



Heritability Estimates, Biometric and Allometric Growth Traits in F1 Progenies of the Nigerian Local Turkeys (*Meleagris gallopova*)

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ABSTRACT

The heritability estimates, biometric and allometric traits of the F1 progenies of Nigerian local turkeys were evaluated from 0 to 8 weeks of age. Mature local turkeys (n=21; 7 males and 14 females) were used to generate 65 poults during the study. Bi-weekly body weight (BW) and linear body measurements (body length, BL; breast girth, BG; shank length, SL; thigh length, TL; and keel length, KL) were taken for the 8 weeks. Results showed that sire significantly ($P < 0.05$) affected the BW of progenies at 2, 4, and 8 weeks of age, and BL of the turkey progenies at 0, 4, and 8 weeks. There were significant differences ($P < 0.05$) in the BG at weeks 0 and 4, KL at week 0; and KL length measurements at weeks 2 and 6 of age. The heritability (h^2) estimates for BW ranged from a low value (0.14) at day-old, to a high value (0.47) at 8 weeks. At weeks 6 and 8, the h^2 values for BW, BL, and BG were all high, and positive, while h^2 values for SL, TL, and KL were low to moderate at week 8, and at week 6, the h^2 values for SL and TL were negative. It was concluded that the biometric traits of Nigerian indigenous turkeys showed high heritability values, hence, may respond to selection. To this end, such potentials can be exploited in the genetic improvement of the Nigerian local turkeys.

Key words: Body weight, Body length, Breast girth, Estimates, Heritability, Growth, Local turkeys.

INTRODUCTION

Nigeria has 180 million poultry, out of which, 90% are indigenous birds (Desha et al. 2016; FAOSTAT 2017). The production of meat and eggs from poultry birds has the potential to meet human dietary protein requirements (Adeyonu et al. 2021). More so, the rearing of local turkeys, even at the family level, is still important in supplying the fast-growing human population with high-quality protein and additional income (Gueye 2009; Bounds and Ziyemba 2018; Gunya et al. 2021). According to Alabi et al. (2006), rural women who keep poultry birds at the family level, generate almost 35% of their household income from this venture. This income is said to be about 25% of the Nigerian minimum wage and 50% of the per capita income of the nation. The importance of rural poultry to third-world countries such as Nigeria is typified in the way the birds are produced and used on a large scale. Rural poultry is the most vital resource in rural Africa,

Asia, and Latin America. This is because these birds are small-sized, easy to manage, have a short period of gestation, highly prolific, can forage for themselves, and have a natural desire to stay around the house (Dessie et al. 2011; Padhr 2016).

Sadly, despite the higher benefits of the turkey bird over the chicken, its production is still hampered in developing countries (Perez-Lara et al. 2013). Yakubu et al. (2013) noted that apart from their high capacity to tolerate heat and survive under arid conditions, turkeys can forage over long distances, and produce meat with improved quality. The Nigerian indigenous turkeys just like the local chickens, have low body weight, slow growth rate, and lay small-sized eggs, due to exposure to low-quality feed regimens (Udoh et al. 2012; Ngu et al. 2014). These local turkeys can survive the disease and harsh environmental conditions that are peculiar to the rural communities due to their resilient nature (Ilori et al. 2017; Manyelo et al. 2020). Arnould and Leterrier (2007)

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concluded that genetic improvement of locally produced birds, including turkeys, can help to alleviate the problem of animal protein shortage especially in a rural area, and will also go a long way in boosting the Nigerian dwindling economy. Selection has been found to improve the growth rate and body composition traits in indigenous poultry (Ankra-Badu et al. 2010). Thus, the Nigerian local turkey can be improved by obtaining information on heritability, and the genetic correlation of key growth and egg traits, in a bid to enhance the accuracy of predicting response to selection, thereby leading to improved growth and egg-laying performance of the local turkey.

