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Genetic Components of Growth Performance Traits of Progenies Derived from Crosses of Four Local and Exotic Chickens in Derived Savanna Environment of Nigeria

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ABSTRACT
Background and Objective: The genetic variation and the hybrid vigor can be exploited in animals by crossing of the different important characteristics of each breed and producing superior crosses for better animal performance. Therefore, the study aimed to contribute to the improvement productivity of Nigerian indigenous chickens through crossbreeding strategy in enhancing the growth characteristics between Nigerian indigenous and Rhode Island Red chickens. **Materials and Methods:** The growth performance characteristics were measured for chickens' progenies produced from pure and crossbred of Nigerian indigenous chickens and Rhode Island Red birds and data obtained were statistically analyzed with analysis of variance and means separation with Duncan's Multiple Range Test. **Results:** The growth performance characteristics were significantly ($p<0.05$) varied among the genetic components progenies produced and crossbred progenies of naked neck had the heavier body weight, body length, chest girth, keel length, shank length, thigh length, wing length coupled with lower feed intakes, higher weight gain and better FCR. Sex wisely, males of all the genetic components produced were better in terms of growth performance traits. **Conclusion:** The study concluded that NIC could be used appropriately as sires and exotic chickens as dams best suited for improving the local stocks for growth performance characteristics in the derived savanna environment of Nigeria.

KEYWORDS
Nigerian indigenous chickens, Rhode Island Red, crossbred, progenies, growth performance traits

INTRODUCTION
The animal proteins are greatest nutrient components derived for poultry production since the animals in this category have short generation interval coupled with quickest turnover rate when set side by side

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with other livestocks[1]. Previous research findings indicated that the native chickens have good genetic attributes such as adaptability to Nigerian local environment, disease resistance, less feed requirements among others[2-4] but were very inferior in growth and egg characteristics compared with the exotic strains[5]. However, one way of achieving rapid improvement in production potential of the native chickens, while retaining those good attributes is by the judicious crossbreeding with exotic strains[5,6]. Since the utilization of high-yielding improved strains developed in the temperate countries also has not been able to meet up with the demands due to lower performance than expected in the tropics, when compared with their performance in their countries of origin because of poor adaptability[7].

Crossing is as method has been deduced for enhancing production performance in livestock production and poultry inclusive, with the main objective to produce superior crosses for production characteristics that affected by various genetic and non-genetic factors[8]. In Nigeria, many authors such as[2-5,9] have established the fact on the crosses between the native/local breeds of chicken with exotic adapted ones under tropics and sub-tropic conditions with better outcomes on production performance and potentials of crossbred chickens. Crossing constitute one of the tools for the exploitation of the genetic variation and the hybrid vigour by combination of the different important characteristics of each breed[10] and by taking advantages of maternal genetic or sex-linked effects which related to particular blends between breeds or lines. The analysis of the combining aptitude and the difference between the productive performances of crossbreds helps in identifying the best possible combinations in the exploitation of hybrid vigor according to the desired objectives[11].

Mahmoud and El-full[12] reported that genetic variation within and between breed largely describes the performance comparisons among breeds and their crosses due to genetic differences among breeds or strains. These differences are as results of complementary and heterosis effects of crossbreeding which is regarded as an important potential source of genetic improvement in the efficiency of human food production from poultry production. It is also important for counting breed effects and attaining in-between values that are higher to reverse utmosts[13]. Meanwhile, the combined characters of better performing exotic lines and the indigenous chickens that produced crossbreds due to the exploitation of potentials of the Nigerian indigenous light chicken ecotype will give ways to the furnish resolution and decrease the camouring of accession of day-old chicks and breeder stocks which more costly now because of recent economic situation of Nigeria[13]. The study is therefore, designed to evaluate the genetic assessment of the Nigerian indigenous chickens, Rhode Island Red and their crossbred progenies in the derived savanna environment of Nigeria based on growth performance traits.

MATERIALS AND METHODS

Experimental site: The experiment was carried out at the Poultry Unit of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Ogbomosho is situated in the derived savanna zone of Nigeria and lies on Longitude 4°15'East of Greenwich Meridian and Latitude 8°15'North of the equator. The altitude is between 300 and 600 m above sea level while the mean temperature and annual rainfall are 27°C and 1247 mm, respectively. The experiment lasted between February and December, 2018.

