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ORIGINAL RESEARCH

Growth performance of Nigerian local chickens in crosses involving an exotic broiler breeder

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Abstract Six-hundred-and-seven-day-old chicks were generated from Nigerian local chickens consisting of three genotypes (Normal-feathered; Frizzled-feathered; Naked neck) and an exotic broiler breeder (Anak Titan) to evaluate growth performance for possible meat-type chicken development. Growth parameters measured were body weight, breast girth and keel length on weekly basis for 20 weeks. Effects of sire, dam and chick genotypes were significant ($P<0.001$) on growth traits. At week 20, chickens sired by the Anak Titan weighed 1,614.82 g followed by Normal-feathered local chickens with body weight of 1,211.32 g. Progenies of Anak Titan and Naked neck dams weighed 1,761.96 and 1,292.80 g at week 20, respectively. Among purebreds, Anak Titan weighed 35.05 g at day-old and had heaviest body weight of 2,360.29 g at 20 weeks compared to the three local strains. The average body weights for the crossbred, Normal-feathered×Anak Titan at day-old and week 20 were 36.39 and 1,577.63 g, respectively. This was followed by Anak Titan×Naked neck with 33.32 g at day-old and 1,514.14 g at week 20. Sex had significant effect ($P<0.05$) at weeks 16 and 20 with the males having higher mean values than their female counterparts. This study revealed that crosses involving Anak Titan sire×Naked neck dam had highest growth performance, and there was no strain differences among the growth performance of purebred Nigerian local chickens.

Keywords Crossbreeding · Exotic · Genotypes · Indigenous chickens · Nigeria

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Introduction

Poultry population in Nigeria is estimated at 140 million (FAO 2009) and village poultry has been reported to account for about 90% of the total poultry production in Nigeria (Sonaiya et al. 1999). Local chickens, particularly at family level, still represent an appropriate system for supplying the fast-growing human population with high-quality protein and providing additional income (Gueye 2003). A report by Alabi et al. (2006) on the contribution of family poultry to women income in the Niger Delta indicated that family poultry husbandry contributes 35% of the income of household women, and it is estimated at about 25% and 50% of Nigerian minimum wage and per capital income, respectively. Adebambo et al. (1999) reported the existence of phenotypic variations in Nigerian local chickens. The occurrence of major genes of feather structure (Frizzled-feathered), feather distribution (Naked neck), dwarf conditions and modifier effects in the Nigerian local chickens had also been reported by Ikeobi et al. (1996) and Peters et al. (2002, 2008, 2010). There are many reports in literature that indicated that the local chickens are slow-growing and lay fewer eggs relative to the exotic types (Pym et al. 2006; Peters et al. 2008; Besbes 2009) and that genetic variation existed for growth and reproductive traits in these local chickens. The genetic profile of these local chickens can be changed through different breeding strategies due to the existence of genetic variation.

Adedeji et al. (2004) reported that Naked neck and Frizzled-feathered chickens performed better than Normal-feathered types in body weight and linear body measurement traits. Findings by Peters et al. (2005) showed that the indigenous chicken genotypes had higher maturing rate than their exotic counterpart. The authors attributed this to the possession of major genes that assisted in early adaptation to the environment. It is imperative to utilize Nigerian local chickens as part of parent stock development for better adaptability (Olawoyin 2006). Furthermore, Olori (2009) pointed out that there was need to identify, develop and conserve those unique features of indigenous chickens that could be of potential value in the future. This study was therefore designed to compare the growth performance of pure and crossbred progenies of Nigerian indigenous chickens in matings involving a broiler breeder strain.

Materials and methods

The research environment

This study was conducted at the Poultry Breeding Unit of the Teaching and Research Farm of the University of Agriculture, Abeokuta, Ogun State, Nigeria. The area lies in the south-western part of Nigeria and has a prevailing tropical climate with a mean annual rainfall of about 1,037 mm. The vegetation is an interphase between the tropical rainforest and the derived savannah (Ilori et al. 2010). The chickens consisted of parent stock of pure exotic breed (Anak Titan), indigenous chickens (Normal-feathered, Frizzled-feathered and Naked neck) and their crossbreds. This research was approved by the Institutional Animal Use and Care Committee of the University of Agriculture, Abeokuta, Ogun State, Nigeria.