Heritability, a vital genetic parameter, refers to the portion of the additive variance that can be attributed to genetic factors, i.e., that which will be transferred from parents to their offspring (Visscher et al. 2008; Awany and Chimusa 2021). Information regarding heritability estimates (h^2) is an important tool in animal breeding that is used to predict probable response to or progress from selection (Visscher et al. 2008). Production traits are interrelated; hence, considerations of such relationships are pertinent in the choice of appropriate methods of selection. More so, breeding programs for meat-type birds involves selecting for body weight (BW) and body conformation, such as the yield of breast portion (Ogah 2011; Hartcher and Lum 2020). Luiting and Uriff (1991) reported that BW traits were influenced by genetics and common or maternal environmental effects. The reports of Arthur and Abplanalp (1992) revealed that the BW traits of birds at various ages had an average heritability of 0.41. Busye et al. (2001) also made a similar observation. The author recorded an h^2 estimate of 0.23 to 0.71, for BW traits at different ages. Since, the common environmental effect largely influences the h^2 estimates for BW traits, particularly when the animals are young, neglect of this effect would lead to an overestimated heritability estimate at early ages. In the work of Nestor et al. (1967), a selected population of turkey birds was found to have un-weighted averages of h^2 estimates of BW in the range of 0.40, 0.42, 0.43, and 0.36 at 0 to 8, 9 to 16, 17 to 24, and over 24 weeks, respectively. In the study of Aslam et al. (2011), a low h^2 of 0.0 and 0.12 was recorded for BW at 1 and 17 days.

This study, therefore, was conducted to evaluate the heritability estimates and the allometric and biometric growth traits among the half-sib progeny of Nigerian local turkeys.

MATERIALS AND METHODS

Experimental Location and Duration

The experiment which lasted for 8 weeks was carried out in 2018 at the turkey section of the Department of Animal Science Poultry Unit, University of Nigeria, Nsukka. The ethical protocols obtained for the study were as permitted for the use of animals in biomedical research by the Ethical Research Committee of the University of Nigeria, Nsukka (2006).

Experimental Birds and Management

The foundation stocks were 21 mature Nigerian local turkeys, comprising of seven sires and fourteen dams. The experimental birds consisted of 65 progenies, produced from mating involving three different strains of local female turkeys (white, black, and bronze). The foundation

stock was grouped into seven, each group containing one sire and two dams in a separate pen and was allowed to breed naturally. Fertile eggs were collected daily with egg crates and stored at room temperature of 21-24°C and relative humidity of 80%. Eggs from hens in each family were identified with a marker. Fertile eggs were taken to the hatchery every 10 days for hatching in batches of 30 eggs per set. The egg collection lasted for 2 months. Soon after hatching, colored markers, rings, and cloths were used to identify chicks from each sire or tom. The markers were regularly checked and replaced as often as possible to prevent the chicks belonging to the various groups from mixing up. Each batch of turkey poults was brooded for six weeks. Adequate brooding house and brooding conditions were also provided to the chicks. Water and feed were given to them *ad libitum*. Also, necessary vaccinations and medications were administered in addition to proper management practices.

Data Collection

The parameters that were evaluated during the study were as follows:

Biometric traits: This includes body weight (BW) and body weight gain. The BW records were measured in grams using a digital weighing scale, and this was done on a bi-weekly basis for eight weeks.

Allometric traits: The allometric traits evaluated include body length, shank length, thigh length, keel length, and breast girth. All these body conformation traits were measured in centimeters with the aid of a measuring tape.

Statistical Analysis

The experiment was carried out using a completely randomized design, and Nested or Hierarchical design. The hierarchical ANOVA model (dams nested within sires) is given as:

$$Y_{ijk} = \mu + a_i + b_{ij} + e_{ijk}$$

Y_{ijk} = an observation of the k th progeny of the j th dam mated to the i th sire.

μ = the mean, i.e., the expected value of the observations, j , $\mu + a_i$ = the effect of the i th sire or expected value of the progeny of i th sire.

$\mu + a_i + b_{ij}$ = the effect of the j th dam mated to the i th sire or expected value of the progeny of the j th dam mated to i th sire.

e_{ijk} = the deviation (error) of the observed value of the k th progeny (of the j th dam mated to the i th sire) from the expected value of the progeny of the j th dam. In other words, the random error due to the uncontrollable environmental and genetic deviations attributed to the individual.

