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Heritability and Repeatability Estimates of Some Measurable Traits in Meat Type Chickens Reared for Ten Weeks in Abeokuta, Nigeria

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***Abstract*—**A total of 150 meat type chickens comprising 50 each of Arbor Acre, Marshall and Ross were used for this study which lasted for 10 weeks at the Federal University of Agriculture, Abeokuta, Nigeria. Growth performance data were collected from the third week through week 10 and data obtained were analysed using the Generalized Linear Model Procedure. Heritability estimates (h^2) for body dimensions carried out on the chicken strains ranged from low to high. Marshall broiler chicken strain had the highest h^2 for body weight 0.46±0.04, followed by Arbor Acre and Ross with h^2 being 0.38±0.12 and 0.26±0.06, respectively. The repeatability estimates for body weight in the three broiler strains were high, and it ranged from 0.70 at week 4 to 0.88 at week 10. Relationships between the body weight and linear body measurements in the broiler chicken strains were positive and highly significant ($p > 0.05$).

***Keywords*—**Broiler chicken strains, heritability, repeatability, traits.

I. Introduction

GENETIC SELECTION has led to improved growth rate, feed conversion and increased meat yield in broiler chickens thereby reducing waste, reducing the number of days to reach market weight and making poultry meat more affordable [9]. There have been rapid increase in the number of farmers owning broiler parent and grandparent stocks leading to an increase in the population of meat type chicken in Nigeria [1].

The use of unsuitable genotypes in hot regions results in decreased growth rate, reduced protein gain and high mortality rate [19]. The implication is that broiler farmers should select the strains that are adaptable to the Nigerian environment with good performance. In places where scales are not available as is the case in most rural African communities [14], linear body measurements such as shank length, drum stick length and wing length can be used in a predictive equation to predict body weight in broilers [4], [15]. The objective of this research was to determine the heritability and repeatability estimates of some measurable traits in three broiler strains, Arbor Acre, Marshall and Ross in South-West, Nigeria.

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II. Materials and Methods

This study was carried out at the Poultry Breeding Unit, Directorate of University Farms, Federal University of Agriculture Abeokuta, Nigeria. A total of 150 pure strain broiler chicks comprising 50 each of Arbor Acre, Marshall and Ross were procured from reputable hatcheries in Abeokuta, Ogun State and Ibadan, Oyo State, respectively. Brooding was done for the first two weeks and the birds were reared for a period of 10 weeks, the three broiler strains were subjected to same management system from day old till 10 weeks of age as described by [16]. Though the broiler strains (Arbor Acre, Marshall and Ross) were separated into three different pens and replicated five times with 10 birds per replicate. The vaccination and medication programmes for the broiler strains were also same throughout the experimental period. The birds were fed *ad libitum* with broiler starter commercial feed containing 21% crude protein (CP) and 2840 (kcal/kg) metabolizable energy (ME) from day old till 5 weeks of age and broiler finisher commercial feed containing 19% CP and 2875 (kcal/kg ME) from 5 to 10 weeks of age. Clean drinking water was also provided *ad libitum* to the birds. Heritability and repeatability were calculated for the growth parameters. Regression and correlation analysis were also carried out on the following growth parameters (body weight, breast girth, shank length, thigh length and wing span). The estimate of heritability was made possible through the pedigree data obtained from the three farms where the broiler chickens were procured.

For the estimate of heritability, sib analysis was used and the formula employed was of the form:

$$h^2 = \frac{4\sigma_S{}^2}{\sigma_S{}^2 + \sigma_W{}^2}$$

where h^2 is narrow sense heritability, $\sigma_s{}^2$ is the sire variance component and $\sigma_w{}^2$ is variance component within.

Standard error of h^2

$$S.E.\left(h^2{}_s\right) = 4\sqrt{\frac{2(1-t)^2\left[1+(K-1)t\right]^2}{K(K-1)(S-1)}}$$

where *t* is the intra-class correlation, k is the coefficient of variance component being estimated and S is the number of sires.

Repeatability (R) was estimated using the relation:

$$R = \frac{\sigma_b^2}{\sigma_b^2 + \sigma_w^2}$$

where σ_b^2 is variance component between and σ_w^2 is variance component within.