Egg collection and identification

Eggs from inseminated dams were collected on a daily basis and stored for 1 week (to accumulate substantial number) in a cold room at 10–14°C and 75–80% relative humidity. The eggs were cleaned, disinfected, fumigated and pedigreed along sire and dam lines before setting in the incubator. Chicks resulting from the use of each dam and sire strains were properly wing-tagged for identification purpose.

Feeding, management and data collection

The breeder chickens were fed with a breeder's ration containing 16% crude protein, 2,616.0 kcal/kg metabolisable energy, 2.5% calcium and 0.45% available phosphorous. The chicks were fed ad libitum with chicks' mash that supplied 21.49% crude protein and 2,816.45 kcal/kg metabolisable 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 2,715.35 kcal/kg metabolisable energy. The birds had free access to water. Growth data which included body weight, breast girth and keel length of the birds were taken on a weekly basis from day-old till 20 weeks of age. Body weight was measured individually using a sensitive weighing scale with a maximum capacity of 2.0 kg. Breast girth was taken as the circumference of the breast around the deepest region of the breast using a tape rule. Keel length was measured as the length region of the sternum with the use of a tape rule.

Data analyses

The growth data of the resulting progenies were analysed using the General Linear Model procedure of Statistical Analysis System- SAS (SAS 2005). The model was fitted for the effects of sire genotype, dam genotype, chick genotype, sex and chick genotype by sex interaction on growth traits. Significant means were separated using Duncan's new multiple range test of SAS (2005). The model used was as described below:

$$Y_{\mathrm{ijklm}} = \mu + \mathrm{G_i} + \mathrm{X_j} + \mathrm{D_k} + \mathrm{C_l} + (\mathrm{GX})_{\mathrm{ij}} + \Sigma_{\mathrm{ijklm}}$$

where Y_{ijklm}=single body measurement, μ=overall mean, $\mathrm{G_i}$=effect of *i*th chick genotype (*i*=1 to 10), $\mathrm{X_j}$=effect of *j*th sex (*j*=1 and 2), $\mathrm{D_k}$=effect of *k*th dam genotype (*k*=1 to 4), $\mathrm{C_l}$=effect of *l*th sire genotype (*l*=1 to 4), $(\mathrm{GX})_{\mathrm{ij}}$= effect of chick genotype by sex interaction and Σ_{ijklm}= random residual error normally distributed with zero mean variance, δ_e^2.

Results

Sire genotype significantly ($P<0.001$) affected body weight, breast girth and keel length of the chickens. Chicks from all the genotypes sired by Anak Titan (Table 1) had the heaviest day-old weight of 33.14 g followed by Naked neck (32.97 g), Normal-feathered (32.64 g) and the least was 32.05 g for the Frizzled-feathered. There was no significant difference in body weight of progenies generated by indigenous sires at week 1 but Anak Titan progenies weighed 56.62 g. Body weight at week 8 followed similar trend with chickens produced by Normal-feathered sires weighing 456.77 g though significantly lower to Anak Titan chickens with body weight of 506.19 g. At week 20, chickens produced from all the genotypes sired by Anak Titan

Table 1 Least-squares means of body weight (g)±s.e.m of chickens as affected by sire and dam genotypes

Genotype group	Age (weeks)							
	N	0	1	4	8	12	16	20
Sire genotype								
Normal	200	32.64±0.27[ab]	50.15±0.51[b]	196.60±3.45[a]	456.77±10.44[b]	736.64±18.43[bc]	987.90±23.51[b]	1,211.32±34.90[b]
Frizzle	118	32.05±0.30[b]	50.51±0.63[b]	204±3.88[a]	411.65±12.27[c]	677.57±21.01[c]	970.22±43.40[b]	1,109.30±62.56[b]
Naked	72	32.97±0.40[a]	50.39±0.74[b]	175.19±8.36[b]	429.28±19.96[bc]	807.66±32.91[b]	996.50±45.15[b]	1,170.75±62.36[b]
Anak Titan	217	33.14±0.24[a]	56.62±0.63[a]	206.03±7.34[a]	506.19±19.94[a]	904.15±34.46[a]	1,319.88±61.67[a]	1,614.82±102.87[a]
Dam genotype								
Normal	260	32.14±0.22[b]	51.37±0.50[b]	187.23±3.80[b]	430.68±9.70[c]	713.12±15.28[c]	953.93±20.59[c]	1,167.74±32.51[bc]
Frizzle	162	32.40±0.27[b]	51.81±0.62[b]	191.57±3.87[b]	407.43±11.28[c]	637.87±20.57[d]	945.87±35.60[c]	1,050.84±51.30[c]
Naked	64	33.05±0.43[b]	52.51±1.11[b]	201.49±7.04[b]	474.91±19.60[b]	854.60±33.71[b]	1,161.00±52.08[b]	1,292.80±78.96[b]
Anak Titan	121	34.36±0.31[a]	56.21±0.81[a]	238.46±11.30[a]	610.26±29.52[a]	1,160.08±53.23[a]	1,516.08±83.5[a]	1,761.96±110.26[a]