RESULTS

Table 1 shows the effect of sire on progenies' average body weight (ABW) of the Nigerian local turkey at two weeks intervals. The body weights of the sire's progeny at weeks 0, 2, 4, 6 and 8 ranged from 38.89±1.11 to 48.00±3.74, 108.33±7.03 to 154.00±4.00, 248.33±17.59 to 292.00±14.97, 368.89±29.65 to 435.00±54.61 and 612.00±36.66 to 797.50±54.57, respectively. There BW of the progenies of the 7 turkey sires differed significantly ($P < 0.05$) only at 2 weeks of age. Although the progenies from sire A, B, C, F and G were comparable ($P > 0.05$) in

Table 1: Sire effect on average body weight (g) of local turkey progenies at two weekly intervals

Parameters/ Sire number	Age (weeks)				
	BW0	BW2	BW4	BW6	BW8
Sire A	38.89±1.11	151.11±0.76 ^a	280.00±5.28	368.89±29.65	704.44±0.77
Sire B	48.00±3.74	154.00±4.00 ^a	292.00±14.97	410.00±31.94	670.00±75.50
Sire C	48.00±3.74	140.00±9.86 ^a	251.11±13.06	397.50±30.10	797.50±54.57
Sire D	42.00±3.39	98.00±18.54 ^b	273.33±6.67	386.67±35.28	613.33±96.15
Sire E	44.17±3.75	108.33±7.03 ^b	248.33±17.59	386.00±34.87	612.00±36.66
Sire F	43.75±1.83	138.75±1.41 ^a	250.00±11.34	374.29±28.52	666.67±83.69
Sire G	45.63±1.75	140.00±7.32 ^a	265.00±13.50	435.00±54.61	792.50±43.74

Mean±SD having different subscripts in the same column are significantly different (P<0.05). BW: Body weight.

Table 2: Sire effect on average body length (cm) of local turkey progenies at two weekly intervals

Parameters/ Sire number	Age (weeks)				
	BLO	BL2	BL4	BL6	BL8
Sire A	13.57±0.38 ^a	21.06±0.42 ^a	23.06±2.53 ^b	29.03±2.70 ^a	35.00±0.33 ^b
Sire B	12.74±0.51 ^{ab}	21.10±0.43 ^a	28.10±0.71 ^a	32.85±1.20 ^a	37.60±1.68 ^a
Sire C	13.78±0.26 ^a	20.49±0.38 ^a	25.94±0.93 ^{ab}	31.92±0.88 ^a	37.90±0.82 ^a
Sire D	12.42±0.45 ^b	20.08±0.57 ^{ab}	27.17±0.44 ^a	18.59±0.72 ^b	35.00±1.00 ^b
Sire E	12.70±0.33 ^{ab}	18.88±0.33 ^b	25.12±0.83 ^{ab}	30.21±0.77 ^a	35.30±0.70 ^b
Sire F	12.99±0.15 ^{ab}	20.44±0.56 ^a	25.64±0.60 ^{ab}	31.24±1.10 ^a	36.83±1.60 ^b
Sire G	12.96±0.51 ^{ab}	20.67±0.37 ^a	26.54±0.32 ^{ab}	32.59±0.59 ^a	38.63±0.85 ^a

Mean±SD having different subscripts in the same columns are significantly different (P<0.05). BL: Body length.

Table 3: Sire effect on breast girth (cm) of local turkey progenies at two weekly intervals

Parameters/ Sire number	Age (Weeks)				
	BRG0	BRG2	BRG4	BRG6	BRG8
Sire A	2.70±0.07 ^a	5.19±0.24	6.91±0.31 ^a	7.94±0.29	10.78±0.49
Sire B	2.68±0.07 ^a	5.00±0.22	7.20±0.41 ^a	9.40±0.40	10.50±0.50
Sire C	2.74±0.06 ^a	5.11±0.27	6.78±0.39 ^a	8.40±0.40	10.25±0.46
Sire D	2.38±0.05 ^b	5.34±0.45	5.17±2.59 ^b	8.00±0.29	10.17±1.20
Sire E	2.63±0.08 ^a	4.40±0.13	6.95±0.47 ^a	7.64±0.30	10.00±0.35
Sire F	2.63±0.06 ^a	5.25±0.25	6.69±0.35 ^a	7.79±0.34	11.17±0.33
Sire G	2.79±0.08 ^a	5.06±0.19	7.38±0.23 ^a	8.25±0.34	11.25±0.42

Mean±SD having different subscripts in the same column are significantly different (P<0.05). BRG: Breast girth.