Experimental birds and their management: The Nigerian indigenous chickens (NIC) and exotic breeds of chickens were used for this experiment and the NIC strains are the frizzled feather, naked neck, normal feather and the Fulani ecotype. The NIC was selected from the available chicken population in the study area while the exotic chicken (Rhode Island Red cocks and hens) were acquired from a reputable farm at 18 weeks of age. A total of 100 birds was sourced and used as a parent for the experiment. This consists of 5 cocks and 15 hens each of naked neck, normal feather, frizzled feather, Fulani ecotype and Rhode

Island Red chickens. Each chicken was properly tagged by the wings for means of identification wing tags made from industrial galvanized aluminum. The experimental chickens were strictly raised under the intensive management system of poultry production and the birds were individually housed in a 2 tiers galvanized battery cage with a space dimension. Birds were individually housed in a cell having $0.14\times0.14\ m^2$ spacing. Prior to the arrival of the experimental parent birds, the pen and cage have been properly disinfected with formalin® and morigard® as instructed by the manufacturer.

Feeds and feeding: The standard commercial breeders and layers mash containing (16% crude protein and 2600 kcal kg^{-1} metabolizable energy) and (16% crude protein and 2800 kcal kg^{-1} metabolizable energy) were fed *ad libitum* to the cocks and hens respectively while clean and cool water was also provided *ad libitum*.

Mating technique: The sire's vents were trimmed to clean up their feathers around the vent at two weeks' interval and the semen was collected through a method of artificial insemination (AI) by the massage technique from the sires from 22 weeks by applying pressure at the back towards the tail many times before sperm production. The semen obtained was immediately inseminated into a doughnut shape in the left vent of the dams while 0.1 mL of undiluted fresh semen collected was used for insemination each time with an inseminator which was monitored twice in a week in the evening.

Mating design: Pure, straight and reciprocal crosses were carried out amongst the Nigerian local chickens and Rhode Island Red to get the crossbred progenies. Below are mating procedures that were adopted:

Pure breeds:

$$\frac{\text{Rhode Island Red (Male)} \times \text{Rhode Island Red (Female)}:}{RIR_m \times RIR_f}$$

$$\frac{\text{Frizzled Feather (Male)} \times \text{Frizzled Feather (Female)}:}{FF_m \times FF_f}$$

$$\frac{\text{Fulani Ecotype (Male)} \times \text{Fulani Ecotype (Female)}:}{FE_m \times FE_f}$$

$$\frac{\text{Naked Neck (Male)} \times \text{Naked Neck (Female)}:}{NN_m \times NN_f}$$

$$\frac{\text{Normal Feather (Male)} \times \text{Normal Feather (Female)}:}{NF_m \times NF_f}$$

Crossbreds

Straight crossing:

$$\frac{\text{Rhode Island Red (Male)} \times \text{Frizzled Feather (Female)}:}{RIR_m \times FF_f}$$

$$\frac{\text{Rhode Island Red (Male)} \times \text{Naked Neck (Female)}:}{RIR_m \times NN_f}$$

$$\frac{\text{Rhode Island Red (Male)} \times \text{Normal Feather (Female)}:}{RIR_m \times NF_f}$$

Reciprocal crossing:

$$\frac{\text{Frizzled Feather (Male)} \times \text{Rhode Island Red (Female)}:}{FF_m \times RIR_f}$$

$$\frac{\text{Normal Feather (Male)} \times \text{Rhode Island Red (Female)}:}{NF_m \times RIR_f}$$

$$\frac{\text{Naked Necked (Male)} \times \text{Rhode Island Red (Female)}:}{NN_m \times RIR_f}$$

$$\frac{\text{Fulani Ecotype (Male)} \times \text{Rhode Island Red (Female)}:}{FE_m \times RIR_f}$$

Egg collection and incubation: Eggs were collected daily and tagged to identify egg belonging to each individual hen. The eggs were stored at room temperature for a few days and were set in the incubator. Eggs were candled on the 5th and 18th day of incubation for the identification of fertile eggs and clear eggs using a candler fixed with a neon florescent tube carried out in a dark room.

Management of the chicks: At hatch, chicks were also tagged according to their sires and were randomly placed into brooder compartments for brooding. All the chickens were reared intensively under natural light while vaccination and medication programs were duly observed from day old.