[a,b,c] Means in a column (within genotype group) with different superscripts are significantly different ($P<0.001$)

N Number of observations, *Normal* normal-feathered, *Frizzle* frizzled-feathered, *Naked* naked neck, *s.e.m.* standard error of mean

averagely had the heaviest body weight of 1,614.82 g. This was followed by Normal-feathered chickens with mean body weight of 1,211.32 g. Naked neck sires when compared with Frizzled-feathered and Normal-feathered chickens, produced offspring with widest breast girth with the values ranging from 7.83 cm at day-old to 30.03 cm at 20 weeks of age (Table 2). The least-squares means of keel length as affected by dam and sire genotypes are presented in Table 3. The mean values varied across weeks with the shortest keel of 9.84 cm for Naked neck sire at 20 weeks of age.

Effects of dam genotype were also significant ($P<0.001$) on body weight, breast girth and keel length. The least-squares means of body weights as affected by dam genotype are presented in Table 1. Pure Anak Titan dams had the significantly heaviest body weight from day-old to week 20 with mean values increasing from 34.36 to 1,761.96 g. Among the indigenous dam genotypes, Naked neck chickens had highest body weight relative to Normal-feathered and Frizzled-feathered chickens. The final body weight of progenies generated from Naked neck dams was 1,292.80 g at 20 weeks of age. Progenies produced by Naked neck dams relative to Normal-feathered and Frizzled-feathered chickens had the largest breast girth with average of 7.77 cm at day-old and 30.64 cm at week 20 as presented in Table 2. The results of the mean values for keel length in Table 3 as affected by dam genotype from day-old to 20 weeks did not follow a particular trend.

Chick genotype significantly ($P<0.001$) affected body weight from day-old to 20 weeks of age. The least-squares means of body weights are presented in Table 4. At day-old, Normal-feathered×Anak Titan chicks had the highest significant body weight of 36.39 g followed by purebred Anak Titan with 35.05 g. Purebred Anak Titan chicks had the heaviest body weight of 63.10 g at week 1. This was followed by progenies of purebred Anak Titan sire mated with Naked neck dam having body weight of 57.64 g which was statistically similar to body weights of Normal-feathered (54.59 g) and Frizzle-feathered (54.99 g) sired by Anak Titan. A significant heaviest body weight of purebred Anak Titan was obtained in week 4 compared to other chick genotypes. The purebred Anak Titan had 366.23 g while Frizzled-feathered×Anak Titan weighed 207.61 g. The body weight (148.91 g) for Normal-feathered×Anak Titan was relatively low but still higher than Naked neck×Anak Titan that had 117.95 g.

The body weight of purebred Anak Titan was still consistently highest with 898.36 g while Normal-feathered×Anak Titan eventually recorded similar body weight with other chick genotypes that were outperforming it at lower ages growing to a body weight of 507.27 g at week 8. Purebred Anak Titan attained 1,512.82 g body weight at week 12 with Normal-

Table 2 Least-squares means of breast girth (cm)±s.e.m. as affected by sire and dam genotypes

