REPEATABILITY OF GROWTH TRAITS IN NIGERIAN LOCAL CHICKENS USING EARLY RECORDS

S.N. IBE

*Department of Animal Breeding & Genetics, Federal University of Agriculture,
Umudike, Umuahia*

Received 7 May, 1994; Accepted 30 January, 1995

ABSTRACT

One hundred and ninety-six records of body weight (WT), shank length (SL), keel length (KL), breast width (BW) and a principal component measure of body size (PC1) from a closed random-mated population of Nigerian local chickens of mixed sexes and genotypes were analyzed, using two records (2 - and 4 - week) from each individual. The repeatability of body weight (0.12 ± 0.071) was low, indicating that selection for 4-week body weight may not result in higher lifetime average body weight. On the other hand, PC1 had a high repeatability of 0.55 ± 0.050 , indicating that an appreciable amount of genetic improvement in lifetime average body size can be realized by using this trait as selection criterion. PC1 is therefore recommended for selection purposes as it is a more reliable measure of an animal's overall body size. Although repeatabilities of SL (0.33 ± 0.064), KL (0.38 ± 0.061) and BW (0.21 ± 0.068) were moderate, selection based on them singly may not be useful in improving overall body growth of an animal, unless selection is designed to improve specific body areas of prime economic value.

Key Words: Repeatability, growth traits, early records, local chicken

INTRODUCTION

The local chicken of Nigeria is small in size and grows slowly. For example, Oluyemi and Ogunmodede (1979) reported mature body weights of 1.18-1.28 kg for males, and 0.92-1.02 kg for females, and corresponding shank lengths of 7.9-8.4cm and 6.6cm. Improvement in body size and overall growth of the Nigerian local chicken is important from economic considerations bordering on the need to increase egg size and to improve the post-lay value of the chickens, since spent local hens

are generally in high demand. Genetic improvement of growth parameters in this population could be brought about by long-term selection within the existing population, provided substantial additive genetic variance for the traits exists. Thereafter, individuals in the select line could be crossed with an improved migrant stock to fix the desired genes. Some response to selection for 12-week body in the local chicken has been reported (Oluyemi and Oyenuga, 1974; Oluyemi, 1979).

Selection is usually based on breeding values of candidates for selection and this value, for a trait that can be measured more than once in an animal's lifetime, for example body weight, depends partly on the repeatability of the trait. The magnitude of a repeatability estimate gives an indication of the extent to which selection practised at any stage will affect subsequent flock performance (Dzakuma *et al.*, 1982). It is desirable to select for early records for the improvement of lifetime records in order to benefit from a shortened generation interval, with its resultant increase in genetic progress. There are no reports of repeatability estimates for body weight and other growth traits in the Nigerian local chicken in available literature. Dalton (1981) gave general estimates of 0.55, 0.94 and 0.88 for 8-week, 18-week and 58-week body weights, respectively in chickens.

The objective of this study is to provide estimates of repeatability of different growth parameters to aid in selection decisions for the improvement of the body size and egg size of the Nigerian local chicken.

MATERIAL AND METHODS

Material

Data used consisted of 196 records of body weight (WT), shank length (SL), keel length (KL), breast width (BW) and a principal component measure of body size (PC1) obtained in nine hatches (at two-weekly intervals) from a closed random-mated population of Nigerian local chickens of mixed sexes and genotypes (normal, frizzle and naked neck) at two and four weeks of age. The management of this population has been fully described by Ebangi and Ibe (1994).

The principal component measure of body size, PC1 was obtained by weighting standardized values of the three linear body measurements, namely SL, KL and BW, with principal component coefficients from analysis of the correlation matrix of the linear parameters, as in expression (1).

$$PC1 = a_{1z1} + a_{2z2} + a_{3z3} \dots\dots\dots (1)$$
 where a_i 's are the derived principal component coefficients, and Z_1 , Z_2 and Z_3 are standardized values of SL, KL and BW, respectively.

Statistical Analysis

The data were generated by and analyzed according to the mixed model in expression (2).

$$Y_{ijkl} = \mu + A_i + H_j + I_{jk} + e_{ijkl} \dots\dots\dots (2)$$
 where Y_{ijkl} is the l -th record of a response variable (WT, SL, KL, BW, PC1), μ is overall mean, A_i is the fixed effect of the i -th age of the individual on measurement ($i = 1, 2$), H_j is the fixed effect of the j -th hatch ($j = 1, \dots, 9$), I_{jk} is the random effect of the k -th individual within the j -th hatch, and e_{ijkl} is the random error, distributed IIND ($0, \sigma^2$).