Table 4: Sire effect on shank length (cm) of local turkey progenies at two weekly intervals

Parameters/ Sire number	Age (weeks)				
	SLO	SL2	SL4	SL6	SL8
Sire A	2.37±0.06	3.49±0.07	4.70±0.15	5.87±0.13	7.17±0.19
Sire B	2.40±0.05	3.70±0.09	4.90±0.23	5.94±0.18	7.00±0.71
Sire C	4.84±2.45	3.36±0.10	4.46±0.15	5.53±0.28	7.62±0.28
Sire D	2.36±0.06	3.66±0.16	4.73±0.03	5.80±0.23	7.17±0.44
Sire E	2.28±0.04	3.45±0.06	4.45±0.12	5.64±0.38	6.50±0.16
Sire F	2.35±0.03	3.38±0.08	4.55±0.03	5.43±0.28	7.43±0.40
Sire G	2.44±0.05	3.64±0.13	4.66±0.09	5.64±0.27	7.50±0.23

Values (Mean±SD) in the same column differ non-significantly (P>0.05). SL: Shank length.

their BW, the values were statistically (P<0.05) higher than the BW of the progenies of sire D and E. The BW of the progenies of the sires at weeks 0, 4, 6, and 8 were found to be statistically (P>0.05) the same.

Body Length (cm)

There were significant (P<0.05) differences in average body length (ABL) traits of the Nigerian local turkey progeny at weeks 2, 4, 6, and 8 as shown in Table 2. The mean body lengths of the turkey sire's progeny ranged from 12.42±0.45 at week 0 to 38.63±0.85 at week 8.

Breast Girth

The results on the effect of sire on the average breast girth of sires' progeny of Nigerian indigenous local turkeys from weeks 1 to 8 are shown in Table 3. The mean breast girth value of the sire progenies ranged from 2.38±0.05 for week one, to 11.25±0.42 at week 8 of age. There were significant differences (P<0.05) among the breast girth trait

of the local turkey progeny at weeks 0 and 4. The mean breast girth value of sire A, B, C, E, F, and G was the same (P>0.05) and were significantly (P<0.05) higher than those of sire D. The mean breast girth value of the progenies at week zero ranged from 2.38±0.05 to 2.79±0.08.

Shank Length

The effects of sire on the average thigh and shank lengths of the Nigerian indigenous local turkey progenies from weeks 1 to 8 are shown in Table 4 and 5. There were no significant (P<0.05) differences among the thigh length and shank length of the turkey sire progeny. The mean values for thigh length ranged from 3.40±0.10 at week one to 12.16±0.37 at week 8, and 0.28±0.04 at week 0, to 7.62±0.28 at week 8 for the shank length.

Keel Length

The results in Table 6 showed that there were significant (P<0.05) differences at 0, 4, and 8 weeks of age

Table 5: Sire effect on thigh length (cm) of local turkey progenies at two weekly intervals

Parameters	Age (weeks)				
	THLO	THL2	THL4	THL6	THL8
Sire A	3.78±0.09	3.46±0.05	7.99±0.20	8.58±0.33	11.00±0.17
Sire B	3.46±0.05	5.72±0.24	8.56±0.31	9.30±0.20	11.13±0.66
Sire C	3.68±0.09	5.92±0.20	7.51±0.24	9.21±0.34	11.67±0.63
Sire D	3.40±0.10	5.92±0.32	5.77±2.63	9.67±0.33	10.83±0.60
Sire E	3.53±0.14	5.62±0.10	7.90±0.31	9.12±0.38	10.74±0.27
Sire F	3.54±0.09	6.09±0.18	7.88±0.16	9.06±0.36	11.25±0.70
Sire G	3.50±0.09	5.60±0.16	8.00±0.22	8.93±0.45	12.16±0.37

Values (Mean±SD) in the same column differ non-significantly ($P>0.05$). THL: Thigh length.