Genotype group	N	Age (weeks) 0	1	4	8	12	16	20
Sire genotype								
Normal	200	7.12±0.13^{b}	8.35±0.04^{c}	14.12±0.10^{a}	19.43±0.16^{bc}	23.38±0.21^{bc}	26.06±0.25^{b}	28.28±0.32^{b}
Frizzle	118	7.01±0.05^{b}	8.48±0.05^{bc}	14.18±0.11^{a}	18.94±0.20^{c}	22.68±0.27^{c}	25.16±0.39^{b}	26.45±0.52^{c}
Naked	72	7.83±0.31^{a}	8.69±0.09^{a}	13.58±0.25^{b}	19.63±0.32^{ab}	23.97±0.40^{b}	26.05±0.48^{b}	30.03±1.05^{a}
Anak Titan	217	7.21±0.04^{b}	8.58±0.05^{ab}	14.06±0.16^{a}	20.10±0.28^{a}	24.96±0.33^{a}	28.41±0.45^{a}	30.71±0.72^{a}
Dam genotype								
Normal	260	7.04±0.10^{b}	8.38±0.04^{c}	13.88±0.10^{b}	19.12±0.15^{c}	23.17±0.18^{c}	25.84±0.21^{c}	27.76±0.30^{b}
Frizzle	162	7.00±0.05^{b}	8.52±0.05^{bc}	13.89±0.10^{b}	18.75±0.18^{c}	22.85±0.26^{c}	24.93±0.32^{c}	26.42±0.50^{b}
Naked	64	7.77±0.32^{a}	8.56±0.09^{ab}	14.28±0.20^{a}	20.25±0.32^{b}	24.24±0.37^{b}	27.73±0.47^{b}	30.64±1.09^{a}
Anak Titan	121	7.60±0.05^{a}	8.70±0.06^{a}	14.64±0.26^{a}	21.48±0.40^{a}	27.06±0.50^{a}	29.35±0.65^{a}	31.82±0.71^{a}

^{a,b,c} Means in a column (within genotype group) with different superscripts are significantly different ($P<0.001$)

N Number of observations, *Normal* normal-feathered, *Frizzle* frizzled-feathered, *Naked* naked neck, *s.e.m.* standard error of mean

feathered×Anak Titan weighing 1,060.64 g and Anak Titan×Naked neck having 951.86 g. Heaviest weight at week 12 among the pure indigenous was recorded by Frizzled-feathered with body weight of 807.66 g. The crossbreds, Normal-feathered×Anak Titan and Anak Titan×Naked neck though statistically similar weighed 1,419.00 and 1,306.33 g in the order listed at week 16. Body weights obtained for the pure indigenous chickens at week 16 followed the same trend with the performance at lower ages.

Purebred Anak Titan ranked highest having body weight of 2,360.29 g at week 20. Comparatively, Normal-feathered×Anak Titan, Anak Titan×Naked neck and Frizzled-feathered×Anak Titan ranked next weighing 1,577.63, 1,514.14 and 1,414.92 g, respectively. Purebred Naked neck had body weight of 1,225.44 g relative to Normal-feathered (1,177.24 g) and Frizzled-feathered (995.77 g).

The largest breast girth at day-old was 8.09 cm for purebred Naked neck while purebred Anak Titan had 7.88 cm (Table 5). The performance of Frizzled-feathered×Anak Titan and Naked neck×Anak Titan was statistically similar with breast girth of 7.61 and 7.42 cm, respectively. At week 1, Naked neck×Anak Titan had the largest breast girth of 8.86 cm after purebred Anak Titan measuring 8.93 cm. Consistently, the performance of chick genotypes were ranked as purebred Anak Titan, Normal-feathered×Anak Titan and Anak Titan×-Naked neck at week 8 (25.31, 20.53 and 19.81 cm), week 12 (30.09, 26.95 and 24.85 cm), week 16 (32.97, 30.79 and 29.06 cm) and week 20 (35.48, 32.38 and 30.88 cm),

Table 3 Least-squares means of keel length (cm)±s.e.m as affected by dam and sire genotypes

Genotype group	N	Age (weeks) 0	1	4	8	12	16	20
Sire genotype								
Normal	200	1.54±0.02^{a}	2.47±0.04^{a}	4.65±0.04^{ab}	6.98±0.08^{a}	8.27±0.08^{b}	10.23±0.13^{a}	10.95±0.20^{a}
Frizzle	118	1.50±0.02^{a}	2.07±0.03^{c}	4.63±0.05^{ab}	6.61±0.09^{b}	7.86±0.12^{c}	10.55±1.01^{a}	10.71±0.23^{a}
Naked	72	1.53±0.05^{a}	2.26±0.05^{b}	4.50±0.10^{b}	6.59±0.15^{b}	8.41±0.15^{b}	9.29±0.24^{a}	9.84±0.42^{b}
Anak Titan	217	1.41±0.06^{a}	2.13±0.03^{c}	4.71±0.06^{a}	6.93±0.10^{a}	9.23±0.13^{a}	10.70±0.20^{a}	11.51±0.31^{a}
Dam genotype								
Normal	260	1.51±0.05^{a}	2.38±0.03^{a}	4.62±0.04^{b}	6.85±0.07^{b}	8.38±0.08^{b}	10.20±0.12^{a}	10.89±0.22^{b}
Frizzle	162	1.43±0.02^{a}	2.07±0.03^{c}	4.55±0.04^{b}	6.51±0.07^{c}	7.97±0.11^{c}	10.63±0.98^{a}	10.36±0.19^{b}
Naked	64	1.57±0.05^{a}	2.22±0.04^{b}	4.71±0.09^{ab}	6.87±0.14^{b}	8.64±0.94^{b}	9.83±0.21^{a}	10.31±0.39^{b}
Anak Titan	121	1.47±0.02^{a}	2.20±0.04^{b}	4.85±0.09^{a}	7.33±0.16^{a}	9.71±0.22^{a}	10.53±0.30^{a}	11.54±0.34^{a}

