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Genetic parameter estimates for body weight and linear body measurements in pure and crossbred progenies of Nigerian indigenous chickens

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Abstract

This study was conducted to estimate genetic parameters for progenies of Nigerian indigenous chickens generated in matings involving exotic broiler parent stock.

Heritability estimates for body weight ranged from 0.05 at 1 day-old to 0.45 at weeks 12 and 16 while the highest heritability estimate for breast girth was 0.72 at week 12. Genetic correlations among the growth traits ranged from 0.43 to 0.99 at weeks 1 and 20 respectively. Phenotypic correlation coefficients obtained among body weight and linear body measurements were positive. At 1 day-old, the phenotypic correlations were very low with the highest value being 0.15 between body weight and breast girth and the value increased to 0.92 at week 20.These results suggest that additive heritabilities are low for body weight and linear body measurements in the early period of growth in pure and crossbreds of Nigerian indigenous chickens.

Keywords: Correlations, heritability, local chickens

Introduction

There is need to improve the productivity of Nigerian local chickens that are, up till now, characterized by small body weight, small egg size and few egg numbers (Nwagu and Nwosu 1994; Adebambo et al 1999). Olawoyin (2006) concluded that genetic improvement of Nigerian indigenous cockerels can help to alleviate the problems of animal protein shortage especially in the rural areas. Knowledge of genetic parameters of traits of interest is very crucial to the use of artificial selection which will culminate in genetic improvement using appropriate breeding plans. Information regarding heritability estimates is very useful in animal breeding as a means to predict 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.

Adedeji et al (2004) reported that heritabilities for growth traits in each sire strain up to eight weeks were generally high. Ndofor-Foleng et al (2006) estimated heritability for body weight of local chicken ecotypes reared in Nsukka in the derived savanna zone of Nigeria. On the average, heritabilities of 0.40 and 0.37 were obtained for light and heavy chickens, respectively. While there are some reports in literature about heritability estimates for body weight for local chickens, there is little or no information on what the genetic parameter estimates would look like when the data from pure and crossbred chickens are pulled together to generate these estimates. This study therefore was aimed at estimating genetic parameters (heritability, genetic and phenotypic correlations) of growth traits among pure and crossbred progenies of Nigerian indigenous chickens.

Materials and methods

This investigation was carried out at the Poultry Breeding Unit of the University of Agriculture, Abeokuta, Ogun State, Nigeria. The experimental birds consisted of 607 progenies produced from mating involving Nigerian indigenous chickens (normal-feathered, frizzle-feathered and naked neck) and exotic broiler parent stock (Anak Titan). So many genotypes were generated in a straight and reciprocal cross. Semen was collected in the afternoon from each sire. Each dam was at the same time inseminated with fresh undiluted semen twice a week from same sire throughout the period of insemination. Fertile eggs from inseminated birds were collected on a daily basis. The eggs were pedigreed along sire and dam lines. Only eggs with good shape and unbroken shells were separated and stored for one week in a cold room at 10-14^{0}C and 75-80% relative humidity. The eggs were disinfected and fumigated before setting in the incubator.

Chicks resulting from the use of each dam and sire strain were properly wing-tagged for identification purpose. The chicks were housed in previously-disinfected brooder cages in the brooding unit. Each batch was brooded for three weeks. Necessary medications and vaccinations were administered in addition to proper management practices. The chicks were fed *ad libitum* with chick starter mash that supplied 21.49% crude protein and 2816.45 Kcal/Kg metabolizable energy from 0 to 8 weeks of age. After this, they were fed on a grower’s ration that supplied 16.90% crude protein and 2715.35 Kcal/Kg metabolizable enery. The birds had free access to feed and water. Growth data which included body weight, body length, wing length, wing span, breast girth, keel length, shank length and thigh length of the birds were taken on a weekly basis from 1 day-old till 20 weeks of age as described below.

- Body weight: This was taken for individual live birds.
- Breast girth: Breast girth was taken as the circumference of the breast around the deepest region of the breast.
- Keel length: It was taken as the length of the sternum.
- Shank length: This was taken as the distance between the hock joint to the tarsometatarsus.
- Thigh length: The thigh length was taken as the distance between the hock joint and the pelvic joint.
- Wing length: From the distance between the tip of the phalanges and the coracoid-humerus joint, the wing length was measured.
- Wing span: This was measured as the distance between the left wing tip to the right wing tip across the back of the chicken.
- Body length: Body length was taken as the distance between the tip of the beak and the longest toe without the nail (Molenaar et al 2008).