Feed and feeding of the chicks: During brooding stage, the standard commercial chick mash of 18% crude protein and 2650 kcal kg^{-1} metabolizable energy was fed *ad libitum* from day old to eight weeks of age. The chicks were assigned to a feeder at the rate of 100 birds to one tray or 1 pan of tube feeder and one drinker of 2 to 4 L capacity. From eight weeks of age, birds were fed standard commercial growers mash containing 16% crude protein and 2700 kcal kg^{-1} metabolizable energy. However, at 18 weeks of age, layers were fed commercial layer's mash containing 16% crude protein and 2800 kcal kg^{-1} metabolizable energy and water was supplied *ad libitum*.

Data collection: Data were obtained on the growth traits from 80 selected progenies generated from the mating of purebred, crossbred and reciprocal birds for the period of 20 weeks according to sex of the birds. However, the following measurements were taken on a weekly basis: body weight (g), body length (cm), keel length (cm), shank length (cm), thigh length (cm), breast girth (cm) and wing length (cm) (growth traits) while pooled data were used for feed intake (g), daily body weight gain (g) and feed conversion ratio (FCR) as described by FAO[14].

Statistical analysis: Data obtained from growth performance characteristics was subjected to analysis of variance for the fixed effects of genotype and age using two-way Analysis of Variance (ANOVA) while the least significant difference was determined using the 2018 version of the Duncan's Multiple Range Test. The significance level was at $p<0.05$. The general linear model procedure of SAS used. However, sex was included in the measurement of the growth traits and this model was adopted:

$$Y_{ijk1} = \mu + A_i + B_j + S_k + (AB)_{ij} + (AS)_{ik} + (BS)_{jk} + (ABS)_{ijk} + e_{ijk1}$$

Where,

Y_{ijk1}: Observed value of a dependent variable
μ: General mean
A_i: Fixed effect of the i^{th} genotype (i: 1, 2, 3, 4, 5, 6, 7, 8)
B_j: Fixed effect of the j^{th} age (j: 1..................n)
S_k: Fixed effect of the k^{th} sex (k: 1, 2)
$(AB)_{ij}$: Interaction of i^{th} genotype and j^{th} age
$(AS)_{ik}$: Interaction of i^{th} genotype and k^{th} sex
$(BS)_{jk}$: Interaction of j^{th} age and k^{th} sex
$(ABS)_{ijk}$: Interaction of i^{th} genotype, j^{th} age and k^{th} sex
e_{ijk1m}: Random error common to measurement in each bird and assume to be normally and independently distributed with a mean of zero and variance δ^2

RESULTS AND DISCUSSION

The genotypes significantly affected (p<0.05) bodyweight and linear measurements at all ages as shown in Table 1-6. At day old, RIR birds had the highest body weight (45.15 g) and thigh length (3.89 cm) while RIR×NF crosses were best in body length (7.25 cm), chest girth (9.36 cm) and wing length (7.25 cm) with FF birds having better shank length (2.39 cm) . Similarly, body weight, body length, chest girth, keel length and wing length at 4 weeks' old were highest in the resulting RIR×NN crossbred while NN birds had more of shank length and thigh length. The values obtained for body weight, body length, keel length, shank length and wing length in crosses involving NN×RIR at 8 weeks were significantly better than other crosses while chest girth and thigh length favoring FE×RIR and RIR×FF respectively. However, at 12 weeks, NN×RIR crossbred had the heaviest body weight (958 g), highest body length (20.85 cm), chest girth (23.10 cm), keel length (10.75 cm), thigh length (15.70 cm) and wing length (34.60 cm) while shank length favoring crosses involving RIR×NF of value 9.67 cm. Similarly, the ranking does not change at 16 weeks; NN×RIR crossbred recorded significant highest body weight (1444.20 g), body length (23.70 cm), chest girth (25.65 cm), keel length (11.37 cm), shank length (9.67 cm), thigh length (17.55 cm) and wing length

Table 1: Least square mean values and standard errors of growth traits of pure, straight and reciprocal F_1 chickens as affected by genotypes and sex at day old