^{a,b,c} Means in a column (within genotype group) with different superscripts are significantly different ($P<0.001$)

N number of observations, *Normal* normal-feathered, *Frizzle* frizzled-feathered, *Naked* naked neck, *s.e.m.* standard error of mean

Table 4 Least-squares means of body weight (g)±s.e.m as affected by chick genotype

Chick genotype	Age (weeks)							
	N	0	1	4	8	12	16	20
Normal×Normal	182	32.27±0.28^{cd}	49.96±0.54^{e}	199.70±3.50^{bc}	453.21±11.03b^{cd}	712.55±18.06^{cd}	960.75±22.49^{e}	1,177.24±35.18^{de}
Frizzle×Frizzle	86	31.50±0.34^{d}	49.00±0.68^{e}	202.68±4.18^{bc}	400.82±12.55^{de}	637.03±21.43^{d}	891.92±41.20^{ef}	995.77±54.91^{e}
Naked×Naked	42	32.91±0.51^{cd}	49.76±0.92^{e}	211.61±7.81^{b}	471.00±23.42b^{cd}	807.66±32.91^{c}	1,098.71±42.18^{de}	1,225.44±73.93^{cde}
Anak×Anak	41	35.05±0.49^{ab}	63.10±1.41^{a}	366.23±9.71^{a}	898.36±26.83^{a}	1,512.82±61.80^{a}	2,028.79±100.72^{a}	2,360.29±168.90^{a}
Normal×Anak	18	36.39±0.72^{a}	52.06±1.31^{cde}	148.91±9.62^{e}	507.27±21.18^{b}	1,060.64±41.94^{b}	1,419.00±76.36^{b}	1,577.63±87.48^{b}
Frizzle×Anak	32	33.53±0.57^{bc}	54.56±1.20^{bcd}	207.61±8.94^{b}	442.84±30.67^{bcd}	794.13±46.26^{c}	1,191.29±102.91^{cd}	1,414.92±73.93^{bcd}
Naked×Anak	30	33.07±0.67^{cd}	51.27±1.23^{de}	117.95±7.39^{f}	348.44±28.34^{e}	630.00±20.44^{d}	710.30±67.45^{f}	1,031.00±108.54^{e}
Anak×Normal	78	31.83±0.34^{cd}	54.59±0.93^{bcd}	154.79±9.09^{de}	363.10±17.27^{e}	714.75±28.75^{cd}	929.17±49.68^{e}	1,119.65±85.95^{de}
Anak×Frizzle	76	33.41±0.41^{c}	54.99±0.95^{bc}	177.55±6.62^{cd}	415.79±20.08^{cde}	729.13±39.07^{cd}	1,058.48±63.47^{de}	1,179.33±109.23^{de}
Anak×Naked	22	33.32±0.82^{c}	57.64±2.32^{b}	184.80±12.91^{bc}	483.00±36.70^{bc}	951.86±73.24^{b}	1,306.33±138.27^{bc}	1,514.14±229.45^{bc}

^{a,b,c,d,e,f}Means within a column with different superscripts are significantly different (P<0.001)

N Number of observations, *Normal* normal-feathered, *Frizzle* Frizzled-feathered, *Naked* Naked neck, *Anak* Anak Titan, *s.e.m.* standard error of mean

respectively. Among the purebred indigenous chickens, Naked neck birds consistently had the largest breast girth from day-old to 20 weeks of age.

