genetics*, 42, 565-569.

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