Parameters	N	BDW (g)	BDL (cm)	CG (cm)	KL (cm)	Shank (cm)	Thigh (cm)	WL (cm)
Genotype								
FE	80	31.95±0.64^{de}	7.02±0.09^{b}	8.25±0.06^{d}	1.00±00	2.15±0.04^{b}	3.08±0.06^{c}	4.46±0.07^{f}
FF	80	28.12±0.40^{h}	6.77±0.10^{cd}	7.89±0.05^{e}	0.99±00	2.39±0.05^{a}	3.10±0.06^{c}	4.86±0.06^{e}
NF	80	29.97±0.43^{g}	6.82±0.10^{cd}	7.88±0.10^{e}	1.00±00	2.17±0.03^{b}	3.12±0.07^{c}	4.47±0.07^{f}
NN	80	28.62±0.31^{gh}	5.60±0.07^{f}	7.49±0.05^{g}	0.99±00	2.01±0.02^{c}	2.74±0.05^{d}	3.35±0.08^{g}
RIR	80	45.15±0.80^{a}	6.98±0.01^{c}	8.94±0.03^{b}	0.99±00	1.96±0.01^{c}	3.89±0.03^{a}	4.83±0.05^{e}
RIR×FE	80	31.00±0.61^{e}	6.08±0.04^{e}	7.77±0.08^{f}	1.00±00	2.14±0.04^{b}	3.33±0.08^{b}	6.83±0.20^{b}
RIR×FF	80	30.70±0.15^{f}	6.16±0.04^{e}	8.50±0.90^{c}	1.00±00	1.93±0.01^{c}	3.00±0.01^{c}	4.50±0.06^{f}
RIR×NF	80	42.00±0.64^{ab}	7.25±0.04^{a}	9.35±0.06^{a}	1.00±00	2.00±0.01^{c}	2.05±0.00^{f}	7.25±0.04^{a}
RIR×NN	80	31.22±0.70^{de}	6.17±0.08^{e}	6.76±0.09^{h}	0.99±00	1.96±0.00^{c}	2.44±0.04^{e}	6.39±0.17^{c}
FF×RIR	80	34.40±0.55^{c}	6.70±0.06^{d}	7.60±0.07^{fg}	1.00±00	1.92±0.02^{c}	2.22±0.04^{f}	7.15±0.15^{a}
NF×RIR	80	32.85±0.87^{d}	6.05±0.05^{e}	7.61±0.11^{g}	1.00±00	1.79±0.03^{d}	3.81±0.17^{a}	5.39±0.24^{d}
NN×RIR	80	38.30±0.74^{b}	6.65±0.08^{d}	9.00±0.09^{b}	1.00±00	1.94±0.01^{a}	2.16±0.03^{f}	7.25±0.09^{a}
FE×RIR	80	38.33±0.14^{b}	6.68±0.08^{d}	9.02±0.03^{b}	1.00±00	1.91±0.01^{ab}	2.13±0.03^{f}	7.23±0.05^{ab}
Sex								
Male	488	33.82±0.43	6.47±0.04	8.13±0.05	1.00±0.01	2.06±0.01	2.93±0.04	5.55±0.09
Female	552	32.95±0.32	6.56±0.04	8.05±0.05	1.00±0.01	2.01±0.01	2.89±0.05	5.57±0.09

^{abcdef}Means along the same column at each subclass with different superscripts are significantly (p<0.05) different, N: Number of Observation, BDW: Body weight, BDL: Body length, CG: Chest girth, KL: Keel length, WL: Wing length, FE: Fulani ecotype, FF: Frizzle feather, NF: Normal feather, NN: Naked neck, RIR: Rhode Island Red, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red frizzle feather crossbred, RIR×NF: Rhode Island Red normal feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, NN×RIR: Naked necked Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, FE×RIR: Fulani ecotype Rhode Island Red and FF×RIR: Frizzle feather Rhode Island Red crossbred

Table 2: Least square mean values and standard errors of growth traits of pure, straight and reciprocal F_1 chickens as affected by genotypes and sex at 4 weeks of age