Statistical analyses

Mixed-Model Least Squares and Maximum Likelihood Computer Program (Harvey 1990) which used Henderson’s Method 3 (Henderson 1953) was used to estimate the observable variance components due to sire (δ^2s), dam (δ^2d) and error (δ^2e) by equating computed mean squares to their expectations and solving for the components. Heritabilities, genetic and phenotypic correlations were estimated using standard expressions (Becker 1984). The appropriate standard errors of the estimated heritabilities, genetic and phenotypic correlations were also computed.

Results

Estimates of heritability from sire component of variance for body weight and other linear body measurements are presented in Tables 1-7 from 1 day-old to week 20. Generally, heritability estimates for all the growth parameters ranged from very low to high. Heritability estimates for body weight was 0.05 at 1 day-old and increased progressively to 0.99 at week 16. For wing length, heritability was 0.15 at 1 day-old and increased to 0.29 at week 16. The highest heritability for wing span was 0.48 at week 16. Shank length had heritability of 0.27, 0.23, 0.92, 0.70, 0.52, 0.41 and 0.06 at 1 day-old, weeks 1, 4, 8, 12, 16 and 20 respectively. Heritability estimates for thigh length were very low except at weeks 12 and 16 with 0.37 and 0.24 respectively. Heritability for body length varied from 1 day-old to week 20 without definite trend but with highest value of 0.41 at week 12. For breast girth, heritability estimates were 0.4, 0.72 and 0.61 at day-old, week 12 and 16 in the order listed. Keel length had low to high heritability with the highest value of 0.63 at eight weeks of age.

le 1. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at 1 day-old

	Body weight	Wing length	Wing span	Shank length	Thigh length	Body length	Breast girth	Keel length
ly weight	**0.05**	0.26	0.70	-0.51	0.86	-0.53	0.28	0.29
ng length	0.09	**0.15**	0.99	0.62	0.98	0.13	0.99	0.82
ng span	0.07	0.64	**0.03**	0.89	0.97	0.99	0.99	0.99
nk length	0.03	0.24	0.34	**0.27**	0.29	-0.32	0.57	0.99
gh length	0.06	0.64	0.85	0.23	**0.09**	0.16	0.99	0.54
ly length	0.09	0.48	0.52	0.14	0.52	**0.12**	-0.84	-0.58
ast girth	0.15	0.57	0.56	0.38	0.45	0.34	**0.40**	0.79
el length	0.02	0.48	0.47	0.69	0.41	0.30	0.48	**0.14**

ndard errors: 0.043 - 0.084

itabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal.

le 2. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at week 1

	Body weight	Wing length	Wing span	Shank length	Thigh length	Body length	Breast girth	Keel length
ly weight	**0.11**	0.85	0.13	-0.33	0.51	0.99	0.99	0.99
ng length	0.71	**0.09**	0.99	0.42	0.99	0.99	0.99	0.90
ng span	0.20	0.20	**0.01**	0.99	0.99	0.73	0.99	0.84
nk length	0.73	0.69	0.15	**0.23**	0.74	0.05	-0.09	0.45
gh length	0.76	0.67	0.18	0.73	**0.10**	0.79	0.79	0.35
ly length	0.80	0.72	0.19	0.70	0.76	**0.23**	0.99	0.99
ast girth	0.85	0.62	0.14	0.72	0.73	0.74	**0.03**	0.99
el length	0.72	0.59	0.12	0.64	0.70	0.74	0.72	**0.03**

ndard errors: 0.034 - 0.099

itabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal.

Table 3. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at week 4

	Body weight	Wing length	Wing span	Shank length	Thigh length	Body length	Breast girth	Keel length
Body weight	**0.2**	0.08	0.56	0.17	-0.25	0.54	0.99	0.71
Wing length	0.69	**0.12**	0.79	0.99	0.99	0.96	0.16	0.89
Wing span	0.82	0.74	**0.19**	0.82	0.73	0.86	0.51	0.93

Shank length	0.68	0.65	0.72	**0.92**	0.96	0.99	-0.99	0.97
Thigh length	0.81	0.71	0.78	0.73	**0.12**	0.65	-0.43	0.54
Body length	0.87	0.71	0.82	0.72	0.82	**0.1**	0.29	0.99
Breast girth	0.89	0.66	0.79	0.66	0.82	0.84	**0.13**	0.49
Keel length	0.78	0.61	0.66	0.61	0.79	0.76	0.77	**0.1**

Standard errors: 0.037 - 0.076
Heritabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal.