Table 6: Sire effect on keel length (cm) of local turkey progenies at two weekly intervals

Parameters	Age (weeks)				
	KLO	KL2	KL4	KL6	KL8
Sire A	2.37±0.04 ^a	4.49±0.18	5.77±0.18 ^{ab}	5.94±0.29	6.76±0.15 ^b
Sire B	2.38±0.04 ^a	5.12±0.12	6.26±0.41 ^a	6.80±0.20	7.43±0.42 ^{ab}
Sire C	2.39±0.04 ^a	4.66±0.13	5.79±0.25 ^{ab}	6.65±0.23	7.97±0.41 ^a
Sire D	2.12±0.06 ^b	4.58±0.17	5.33±0.17 ^b	6.10±0.31	6.50±0.29 ^b
Sire E	2.25±0.99 ^{ab}	4.12±0.08	5.12±0.18 ^b	6.54±0.20	7.10±0.25 ^{ab}
Sire F	2.41±0.05 ^a	4.50±0.21	5.25±0.10 ^b	6.14±0.14	7.25±0.56 ^{ab}
Sire G	2.34±0.06 ^a	4.55±0.19	5.54±0.24 ^{ab}	6.30±0.24	8.12±0.23 ^a

Mean±SD having different subscripts in the same column are significantly different ($P<0.05$). KL: Keel length.

Table 7: Heritability estimates of biometric and allometric traits of local turkey progenies

Parameters	Age (weeks)				
	0	2	4	6	8
Body weight (g)	0.29 ^{ab}	0.16 ^b	0.14 ^b	0.41 ^a	0.47 ^a
Body length (g)	0.22 ^b	0.69 ^a	0.15 ^b	0.05 ^c	0.70 ^a
Breast girth (cm)	0.80 ^a	0.10 ^b	0.01 ^c	0.62 ^a	0.85 ^a
Shank length (cm)	-0.14 ^c	0.44 ^a	0.16 ^b	-0.29 ^c	0.19 ^b
Thigh length (cm)	0.42 ^a	0.03 ^c	0.51 ^a	-0.21 ^d	0.23 ^b
Keel length (cm)	0.86 ^a	0.60 ^a	0.70 ^a	0.34 ^b	0.14 ^c

Mean±SD having different subscripts in the same column are significantly different ($P<0.05$).

for the keel length. The keel length value of the local turkey progeny was within the range of 2.12±0.06 at week 0 to 8.13±0.23 at week 8. In week 0, the mean keel length values of turkey poults from sire A, B, C, F, and G were similar to those of sire E and were higher ($P<0.05$) than the progenies of sire D. In week 4, the keel length value of sire D, E, and F were similar to those of sire A, C, and G. The progenies of sire B has the highest mean value for keel length. In week 8, the mean keel length value of sire C and G progenies were similar to those of sire B, E, and F. The progenies of sire A and D have the least mean value.

Heritability Estimates

Table 7 shows the heritability (h^2) of the linear body parameters evaluated in the present study. A very high heritability value was obtained for breast girth (0.8), keel length (0.86) and thigh length (0.42) at day-old. Heritability of body weight and body length was moderate at 0 weeks i.e., day-old with the estimated values of 0.29 and 0.22, respectively. Heritability of all other parameters ranged from moderate to high at week 0 with the heritability estimate ranging from 0.22 for body length to 0.85 for keel length. Moreover, estimates of heritability for body weight, body length, and breast girth were high at week 8 with the estimated values of 0.47, 0.70, and 0.83, respectively. Conversely, the heritability estimates for shank length, thigh length, and keel length decreased to low heritability with an estimated value of 0.19 for shank length (low), 0.22 (moderate) for thigh length and 0.13 (low) for the keel. There were no specific trends in the estimate from week 0 to week 8.