There was also a significant (P<0.001) effect of chick genotype on keel length. The least-squares means for keel length as influenced by chick genotype are presented in Table 6. At day-old, purebred Naked neck had keel length measuring 1.71 cm followed by 1.63 cm for purebred Anak Titan, while the crossbred, Normal-feathered×Anak Titan, had 1.46 cm. The performance with respect to keel length at weeks 1 and 4 did not follow any particular trend. However, from weeks 8 to 20, purebred Anak Titan had the longest keel. The Normal-feathered×Anak Titan and Frizzled-feathered×Anak Titan chickens had keel length of 11.61 and 11.63 cm at week 20, respectively.

Effect of sex on body weight was not significant (P>0.05) until weeks 16 and 20 (P<0.05). Males had significantly higher body weight than females at week 16 (1,134.07 and 1,056.38 g) and week 20 (1,396.61 and 1,236.21 g) in the order listed as shown in Table 7. The effect of sex on breast girth showed that males had 29.61 cm compared to 28.26 cm for females at 20 weeks.

Discussion

The results of this study revealed that Anak Titan, either used as sire or dam, exhibited the best growth performance. This indicates its better growth potential over the indigenous types. Among the purebred indigenous chickens, Normal-feathered sire genotype showed highest body weight while Naked neck dam genotype had heaviest weight. This could be exploited and utilised to produce trihybrids. The crossbred (Normal-feathered× Anak Titan) could be used as sire line. This is because the sire line in the mating system will be able to capture the additive effects for growth performance while the dam line involving Naked neck will be very useful in incorporating the adaptive potential in the newly developed strain.

Significant chick genotype differences in body weight were recorded from hatching to 20 weeks of age. This indicates variation in genetic constitution of the chickens used in this study. The increase in body weight for all the chick genotypes studied from day-old to 20 weeks can be explained from the fact that animal growth involves increase in size and changes in functional capabilities of the various tissues and organs of animals from conception through maturity. This observation is consistent with the reports of Peters et al. (2005), Adebambo et al. (2006) and Adedeji et al. (2008). According to Gous (1997), growth is normally accompanied by an orderly sequence of maturational changes and

Table 5 Least-squares means of breast girth (cm)±s.e.m as affected by chick genotype

Chick genotype	Age (weeks)							
	N	0	1	4	8	12	16	20
Normal×Normal	182	7.12±0.14^{cd}	8.37±0.04^{cd}	14.20±0.10^{bc}	19.35±0.17^{cd}	23.10±0.21^{de}	25.75±0.24^{cd}	27.86±0.31^{cd}
Frizzle×Frizzle	86	6.80±0.04^{d}	8.45±0.05^{cd}	14.14±0.12^{bc}	18.89±0.21^{cd}	22.30±0.28^{e}	24.46±0.36^{de}	26.29±0.58^{d}
Naked×Naked	42	8.09±0.50^{a}	8.57±0.12^{bc}	14.70±0.20^{b}	20.47±0.36^{b}	23.97±0.40^{cd}	27.14±0.42^{c}	30.60±1.33^{bc}
Anak×Anak	41	7.88±0.08^{ab}	8.93±0.10^{a}	17.19±0.24^{a}	25.31±0.29^{a}	30.09±0.53^{a}	32.97±0.70^{a}	35.48±0.78^{a}
Normal×Anak	18	7.16±0.10^{cd}	8.22±0.10^{d}	12.80±0.29^{e}	20.53±0.60^{b}	26.95±0.38^{b}	30.79±0.53^{b}	32.38±0.60^{b}
Frizzle×Anak	32	7.61±0.09^{abc}	8.56±0.11^{bc}	14.33±0.25^{b}	19.10±0.50^{cd}	23.71±0.62^{cde}	27.19±0.98^{c}	27.08±1.22^{d}
Naked×Anak	30	7.42±0.13^{abcd}	8.86±0.12^{ab}	11.87±0.25^{f}	18.17±0.45^{d}	23.99±0.73^{cde}	22.76±0.70^{e}	28.18±1.01^{cd}
Anak×Normal	78	6.86±0.04^{d}	8.42±0.08^{cd}	13.04±0.22^{de}	18.41±0.32^{d}	23.38±0.34^{de}	26.17±0.48^{cd}	27.15±0.99^{d}
Anak×Frizzle	76	7.23±0.08^{bcd}	8.60±0.09^{bc}	13.58±0.18^{dc}	18.58±0.31^{d}	23.63±0.47^{cde}	26.16±0.56^{cd}	26.81±0.99^{d}
Anak×Naked	22	7.20±0.10^{bcd}	8.53±0.13^{c}	13.54±0.38^{dc}	19.81±0.62^{bc}	24.85±0.80^{c}	29.06±1.12^{b}	30.88±1.63^{bc}

^{a,b,c,d,e,f}Means within a column with different superscripts are significantly different ($P<0.001$)

N Number of observations, *Normal* normal-feathered, *Frizzle* frizzled-feathered, *Naked* naked neck, *Anak* Anak Titan, *s.e.m.* standard error of mean

involves accretion of protein and increase in length and size, not just an increase in body weight.