Harvey's (1987) Mixed Model Least-Squares and Maximum Likelihood Computer Programme was used to analyze the data. The programme adjusted the data for the non-genetic influences (age and hatch) and thereafter estimated observable components of variance for individual (σ_{12}) and error (σ_e^2) by equating reductions in sums of squares due to fitting different submodels of the full model to

their respective expectations, in line with Henderson's (1953) method of fitting constants.

Repeatability (R) was then estimated with expression (3) and its standard error with the standard expression in Becker (1984).

$$R = \sigma_{12} / (\sigma_{12} + \sigma_e^2) \dots\dots\dots (3)$$

where σ_{12} represents variation due to permanent parts of the record, and $\sigma_1^2 + \sigma_e^2$ the total phenotypic variation. Expression (4) due to Lush (1945) was used to compute the expected relative genetic gain per generation from selection based on repeated records compared with selection on a single record.

$$\Delta G = k / [1 + (k-1) R] \dots\dots\dots (4)$$

where k is the number of records and R is repeatability.

RESULTS AND DISCUSSION

Table 1 shows the principal component coefficients (eigenvector) that were used to obtain values of the trait, PC1 in weeks 2 and 4, according to expression (1). The table also shows that the first two principal components, PC1 and PC2 explain 87.7 and 91.8% of total variation in weeks 2 and 4, respectively. PC1 consists of all positive coefficients, as expected, since it represents a weighted average of the linear measurements. On the other hand, PC2 consists of both positive and negative coefficients which indicate contrasts in the various linear measurements. Thus, whereas PC1 has been regarded as a 'body size' vector, PC2 is regarded as a 'conformation' vector (Brown *et al.*, 1973; Carpenter *et al.*, 1978; Zarnecki *et al.*, 1985; Ibe, 1989). PC1 is believed to be a less biased measure of body size than scale body weight, since it is not influenced by the amount of undigested and unabsorbed food in the gut at the time of measurements (Carpenter *et al.*, 1978; Ibe, 1989).

Least-squares means of the traits by hatch and by age are presented in Table 2. The average body weight at four weeks (71.9g) obtained in this study is smaller than that (113.3g) reported by Akinokun (1974) for non-crested fowls of the Ife Foundation Stock

TABLE 1. EIGENVALUES AND PRINCIPAL COMPONENT WEIGHTS FROM ANALYSIS OF LINEAR BODY MEASUREMENTS

Trait ^a	Week 2 ^b		Week 4	
	PC1	PC2	PC1	PC2
SL	0.612	-0.093	0.581	-0.311
KL	0.569	-0.637	0.579	-0.492
BW	0.549	0.765	0.572	0.813
Eigenvalue	68.24	19.45	82.16	9.60

^a SL = shank length, KL = keel length, BW = breast width
^b PC1 and PC2 are 1st and 2nd principal components, respectively

TABLES 2. LEAST-SQUARES MEANS OF TRAITS BY HATCH AND AGE

Variable		No. Obs.	WT	SL	Trait ^{1,2,3} KL	BW	PC1
Hatch	1	20	86.47 ^a (4.464)	2.92 ^a (0.072)	2.63 ^{de} (0.087)	2.75 ^e (0.078)	1.02 ^{fg} (0.357)
	2	26	79.29 ^a (3.195)	2.95 ^a (0.063)	2.68 ^c (0.076)	2.69 ^e (0.068)	1.07 ^g (0.313)
	3	6	61.32 ^{bc} (8.151)	3.02 ^a (0.131)	2.53 ^{cde} (0.159)	2.55 ^{cde} (0.143)	0.55 ^{defg} (0.652)
	4	42	54.21 ^{bc} (3.081)	2.72 ^b (0.049)	2.32 ^{bc} (0.060)	2.50 ^{cd} (0.054)	-0.23 ^{cd} (0.247)
	5	38	57.16 ^b (3.239)	2.76 ^b (0.052)	2.50 ^d (0.063)	2.61 ^{de} (0.057)	0.38 ^{ef} (0.259)
	6	24	52.50 ^{bc} (4.075)	2.73 ^b (0.065)	2.25 ^{bc} (0.079)	2.58 ^{de} (0.071)	-0.16 ^{cde} (0.326)
	7	12	46.71 ^{bcd} (5.763)	2.63 ^{bc} (0.092)	2.13 ^{ab} (0.112)	2.33 ^{bc} (0.101)	-0.94 ^{bc} (0.461)
	8	16	43.81 ^{cd} (4.991)	2.63 ^{bc} (0.080)	2.24 ^{bc} (0.097)	2.12 ^{ab} (0.087)	-1.05 ^b (0.400)
	9	12	39.25 ^d (5.763)	2.46 ^c (0.092)	1.94 ^a (0.112)	1.96 ^a (0.101)	-2.04 ^a (0.461)
Age (wk)	2	98	43.80 ^a (2.103)	2.56 ^a (0.031)	2.11 ^a (0.038)	2.26 ^a (0.036)	-0.16 (0.148)
	4	98	71.91 ^b (2.103)	2.96 ^b (0.031)	2.61 ^b (0.038)	2.65 ^b (0.036)	-0.16 (0.148)
	4	98	71.91 ^b (2.103)	2.96 ^b (0.031)	2.61 ^b (0.038)	2.65 ^b (0.036)	-0.16 (0.148)