DISCUSSION

Linear Body Measurements

The increasing trend from 0 to 8 weeks obtained in this study for body weight and other linear body measurements as the bird advanced in age is supportive of the previous reports of Adeyinka and Mohammed (2006). This suggests that growth and physiological development are determined mainly by age. The mean body weight, shank length, and thigh length reported in this study at week 8 were lower than the value recorded in the study of Heinrichs et al. (1992). They reported a mean value of 1630g for body weight, 11.6cm for shank length, and 9.3cm for keel length. The difference between their result and our values could either be due to the use of different strains of turkeys or in part due to differences in experimental techniques and management. The significant effect of sires obtained in some linear body measurements and bodyweight of the turkey poult at various ages implies that there are considerable genetic contributions of sires to these traits. Therefore, an appropriate selection program that will ensure the use of proven sire in the poultry combined with good mating systems would yield good results.

Heritability Estimates

According to Abplanalp and Kosin (1995), the majority of the h^2 estimates of BW of turkey range from a low value of 0.16 to a high value of 0.62, with the majority being from 0.35 to 0.50. The heritability estimates of body weight at week 4 (0.14) which we obtained was similar to those reported by Aslam et al. (2011). According to Tullett

and Burton (1982), there is a 97% variation in the weight of chicks at hatching owing to the weight of the fresh eggs and the weight lost from the eggs during incubation.

Besides, 70% of the weight of chicks is attributed to the weight of the eggs (Iqbal et al. 2017). Hence, the results we obtained indicate that body weight at day-old was not heritable, and that the common environmental effect has a huge influence on the estimate of heritability for bodyweight traits, particularly at younger ages. The low heritability at younger ages also indicates less genetic variability, relative to phenotypic variability among the poults. The implication of this is that the selection of traits of interest at younger ages may not result in any appreciable improvement. Therefore, cross-breeding is the first option for the improvement of lowly heritable traits. It will bring about heterosis and gene complimentary in the crossbred individuals. Subsequently, such gain can be consolidated by selection. The moderate to low heritability estimates observed for most of the traits at weeks 0 to 4 could be due to non-additive genetic effects such as dominance and epistasis which are not transferable from parents to their offspring. As from weeks 6 to 8, there was an increase in the observed heritability especially for body weight, breast girth, and body length.

The high heritability estimates of the parameters evaluated in this study are an indication that variability due to additive gene action is probably higher than the non-addictive component, and genetic progress can be made through selection. This implies that a larger proportion of the superiority of the parents will be retained in the offspring. In comparison to other studies, heritability estimates of this study did not follow a specific trend but were slightly higher than the value obtained by Aslam et al. (2011). The value of heritability estimates of body weight obtained in this study at week 8 (0.47) was in line with that reported by Nestor et al. (1967). Since the highest heritability estimates were obtained at weeks 6 and 8 for most of the traits evaluated, selection of local turkey breeders can be carried out at these ages to ensure genetic improvement thereafter.

Conclusion

The findings of our study showed that body weight, body length, and breast girth at 8 weeks could be used as traits for the selection of parents of the next generation, while thigh length and keel length at 4 weeks were the best predictors of genetic improvement through selection. Although the heritability of keel length at week 0 was very high, it is not recommended to carry out the selection at this age, because heritability estimates at earlier ages are usually influenced by maternal and environmental effects. From our results, it was evident that the Nigerian local turkeys vary significantly in their allometric and biometric (growth) traits. In addition, individual differences between sires in both the allometric and the biometric traits suggest the importance of using proven sires in the selective breeding of productive turkey birds. The age differences in the body weight and linear body measurements observed in the study also confirm the fact, that age is the main non-genetic factor that influences growth and physiological development. Given this, evaluations of allometric and biometric growth traits would be most acceptable in growing turkeys between 2 and 8 weeks of age. The

biometric traits of Nigerian local turkey also showed high heritability both at the day-old and particularly, at week 8. Such potentials can be utilized in such a way that the local turkeys can be genetically improved, via selection at the 8th week of age.

Author's Contribution

UNP: Edited the manuscript. EUJ: Edited the manuscript. AEA: Literature search, edited the manuscript. AOA: Designed and supervised the study, wrote the original draft. OCE: Conducted the experiment, collected the data. OCE: Edited the manuscript.

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