III. Results And Discussion

The heritability estimates for traits studied ranged from low to high, the heritability estimates for body weight (0.46±0.02) observed in Marshall at 8 weeks old was greater than the heritability estimates of (0.38±0.03) observed in Arbor Acre at 10 weeks and (0.26±0.06) observed in Ross strains at 8 weeks old; The repeatability estimates for body weight in the three strains were high and it ranged from 0.70 at week 4 to 0.88 at week 10. Arbor Acre had an estimate of 0.74 at week 4 and the highest of 0.86 was observed in week 8. In Marshall Strain, repeatability estimates ranged from 0.72 at week 4 to 0.84 at week 10, while Ross that had the lowest repeatability estimate of 0.70 among the three strains at week 4, recorded the highest repeatability estimate of 0.88 at week 10. The correlation coefficients of body weight and linear body measurements in the three broiler strains showed that the correlation coefficients ranged from 0.77 to 0.97, 0.77 to 0.98 and 0.79 to 0.96 in Arbor Acre, Marshall and Ross strains respectively. Relationships between the body weight and linear body measurements were positively correlated and highly significant ($p>0.05$) in the three broiler strains. Measurements of breast girth, shank length, thigh length and wing span were regressed against body weight using linear function. Ross broiler strain had the highest R^2 values for all the linear body measurements regressed against body weight at weeks 4, 8 and 10 with the following $\%R^2$ values of 85.28%, 82.86% and 83.25%, while Marshall Strain had the highest $\%R^2$ values of 77.18% at six weeks old. From the results obtained in this study, body weight of broiler chicken can be predicted from any of the linear body measurements, that is breast girth, shank length, thigh length and wing span with best accuracy of prediction obtained with thigh length as the estimator. These results are presented in Tables I, II and III respectively.

Heritability estimates for body weight and linear body measurements were similar to those found by [12] and [6], respectively, and diverged from those found by [8], [11], [13] and [18], respectively. Higher repeatability estimates obtained for the broiler strains in this study is in line with the findings of [10] where high repeatability estimates were reported for growth traits in Anak 2000 broiler strain, indicating that the broiler strains used in this study have greater ability to repeat their present performance in future. The positive and significant correlations among the body measurements observed in the three broiler strains indicate high predictability among the variables [17]. The positive relationship between body weight and most of the linear body measurements showed that body weight can be predicted from the linear body measurements. A similar observation was reported by [3]. The best accuracy of prediction was obtained at the 4th week with a $\%R^2$ value of 85.28% which gradually reduced as the birds grew older; this was in agreement with the findings of [7] that reported that linear equation was usually used to estimate growth in livestock, however, as the growth of individual differed with time and age, the estimation of body weight at different ages were mostly non-linear. Coefficient of determination designated as R^2 obtained in this study was lower than the R^2 values reported by [2] and [5], respectively. [2] Reported $\%R^2$ ranged of 73.91% to 97.91%; while in a similar study by [5], $\%R^2$ ranged from 82% to 92%. The differences between R^2 obtained in this study and that of earlier researchers might be attributed to differences in type of strains and locations used. Reference [2] used crossbred egg type chickens, while [5] used Wadi Ross meat type chicken in derived savannah zone of Nigeria.

TABLE I
Heritability and Repeatability Estimates for Body Weight and Linear Body Measurements in Arbor Acre, Marshall and Ross Strain of Broiler Chickens

Strain	Week	Traits				
		BW (g)	BG (cm)	SL (cm)	TL (cm)	WS (cm)
Arbor Acre	4	0.14±0.06(0.74)	0.21±0.04(0.20)	0.46±0.18(0.39)	0.42±0.26(0.46)	0.38±0.24(0.53)
Marshall		0.20±0.06(0.72)	0.14±0.08(0.24)	0.26±0.14(0.36)	0.34±0.10(0.47)	0.56±0.22(0.48)
Ross		0.04±0.02(0.70)	0.28±0.12(0.47)	0.56±0.22(0.47)	0.66±0.16(0.52)	0.34±0.12(0.39)
Arbor Acre	6	0.24±0.08(0.80)	0.06±0.10(0.24)	0.70±0.18(0.53)	0.60±0.36(0.43)	0.62±0.32(0.60)
Marshall		0.34±0.04(0.79)	0.36±0.16(0.44)	0.72±0.16(0.50)	0.64±0.18(0.62)	0.58±0.12(0.86)
Ross		0.24±0.04(0.83)	0.14±0.12(0.36)	0.36±0.22(0.51)	0.40±0.12(0.59)	0.20±0.18(0.42)
Arbor Acre	8	0.22±0.02(0.86)	0.16±0.14(0.50)	0.66±0.12(0.57)	0.48±0.12(0.63)	0.08±0.10(0.57)
Marshall		0.46±0.04(0.81)	0.10±0.08(0.53)	0.16±0.14(0.44)	0.22±0.16(0.35)	0.22±0.08(0.46)
Ross		0.26±0.06(0.86)	0.16±0.06(0.59)	0.46±0.14(0.57)	0.14±0.14(0.63)	0.24±0.10(0.56)
Arbor Acre	10	0.38±0.12(0.83)	0.16±0.10(0.62)	0.17±0.12(0.62)	0.44±0.12(0.71)	0.20±0.06(0.57)
Marshall		0.42±0.08(0.84)	0.08±0.10(0.59)	0.58±0.16(0.53)	0.24±0.12(0.38)	0.60±0.14(0.52)
Ross		0.12±0.02(0.88)	0.28±0.14(0.52)	0.06±0.08(0.64)	0.10±0.06(0.62)	0.26±0.04(0.50)