able 4. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at week 8

	Body weight	**Wing length**	**Wing span**	**Shank length**	**Thigh length**	**Body length**	**Breast girth**	**Keel length**
ody weight	**0.39**	0.69	0.73	0.97	0.93	0.62	0.99	0.99
ing length	0.73	**0.25**	0.99	0.99	0.98	0.99	0.80	0.78
ing span	0.70	0.80	**0.24**	0.99	0.99	0.99	0.82	0.83
hank length	0.74	0.65	0.60	**0.70**	0.99	0.99	0.98	0.99
high length	0.74	0.76	0.69	0.64	**0.16**	0.99	0.99	0.99
ody length	0.70	0.73	0.67	0.65	0.70	**0.05**	0.74	0.80
reast girth	0.83	0.65	0.64	0.65	0.69	0.65	**0.22**	0.99
eel length	0.79	0.65	0.61	0.57	0.69	0.60	0.66	**0.63**

tandard errors: 0.015 - 0.099
eritabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal.

ble 5. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at week 12

	Body weight	**Wing length**	**Wing span**	**Shank length**	**Thigh length**	**Body length**	**Breast girth**	**Keel length**
dy weight	**0.45**	0.05	0.63	0.42	0.63	0.83	0.99	0.99
ng length	0.36	**0.25**	0.87	0.99	0.78	0.69	0.07	0.80
ng span	0.67	0.67	**0.34**	0.99	0.94	0.99	0.63	0.99
ank length	0.51	0.56	0.66	**0.52**	0.85	0.91	0.40	0.99
igh length	0.72	0.55	0.84	0.67	**0.37**	0.93	0.72	0.79
dy length	0.70	0.54	0.84	0.63	0.78	**0.41**	0.82	0.99
east girth	0.86	0.42	0.66	0.49	0.74	0.70	**0.72**	0.99
el length	0.20	0.10	0.15	0.16	0.17	0.17	0.17	**0.02**

ndard errors: 0.024 - 0.099
ritabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal.

able 6. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at week 16

	Body weight	**Wing length**	**Wing span**	**Shank length**	**Thigh length**	**Body length**	**Breast girth**	**Keel length**
ody weight	**0.45**	0.49	0.75	0.29	0.95	-0.96	0.92	0.93
ing length	0.43	**0.29**	0.97	0.96	0.46	0.31	0.06	0.85
ing span	0.73	0.69	**0.48**	0.88	0.80	-0.99	0.48	0.93
ank length	0.46	0.56	0.69	**0.41**	0.54	-0.99	0.06	0.49
igh length	0.72	0.49	0.79	0.56	**0.24**	-0.99	0.97	0.76
ody length	0.08	0.10	0.14	0.12	0.14	**0.01**	-0.99	0.41
reast girth	0.75	0.32	0.58	0.35	0.63	0.08	**0.61**	0.62
eel length	0.69	0.48	0.62	0.53	0.55	0.14	0.50	**0.42**

andard errors: 0.093 - 0.099
eritabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal

able 7. Heritabilities and genetic and phenotypic correlations of growth traits of chickens at week 20

	Body weight	Wing length	Wing span	Shank length	Thigh length	Body length	Breast girth	Keel length
ody weight	**0.02**	0.33	0.44	0.19	0.43	0.13	0.58	0.43
/ing length	0.85	**0.05**	0.99	0.99	0.98	0.99	0.84	0.99
/ing span	0.83	0.94	**0.05**	0.97	0.99	0.99	0.91	0.99
hank length	0.90	0.95	0.91	**0.06**	0.97	0.99	0.85	0.99
high length	0.91	0.97	0.93	0.97	**0.05**	0.94	0.95	0.99
ody length	0.76	0.83	0.80	0.83	0.84	**0.02**	0.67	0.98
reast girth	0.92	0.96	0.92	0.95	0.97	0.83	**0.02**	0.91
eel length	0.84	0.90	0.86	0.90	0.91	0.78	0.90	**0.03**

andard errors: 0.005 - 0.107

eritabilities in bold, genetic correlations on upper diagonal and phenotypic correlations on lower diagonal.

Genetic correlation coefficients among body weight and other body measurements showed that the values ranged from low to high. Genetic correlations among the growth traits were generally positive from 1 day-old to week 20 with very few exceptions at 1 day-old, weeks 1 and 4 that were negative. The genetic correlation coefficients between body weight and wing length were very low except at weeks 1, 8 and 16 with 0.85, 0.69 and 0.49 respectively. In weeks 1 to 20, the range of genetic correlation coefficients among body weight, breast girth and keel length varied from 0.43 to 0.99. The genetic correlation among the linear body measurements were high and positive at 1 day-old except shank length – body length, body length – breast girth and body length – keel length relationships that were negative.