The higher body weight exhibited by purebred Naked neck over Frizzled-feathered could be attributed to the possession of feather distribution gene (Naked neck gene) that had been reported to reduce feather mass by 20–40%. The reduction in feather mass improves heat dissipation through the naked area (Singh et al. 2001). According to Merat (1986), several mechanisms appear to be responsible for higher meat production of chickens with reduced plumage. He stated further that the more rapid dissipation of heat results in less appetite depression and consequently better growth particularly at high ambient temperature. In addition, less feather production leaves more protein for the synthesis of other tissues, mainly muscle. Anak Titan× Normal-feathered birds among the crossbred weighed 1,577.63 g at 20 weeks of age while Anak Titan×Naked neck birds had body weight of 1,514.14 g at the same age. These two crossbreds ranked relatively closer to purebred Anak Titan (2,360.29 g), which is an exotic breed. In addition, these two crossbreds (Normal-feathered×Anak Titan and Anak Titan×Naked neck) showed significant higher body weights over their purebred local strains. Those individuals of each strain having the best cross progeny can be mated to propagate their respective strains. This would lead to improved cross performance whether it is the result of overdominace, epistasis or only additive effects.

Table 6 Least-squares means of keel length (cm)±s.e.m as affected by chick genotype

Chick genotype	Age (weeks)							
	N	0	1	4	8	12	16	20
Normal×Normal	182	1.55±0.02^{abc}	2.52±0.04^{a}	4.70±0.04^{bcd}	6.99±0.08^{b}	8.24±0.09^{c}	10.24±0.14^{ab}	10.88±0.22^{b}
Frizzle×Frizzle	86	1.52±0.02^{abcd}	2.02±0.02^{cd}	4.53±0.05^{d}	6.55±0.08^{bc}	7.60±0.12^{d}	10.82±1.39^{ab}	10.44±0.23^{b}
Naked×Naked	42	1.71±0.06^{a}	2.34±0.04^{ab}	4.86±0.11^{bc}	6.99±0.17^{b}	8.41±0.15^{c}	9.71±0.24^{ab}	10.25±0.50^{b}
Anak×Anak	41	1.63±0.04^{ab}	2.32±0.06^{ab}	5.64±0.09^{a}	8.69±0.16^{a}	11.12±0.23^{a}	12.64±0.40^{a}	13.19±0.39^{a}
Normal×Anak	18	1.46±0.05^{abcd}	2.00±0.05^{cd}	3.87±0.07^{e}	6.85±0.27^{bc}	8.72±0.18^{bc}	10.13±0.24^{ab}	11.61±0.27^{b}
Frizzle×Anak	32	1.43±0.03^{bcd}	2.21±0.06^{bc}	4.96±0.09^{b}	6.78±0.23^{bc}	8.56±0.27^{bc}	9.84±0.37^{ab}	11.63±0.65^{b}
Naked×Anak	30	1.26±0.02^{d}	2.15±0.09^{bcd}	3.94±0.12^{e}	5.91±0.22^{d}	8.66±0.39^{bc}	7.85±0.36^{b}	8.40±0.44^{c}
Anak×Normal	78	1.42±0.15^{bcd}	2.08±0.04^{cd}	4.42±0.09^{d}	6.41±0.12^{c}	8.82±0.17^{bc}	9.99±0.25^{ab}	10.97±1.00^{b}
Anak×Frizzle	76	1.31±0.02^{cd}	2.13±0.05^{bcd}	4.59±0.06^{cd}	6.46±0.11^{bc}	8.51±0.17^{c}	10.16±0.28^{ab}	10.16±0.33^{b}
Anak×Naked	22	1.33±0.04^{cd}	1.98±0.04^{d}	4.43±0.16^{d}	6.63±0.23^{bc}	9.15±0.29^{b}	10.14±0.44^{ab}	10.51±0.50^{b}