BW = Body Weight, BG = Breast Girth, SL = Shank Length, TL = Thigh Length and WS = Wing Span and
Values within parentheses represent repeatability

TABLE II
PEARSON CORRELATION COEFFICIENT OF BODY WEIGHT AND LINEAR BODY MEASUREMENTS IN BROILER CHICKENS AT 10 WEEKS OF AGE

Strain/Trait	BW	BG	SL	TL	WS
Arbor Acre/ Marshall/Ross					
BW	1.00				
BG	0.80/0.82/0.82	1.00			
SL	0.95/0.94/0.95	0.77/0.77/0.83	1.00		
TL	0.94/0.93/0.93	0.79/0.80/0.83	0.95/0.98/0.95	1.00	
WS	0.94/0.93/0.94	0.77/0.79/0.79	0.95/0.96/0.96	0.97/0.95/0.95	1.00

Significant (P< 0.05), BW = Body Weight, BG = Breast Girth, SL = Shank Length, TL = Thigh Length and WS = Wing Span.

TABLE III
LINEAR REGRESSION EQUATIONS PREDICTING BODY WEIGHT FROM LINEAR BODY MEASUREMENTS AT TEN WEEKS OF AGE IN BROILER CHICKENS

Strain	Equations	R^2	RMSE	Level of significance
Arbor Acre	BW = -632.34946 + 152.77402BG	0.62	196.87	***
	BW = -1478.06080 + 348.80118SL	0.55	212.28	***
	BW = -2705.74093 + 228.45305TL	0.74	163.71	***
	BW = -2073.90627 + 78.53803WS	0.57	209.72	***
	BW = -2357.55240 + 64.41500BG + 64.16074SL + 152.83149TL + -9.60012WS	0.79	152.57	***
Marshall	BW = -1529.43079 + 205.21345BG	0.76	157.37	***
	BW = -1560.54348 + 360.40217SL	0.70	176.47	***
	BW = -1230.20883 + 150.27933TL	0.49	227.47	***
	BW = -3396.85175 + 105.01730WS	0.63	195.58	***
	BW = -2046.66456 + 132.88159BG + 116.28790SL + 41.82119TL + -4.36879WS	0.83	138.46	***
Ross	BW = -1109.64724 + 187.45910BG	0.62	200.25	***
	BW = -1525.67632 + 363.03275SL	0.62	198.63	***
	BW = -3065.01888 + 249.79022TL	0.67	186.50	***
	BW = -2782.04004 + 94.67644WS	0.58	210.06	***
	BW = -3330.40501 + 81.15124BG + 99.90004SL + 73.08993TL + 32.17695WS	0.83	137.32	***

BW = Body Weight, BG = Breast Girth, SL = Shank Length, TL = Thigh Length, and WS = Wing Span. *** P< 0.001

IV. CONCLUSION

Marshall broiler strain had the highest estimate of heritability for body weight followed by Arbor acre and Ross, but none of the chicken strains maintained a high heritability estimate from 4th to 10th week, considering the linear body measurements. Ross broiler strain showed the highest repeatability estimates for body weight and shank length, Arbor Acre showed the highest estimates for breast girth and thigh length, while Marshall strain had the highest estimate for wing span, indicating more records would be required to realize expected response from selection. From the results of this study, body weight of broiler chickens could be predicted from any of the linear body measurements considered with best accuracy of prediction obtained at the 4th week and the thigh length as the most efficient estimator.

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