Parameters	N	BDW (g)	BDL (cm)	CG (cm)	KL (cm)	Shank (cm)	Thigh (cm)	WL (cm)
Genotype								
FE	80	152.82 ± 4.47^{d}	11.69 ± 0.12^{ab}	13.53 ± 0.09^{a}	4.73 ± 0.09^{c}	4.00 ± 0.09	5.73 ± 0.08^{f}	15.79 ± 0.21^{e}
FF	80	$157..45\pm4.43^{d}$	10.81 ± 0.15^{cd}	11.84 ± 0.12^{g}	4.15 ± 0.07^{c}	4.36 ± 0.07^{c}	5.69 ± 0.08^{f}	17.69 ± 0.15^{a}
NF	80	133.45 ± 3.12^{e}	10.65 ± 0.13^{d}	12.47 ± 0.10^{e}	4.43 ± 0.04^{f}	4.15 ± 0.04^{d}	5.69 ± 0.08^{f}	16.27 ± 0.13^{d}
NN	80	169.45 ± 3.47^{c}	11.80 ± 0.12^{ab}	12.95 ± 0.12^{d}	4.18 ± 0.05^{h}	4.93 ± 0.05^{a}	7.34 ± 0.07^{a}	17.17 ± 0.22^{b}
RIR	80	148.93 ± 3.37^{d}	10.46 ± 0.10^{d}	11.56 ± 0.08^{g}	4.66 ± 0.07^{d}	3.55 ± 0.07^{f}	5.28 ± 0.05^{d}	16.61 ± 0.19^{c}
RIR×FE	80	148.00 ± 3.52^{d}	11.20 ± 0.08^{b}	12.30 ± 0.06^{f}	4.42 ± 0.03^{f}	3.95 ± 0.05	6.45 ± 0.05^{d}	17.52 ± 0.13^{a}
RIR×FF	80	147.07 ± 1.26^{d}	11.13 ± 0.03^{bc}	13.32 ± 0.07^{ab}	4.25 ± 0.05^{g}	4.00 ± 0.05	6.16 ± 0.03^{e}	16.85 ± 0.05^{c}
RIR×NF	80	171.70 ± 4.88^{c}	11.17 ± 0.14^{b}	12.72 ± 0.15^{e}	4.60 ± 0.10^{d}	4.46 ± 0.29^{b}	6.33 ± 0.09^{de}	17.39 ± 0.22^{ab}
RIR×NN	80	194.45 ± 3.80^{a}	11.99 ± 0.08^{a}	13.67 ± 0.07^{a}	5.10 ± 0.05^{a}	4.08 ± 0.04^{e}	6.79 ± 0.09^{b}	17.62 ± 0.32^{a}
FF×RIR	80	171.95 ± 8.41^{c}	11.18 ± 0.21^{b}	12.65 ± 0.23^{e}	4.81 ± 0.07^{b}	4.40 ± 0.06^{bc}	6.27 ± 0.11^{de}	17.12 ± 0.27^{b}
NF×RIR	80	151.90 ± 5.26^{d}	$11..09\pm0.11^{bc}$	12.47 ± 0.14^{e}	4.61 ± 0.08^{d}	3.92 ± 0.08^{e}	6.46 ± 0.08^{b}	17.17 ± 0.16^{b}
NN×RIR	80	176.45 ± 6.30^{bc}	11.20 ± 0.14^{b}	13.20 ± 0.16^{ab}	4.52 ± 0.06^{e}	4.37 ± 0.06^{c}	5.67 ± 0.07^{f}	16.77 ± 0.07^{d}
FE×RIR	80	176.45 ± 6.30^{bc}	11.20 ± 0.14^{b}	13.20 ± 0.16^{ab}	4.52 ± 0.06^{e}	4.37 ± 0.06^{c}	5.67 ± 0.07^{f}	16.77 ± 0.07^{d}
Sex								
Male	488	169.13 ± 2.02^{a}	11.22 ± 0.05^{a}	12.93 ± 0.05^{a}	4.63 ± 0.03^{a}	4.19 ± 0.03^{a}	6.32 ± 0.05^{a}	17.29 ± 0.09^{a}
Female	552	156.33 ± 2.08^{b}	11.08 ± 0.05^{b}	12.53 ± 0.06^{b}	4.49 ± 0.05^{b}	4.15 ± 0.05^{b}	6.21 ± 0.04^{b}	17.02 ± 0.07