^{a,b,c,d,e,f}Means within a column with different superscripts are significantly different ($P<0.001$)

N Number of observations, *Normal* normal-feathered, *Frizzle* frizzled-feathered, *Naked* naked neck, *Anak* Anak Titan, *s.e.m.* standard error of mean

Table 7 Least-squares means of growth parameters (±s.e.m.) as affected by sex

Growth parameters	Sex	N	Age (weeks)						
			0	1	4	8	12	16	20
Bodyweight (g)	M	229	32.76 ± 0.24^{a}	53.30 ± 0.59^{a}	195.34 ± 5.51^{a}	456.37 ± 15.80^{a}	811.17 ± 28.89^{a}	$1,134.07\pm49.07^{a}$	$1,396.61\pm75.28^{a}$
	F	378	32.74 ± 0.18^{a}	52.13 ± 0.41^{a}	201.65 ± 3.62^{a}	463.98 ± 9.79^{a}	768.90 ± 16.87^{a}	$1,056.38\pm26.21^{b}$	$1,236.21\pm38.15^{b}$
Breast girth (cm)	M	229	7.20 ± 0.10^{a}	8.54 ± 0.05^{a}	13.90 ± 0.13^{a}	19.46 ± 0.23^{a}	24.01 ± 0.28^{a}	26.68 ± 0.36^{a}	29.61 ± 0.56^{a}
	F	378	7.22 ± 0.07^{a}	8.48 ± 0.03^{a}	14.15 ± 0.09^{a}	19.63 ± 0.15^{a}	23.68 ± 0.19^{a}	26.43 ± 0.24^{a}	28.26 ± 0.36^{b}
Keel length (cm)	M	229	1.48 ± 0.05^{a}	2.21 ± 0.03^{a}	4.68 ± 0.05^{a}	6.80 ± 0.09^{a}	8.61 ± 0.12^{a}	10.12 ± 0.16^{a}	10.97 ± 0.25^{a}
	F	369	1.49 ± 0.01^{a}	2.27 ± 0.02^{a}	4.64 ± 0.03^{a}	6.87 ± 0.06^{a}	8.45 ± 0.08^{a}	10.38 ± 0.33^{a}	10.83 ± 0.17^{a}

^{a,b,c}Means within a column under the same parameter with different superscripts are significantly different ($P<0.05$)

M Male, *F* female, *N* number of observations, *s.e.m.* standard error of mean

Breast girth and keel length are two important parameters associated with breast meat yield. Purebred Anak Titan had the largest significant breast girth (33.48 cm) followed by Normal-feathered×Anak Titan (32.38 cm) and Anak Titan×Naked neck (30.88 cm). This is an indication that these two crossbreds would result in greater amount of breast muscle compared to other crossbred genotypes. Among the purebred indigenous, the Naked neck birds had a breast girth of 30.60 cm compared to that of Normal-feathered (27.86 cm) and of Frizzled-feathered (26.29 cm). Cahaner et al. (1987) reported that the higher meat yield in Naked neck genotype probably resulted from the greater yield of breast muscle relative to the Normal-feathered chicken genotype.

Males had higher significant body weight and breast girth at weeks 16 and 20 than their female counterpart. This could be due to the hormone, testosterone. Apart from testosterone stimulating and maintaining secondary sexual development, it also affects the growth process and the development of body parts and features not directly related to reproduction (Warwick and Legates 1979). The observed sexual dimorphism in favour of the males had also been reported by Adedeji et al. (2008); Sola-Ojo et al. (2008). They further stated that the aggressiveness of males over the females especially when reared together put the females at a disadvantage for feed and water.

Conclusion

Growth performance of Nigerian local chickens (Normal-feathered, Frizzled-feathered and Naked neck) from day-old through 20 weeks were comparable, although there were slight differences in mean values. Genetic variations existed in crossbreeding the local chickens with exotic breed on body weight, breast girth and keel length. Improvement in growth performance of Nigerian local chickens can be achieved through crossbreeding with exotic types. Among the crossbreds evaluated in this study, Normal-feathered (sire)×Anak Titan (dam) had the best growth performance followed by Anak Titan (sire)×Naked neck (dam). This study underscores the inherent genetic variation that existed in the Nigerian local chicken and why they should be included to expand the narrow genetic base on which the world's chicken breed currently operates.

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