- 1 WT = body weight, SL = shank length, KL = keel length, BW = breast width
PC1 = 1st principal component
- 2 Standard errors in parentheses
- 3 Means in same column for hatch and age with different superscripts are significantly different ($P < 0.001$) (See Table 3).

TABLE 3. ABRIDGED LEAST-SQUARES ANALYSIS OF VARIANCE TABLE FOR ALL TRAITS

Source	d.f.	Mean Squares					E (MS)
		WT	SL	KL	BW	PC1	
Age	1	38704.1***	7.80***	12.35***	7.48***	0.00 ^{ns}	
Hatch	8	4764.8***	0.44***	1.02***	1.12***	17.33***	
Indiv/ hatch	89	398.6	0.10	0.15	0.12	2.55	$\sigma_e^2 + 2\sigma_1^2$
Error	97	310.9	0.05	0.07	0.08	0.74	σ_e^2
Total	195						

*** $P < 0.001$ ns = $P > 0.05$

at the same age. This discrepancy may be attributed to differences in the genetic constitution of the base populations used as well as their subsequent breeding and management. With the exception of the effect of age on PCI, there were significant ($P < 0.001$) effects of hatch and age on all the traits. Table 3 gives the mean squares of the fixed effects for all traits. The result obtained justifies the inclusion of the two non-genetic factors (age and hatch) in the mixed model (2) as important sources of variation, to ensure less biased estimates of random effects for the estimation of repeatability.

Expressions for the expectations of mean squares used to estimate the required variance components are given in Table 3. The estimated components and the repeatability coefficient for each of the traits are shown in Table 4. Body weight at 4 weeks is lowly repeatable, indicating that animals do not rank consistently high (or low) in the population. Implications of this are that selection for 4-week body weight is not expected to result in higher lifetime average body weight and that more than two records per individual will be required. In other words, selection for the improvement of lifetime average body weight may have to be done using 12-week body weight, with 6 records per individual on a

biweekly bases. This will result in 60% greater genetic gain than selection based on 4-week body weight, with only 2 records per individual (Table 5). However, there is the problem of cost of collecting additional records. Previous studies involving estimation of heritability of body weight and selection for the improvement of this character in the local chicken of Nigeria (Oluyemi and Oyenuga, 1971; Oluyemi and Oyenuga, 1974; Oluyemi, 1979) have been based on 12-week body weight.

On the other hand, PCI, another quantitative measure of body size in animals, is highly repeatable, indicating that animals rank consistently high (or low) in a population to the extent that elimination of animals with low PCI values through selection will raise the lifetime average body size of selected animals by an appreciable amount. Selection for 4-week PCI, with 2 records per individual (Table 5) is expected to result in improvement in body size, measured by PCI, at later ages. In addition to being a less biased measure of body size than scale body weight, PCI does not require additional records for appreciable genetic progress to be made. This trait is therefore recommended as a selection criterion for the improvement of overall body size. The only advantage scale body weight has is ease of measurement. However, the

TABLE 4. VARIANCE COMPONENTS AND REPEATABILITY OF TRAITS

Trait ^a	σ_1^2	σ_e^2	R	S.E.
WT	43.8459	310.9064	0.12	0.71
SL	0.02542	0.0515	0.33	0.064
KL	0.04153	0.0679	0.38	0.061
BW	0.02157	0.0788	0.21	0.068
PCI	0.90711	0.7396	0.55	0.050

^a See Table 2 for meanings of trait abbreviations

TABLE 5. EXPECTED RELATIVE GENETIC GAIN PER GENERATION OF SELECTION BASED ON K RECORDS FOR EACH TRAIT

No. records (k)	Age (Wks.)	WT	SL	KL	BW	PCI
1	2	1.00	1.00	1.00	1.00	1.00
2	4	1.34	1.23	1.20	1.28	1.14
3	6	1.56	1.34	1.31	1.45	1.20
4	8	1.71	1.42	1.37	1.57	1.23
5	10	1.84	1.47	1.41	1.65	1.25
6	12	1.94	1.50	1.44	1.71	1.26
7	14	2.02	1.53	1.46	1.76	1.28
8	16	2.08	1.55	1.47	1.80	1.28
9	18	2.14	1.57	1.49	1.83	1.29
10	20	2.19	1.58	1.50	1.86	1.30

extra effort required to take linear measurements and compute PCI for selection purposes seems worth it.