^{babcdef}Means along the same column at each subclass with different superscripts are significantly ($p<0.05$) different, N: Number of Observation, BDW: Body weight, BDL: Body length, CG: Chest girth, KL: Keel length, WL: Wing length, FE: Fulani ecotype, FF: Frizzle feather, NF: Normal feather, NN: Naked neck, RIR: Rhode Island Red, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red frizzle feather crossbred, RIR×NF: Rhode Island Red normal feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, NN×RIR: Naked necked Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, FE×RIR: Fulani ecotype Rhode Island Red and FF×RIR: Frizzle feather Rhode Island Red crossbred

Table 3: Least square mean values and standard errors of growth traits of pure, straight and reciprocal F_1 chickens as affected by genotypes and sex at 8 weeks of age

Parameters	N	BDW (g)	BDL (cm)	CG (cm)	KL (cm)	Shank (cm)	Thigh (cm)	WL (cm)
Genotype								
FE	76	422.27 ± 12.18^{d}	14.84 ± 0.15^{d}	17.47 ± 0.16^{bc}	7.02 ± 0.11^{b}	6.08 ± 0.08^{c}	7.82 ± 0.08^{g}	24.04 ± 0.26^{d}
FF	78	363.75 ± 12.35^{d}	14.46 ± 0.17^{d}	17.06 ± 0.15^{d}	6.35 ± 0.09^{d}	5.45 ± 0.09	9.72 ± 0.26^{bc}	25.20 ± 0.26^{a}
NF	77	321.55 ± 12.45^{f}	14.28 ± 0.19^{e}	16.94 ± 0.17^{d}	6.43 ± 0.05^{d}	5.48 ± 0.06^{d}	7.36 ± 0.09^{g}	22.51 ± 0.21^{c}
NN	72	322.10 ± 15.13^{f}	15.45 ± 0.16^{c}	17.30 ± 0.16^{c}	6.86 ± 0.10^{c}	5.64 ± 0.08^{d}	9.46 ± 0.11^{c}	24.97 ± 0.22^{c}
RIR	70	518.97 ± 11.94^{b}	15.61 ± 0.13^{c}	17.73 ± 0.18^{b}	7.40 ± 0.08^{a}	6.45 ± 0.09^{b}	9.93 ± 0.12^{b}	26.97 ± 0.20^{a}
RIR×FE	78	554.97 ± 13.45^{ab}	15.73 ± 0.11^{bc}	17.10 ± 0.13^{d}	7.36 ± 0.09^{a}	5.31 ± 0.07^{e}	9.98 ± 0.11^{b}	25.57 ± 0.22^{b}
RIR×FF	77	350.07 ± 10.49^{f}	14.08 ± 0.11^{e}	16.00 ± 0.12^{f}	6.48 ± 0.06^{d}	5.99 ± 0.11^{c}	10.81 ± 0.10^{a}	24.00 ± 0.12^{d}
RIR×NF	76	453.50 ± 11.68^{c}	14.50 ± 0.05^{f}	15.75 ± 0.12^{f}	6.62 ± 0.07^{c}	4.87 ± 0.03^{f}	9.25 ± 0.07^{d}	24.50 ± 0.14^{d}
RIR×NN	74	428.92 ± 16.74^{c}	15.59 ± 0.19^{c}	17.01 ± 0.23^{d}	7.12 ± 0.12^{ab}	4.89 ± 0.09^{f}	8.92 ± 0.22^{e}	24.49 ± 0.28^{d}
FE×RIR	72	515.25 ± 12.64^{b}	16.12 ± 0.15^{b}	18.12 ± 0.18^{a}	7.05 ± 0.07^{b}	4.85 ± 0.06^{f}	9.20 ± 0.09^{d}	25.81 ± 0.22^{b}
FF×RIR	75	510.45 ± 21.95^{b}	15.57 ± 0.19^{c}	17.70 ± 0.27^{b}	7.13 ± 0.13^{ab}	6.82 ± 0.09^{a}	9.88 ± 0.13^{b}	27.12 ± 0.58^{a}
NF×RIR	74	397.85 ± 15.75^{e}	14.93 ± 0.17^{d}	16.57 ± 0.23^{e}	6.58 ± 0.09^{c}	4.59 ± 0.06^{g}	8.59 ± 0.14^{f}	23.79 ± 0.27^{b}
NN×RIR	77	582.20 ± 24.54^{a}	16.79 ± 0.22^{a}	17.92 ± 0.23^{ab}	7.35 ± 0.09^{a}	6.79 ± 0.07^{a}	9.25 ± 0.14^{f}	27.62 ± 0.26^{a}
Sex								
Male	480	470.44 ± 8.70^{a}	15.39 ± 0.08^{a}	17.30 ± 0.09^{a}	7.04 ± 0.04^{a}	5.78 ± 0.05^{a}	9.56 ± 0.08^{a}	25.34 ± 0.13^{a}
Female	496	415.52 ± 6.55^{b}	15.07 ± 0.06^{b}	16.95 ± 0.08^{b}	6.77 ± 0.04^{b}	5.49 ± 0.05^{b}	8.93 ± 0.06^{b}	24.34 ± 0.14^{b}