The phenotypic correlation coefficients obtained among body weight and linear body measurements were all positive. At 1 day-old, the phenotypic correlations were very low with the highest value being 0.15 between body weight and breast girth. In subsequent weeks, phenotypic correlation increased till week 20 when body weight –breast girth relationship had correlation coefficient of 0.92. Following the same trend, the phenotypic correlation among the linear body measurements increased as the birds advanced in age. The least phenotypic correlation coefficient was 0.12 between keel length and wing span while the highest was 0.72 between body length and thigh length at 1 day-old. At twenty weeks of age, the correlation was 0.78 (keel length- body length relationship) and 0.97 (thigh length – wing length relationship).

Discussion

The heritability estimates obtained in this study fall within the range reported by Momoh and Nwosu (2008) in crossbreeding study involving two ecotypes of Nigerian local chickens. Estimates of the heritability of chicks at 1 day-old, week 1 and 4 were low indicating that body weight and linear body measurements at these ages are to a very large extent a function of environmental factors. The low heritability at younger ages also indicates less genetic variability relative to phenotypic variability among the chicks. The implication of this is that selection for trait of interest may not result in any appreciable improvement. Therefore, crossbreeding will bring about genetic improvement resulting from heterosis relative to only selection. It is however, important to state that this genetic improvement due to crossbreeding will only be permanent if selection is applied to the crossbred lines over many generations. The low heritability estimates observed could be due to non-additive genetic effects such as dominance and epistasis.

As from week 8, there was an increase in the observed heritability. Therefore, heritability estimates of the parameters increased to medium and high values. Moderate to high heritability estimate is an indication that variability due to additive gene action is probably higher than the non- additive component and genetic progress can be made through selection. This then implies that a large proportion of the superiority of the parents will be retained in the offspring. Comparatively, heritabilities in this study were slightly higher than the values obtained by Adeyinka et al (2004) which ranged from 0.013± 0.08 for keel length to 0.32±0.22 for weight at 1 day-old with the heritability estimates for weights at various ages being moderate in a population of naked neck broiler chickens.

Since highest heritabilities were obtained at weeks 12 and 16 in this study, selection of broiler breeders can be carried out at these ages. This then implies that a large proportion of the superiority of the parent will be retained in the offspring. Moreover, the increase in heritability estimates till week 16 and decline at week 20 could indicate various expressions of different genes at different ages of the chickens' growth. In mapping Quantitative trait loci (QTL) for body weight at three, six and nine weeks of age in a broiler-layer cross, Sewalem et al (2002) reported that QTL on chromosomes 1, 2, 4, 7 and 8 affected body weight at two ages and one chromosome 13 QTL affected body weight at all the three ages (weeks 3, 6 and 9) investigated. It was further reported that the QTL for body weight at weeks 6 and 9 on chromosome 2, 4 and 8 were not detected at week 3, and the QTL for week 3 body weights was suggestive at week 6 but not detected at week 9. Sewalem et al (2002) therefore inferred that a different set of genes may be involved in early growth of the chickens. It is possible that these genes are involved on the development of digestive organs or skeletal growth and that the later growth of muscle tissue which is the major component of body weight gain as the chickens grow, is influenced by another set of genes. This may explain the trend of heritability estimates across different ages of the chickens used in this study. The decrease in heritability for body weight at week 20 could be an indication that the chickens were at the decelerating phase of their growth.

The genetic correlation is the correlation between the additive and breeding values for two traits or between the sums of additive effects of the genes influencing the two traits. Genetic correlations between the growth traits were generally positive. This means that as the body weight was increasing, a corresponding increase was expressed in other body measurements. These results also indicated pleiotropic effects, suggesting that the traits were controlled by the same set of genes. Correlation coefficients obtained in this study ranged from low to high. Medium to high correlation coefficient between body weight and other linear body parameters implies that selection for body weight will bring about selection for the other body parameters. Also, positive phenotypic correlation coefficients varying from low to high were obtained in this study and are consistent with the reports of Adedeji et al (2008) and Adebambo et al (2006).

Conclusion

- Changes in heritability estimates across different ages could indicate various expressions of different genes at different ages of the chickens' growth and the reduction of environmental effects. Crossbreeding followed by selection will bring about improved growth performance of Nigerian local chicken stocks.

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