Repeatabilities of the three components of PCI in this study, namely SL, KL and BW are moderate (Table 4): 0.33, 0.38 and 0.21, respectively. Additional records (>2) may not result in a significantly greater genetic gain than with only 2 records, particularly for SL and KL. However, selection based on these linear parameters singly may not be useful in improving overall body growth of an animal, despite the high positive correlation reported between body weight and each of them (Ibe, 1989). Such selection may be advocated when it is desired to alter the shape of animals and to shift the muscle mass toward the portion of the carcass of greater economic value (Trenkle and Marple, 1983). Selection on an index of body size (PCI) and body conformation (for example PC2 - Table 1) comprising these linear parameters is to be preferred.

REFERENCES

- AKINOKUN, O. (1974.) The Ife Foundation. Stock of Nigeria local chickens: 2. Frequency of crests and its mode of inheritance. Proc. 2nd Annual Conf. Genetics Society of Nigeria, pp. 25-29. BECKER, W.A. (1984.) Manual of Quantitative Genetics, 4th ed. Academic Enterprises, Washington, U.S.A.
- BECKER, W.A. (1984.) Manual of Quantitative Genetics. 4th ed. Academic Enterprises, Washington, U.S.A.
- BROWN, J.E., BROWN, C.J. and BUTTS, W.T. (1973.) Evaluating relationships among immature measures of size, shape and performance of beef bulls. 1. Principal components as measures of size and shape in young Hereford and Angus bulls. J. Anim. Sci. 36: 1010-1020.
- CARPENTER, J.A., FITZBUGH, T.C., CARTWRIGHT, T.C., THOMAS, R.C. and MELTON, A.A. (1978.) Principal components for cow size and shape. J. Anim. Sci. 46: 370-375.
- DALTON, D.C. (1981.) An Introduction to Practical Animal Breeding. The English Language Book Society and Granada, London.
- DZAKUMA, J.M., WHITEMAN, J.V. and McNEW, R.W. (1982.) Repeatability of lambing rate. 54:540-543.
- EBANGI, A.L. and IBE, S.N. (1994.) Heritabilities of and genetic correlations between some growth traits in Nigerian local chickens. Nig. J. Anim. Prod. 21 (1&2):19-24.
- HARVEY, W.R. (1987.) Mixed Model Least - Squares and Maximum Likelihood Computer Programm (LSMLMW). Ohio State University.
- HENDERSON, C.R. (1953.) Estimation of variance and covariance components. Biometrics 9: 226-252.
- IBE, S.N. (1990.) Measures of size and conformation in commercial broilers. J. Anim. Breed. Genet. 106: 461 - 469.
- IBE, S.N. (1990.) Effect of feed restriction on principal components measures of body size and conformation in commercial broiler chickens. J. of Anim. Prod. 17:1-5.
- LUSH, J.L. (1945.) Animal Breeding Plans. 3rd ed. Iowa State College Press, Ames, Iowa.
- OLUYEMI, J.A. (1979.) Selection of the Nigerian indigenous fowl for 12-week body weight. Nig. J. Anim. Prod. 6: 15-20
- OLUYEMI, J.A. and OYENUGA, V.A. (1971.) A preliminary evaluation of the Nigerian indigenous fowl as a table bird. Proc. Agric. Soc. Nigeria 8: 22-27.
- OLUYEMI, J.A. and OYENUGA, V.A. (1974.) Evaluation of the Nigerian indigenous fowl. Proc. 1st World Congress on Genetics Applied to Livestock Production, Madrid, pp. 1187-1189.
- OLUYEMI, J.A. and OGUNMODEDE, B.K. (1979.) Some physical characteristics of the indigenous fowl and duck of Nigeria. Nigerian Journal of Genetics III: 53-60.
- TRENKLE, A. and MARPLE, D.N. (1983.) Growth and development of meat animals. J. Anim. Sci. 57 (Suppl. 2): 273-283.
- ZARNECKI, A., FIMLAND, E. and RONNINGEN, K. (1985.) Conformational traits and their relation to production in Norwegian Red cattle. Z. Tierzuchtg. Zuchtgsbiol. 102: 271- 284.