^{abcdef}Means along the same column at each subclass with different superscripts are significantly ($p<0.05$) different, N: Number of observation, BDW: Body weight, BDL: Body length, CG: Chest girth, KL: Keel length, FE: Fulani ecotype, FF: Frizzle feather, NF: Normal feather, NN: Naked neck, RIR: Rhode Island Red, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red frizzle feather crossbred, RIR×NF: Rhode Island Red normal feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, NN×RIR: Naked necked Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, FE×RIR: Fulani ecotype Rhode Island Red and FF×RIR: Frizzle feather Rhode Island Red crossbred

(38.12 cm). The values recorded for body weight, body length, chest girth, shank length, thigh length and wing length of 1548.75, 27.60, 29.50 g and 10.89, 18.58 and 38.20 cm favored the crosses of NN×RIR birds while keel length (13.00 cm) was better in RIR chicken at 20 weeks of age. Consistently, values of body weight and other body conformations measured increased with the age of the birds in all the genetic stocks considered. The potential for an increase in all body weight and other linear body

Table 4: Least square mean values and standard errors of growth traits of pure, straight and reciprocal F_1 chickens as affected by genotypes and sex at 12 weeks of age

Parameters	N	BDW (g)	BDL (cm)	CG (cm)	KL (cm)	Shank (cm)	Thigh (cm)	WL (cm)
Genotype								
FE	76	637.20±17.18^{ef}	17.06±0.33^{c}	19.43±0.21^{d}	7.80±0.09^{g}	7.17±0.09^{d}	10.18±0.12^{g}	29.78±0.28^{g}
FF	78	532.37±21.41^{gh}	17.15±0.21^{e}	19.27±0.24^{d}	7.85±0.14^{g}	6.83±0.12^{e}	12.27±0.22^{c}	31.28±0.64^{de}
NF	77	518.22±17.73^{h}	15.97±0.46^{fe}	19.13±0.26^{d}	7.52±0.09^{h}	6.61±0.10^{e}	9.65±0.13^{e}	27.48±0.23^{g}
NN	72	674.87±24.67^{de}	18.17±0.24^{d}	20.98±0.20^{b}	8.48±0.11^{e}	7.53±0.10^{d}	13.44±0.17^{b}	32.12±0.17^{b}
RIR	70	940.89 ±25.12^{a}	18.42±0.37^{b}	19.80±0.31^{c}	8.61±0.10^{d}	8.543±0.11^{b}	11.95±0.19^{d}	32.57±0.32^{b}
RIR×FE	78	835.19±19.59^{a}	18.99±0.16^{b}	19.89±0.44^{c}	8.47±0.12^{e}	7.26±0.09^{d}	12.23±0.14^{c}	33.03±0.53^{a}
RIR×FF	77	590.78±10.78^{g}	17.97±0.16^{c}	19.97±0.16^{c}	8.24±0.04^{f}	8.24±0.04^{b}	13.00±0.08^{b}	27.97±0.16^{g}
RIR×NF	76	770.00±34.23^{c}	18.37±0.21^{b}	19.62±0.27^{c}	8.00±0.19^{f}	9.67±0.81^{a}	13.25±0.49^{a}	31.75±0.50^{c}
RIR×NN	74	900.87±33.52^{ab}	19.09±0.29^{b}	20.87±0.28^{b}	8.86±0.13^{c}	7.50±0.14^{d}	12.14±0.20^{c}	30.19±0.63^{d}
FE×RIR	72	816.60±18.92^{b}	20.41±0.23^{a}	21.95±0.29^{a}	9.21±0.09^{b}	8.02±0.08^{c}	12.05±0.13^{c}	32.58±0.17^{b}
FF×RIR	75	840.15±18.92^{b}	20.09±0.17^{a}	22.19±0.24^{a}	9.99±0.14^{a}	8.41±0.08^{bc}	12.22±0.21^{c}	32.62±0.31^{b}
NF×RIR	74	608.90±28.45^{f}	18.38±0.29^{bc}	19.52±0.50^{c}	8.65±0.13^{c}	7.31±0.14^{d}	11.57±0.23^{d}	30.52±0.41^{e}
NN×RIR	77	958.35±29.47^{a}	20.85±0.24^{a}	23.10±0.41^{a}	10.75±0.14^{a}	8.78±0.09^{b}	15.70±0.24^{a}	34.60±0.44^{a}
Sex								
Male	480	780.73±14.64^{a}	19.09±0.13^{a}	21.11±0.12^{a}	8.81±0.06^{a}	8.35±0.16^{a}	12.67±0.13^{a}	31.96±0.19^{a}
Female	496	624.28±9.21^{b}	17.69±0.12^{b}	19.45±0.12^{b}	8.19±0.06^{b}	7.25±0.04^{b}	11.49±0.07^{b}	30.29±0.17^{b}

^{abcdef}Means along the same column at each subclass with different superscripts are significantly ($p<0.05$) different, N: Number of observation, BDW: Body weight, BDL: Body length, CG: Chest girth, KL: Keel length, WL: Wing length, FE: Fulani ecotype, FF: Frizzle feather, NF: Normal feather, NN: Naked neck, RIR: Rhode Island Red, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red frizzle feather crossbred, RIR×NF: Rhode Island Red normal feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, NN×RIR: Naked necked Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, FE×RIR: Fulani ecotype Rhode Island Red and FF×RIR: Frizzle feather Rhode Island Red crossbred

Table 5: Least square mean values and standard errors of growth traits of pure, straight and reciprocal F_1 chickens as affected by genotypes and sex at 16 weeks of age

Parameters	N	BDW (g)	BDL (cm)	CG (cm)	KL (cm)	Shank (cm)	Thigh (cm)	WL (cm)
Genotype								
FE	75	984.02±23.62^{f}	19.51±0.16^{f}	22.14±0.22^{f}	9.62±0.10^{e}	8.89±0.11^{c}	12.22±0.14^{e}	32.83±0.32^{f}
FF	76	879.12±28.08^{d}	20.47±0.20^{e}	22.80±0.20^{e}	9.46±0.16^{f}	7.77±0.13^{e}	14.48±0.17^{c}	33.40±0.50^{e}
NF	76	815.87±25.85^{h}	18.89±0.19^{g}	21.37±0.24^{g}	8.87±0.10^{g}	8.06±0.14^{d}	11.55±0.15^{f}	31.83±0.39^{g}
NN	71	1025.98±34.57^{e}	21.29±0.19^{c}	23.77±0.20^{c}	10.47±0.13^{c}	8.82±0.13^{c}	15.62±0.20^{b}	34.73±0.30^{d}
RIR	68	1038.08±34.53^{e}	20.77±0.33^{d}	22.44±0.35^{e}	9.89±0.13^{e}	9.21±0.08^{b}	14.14±0.28^{d}	35.26±0.33^{c}
RIR×FE	77	1050.38±28.30^{d}	20.31±0.17^{e}	23.25±0.18^{d}	10.18±0.12^{c}	7.70±0.12^{e}	15.63±0.22^{b}	35.91±0.50^{b}
RIR×FF	76	795.00±20.81^{h}	21.00±0.16^{c}	23.00±0.16^{d}	10.50±0.24^{c}	8.75±0.12^{c}	14.00±0.16^{d}	34.00±0.16^{e}
RIR×NF	75	973.60±46.69^{f}	19.60±0.28^{f}	22.70±0.46^{e}	9.90±0.19^{e}	7.40±0.13^{f}	13.70±0.20^{d}	33.08±0.45^{f}
RIR×NN	73	1079.15±52.26^{c}	22.15±0.47^{b}	23.88±0.38^{c}	10.83±0.15^{b}	9.20±0.16^{b}	15.16±0.27^{b}	34.80±0.42^{d}
FE×RIR	71	1145.69±15.07^{b}	22.13±0.14^{b}	23.93±0.11^{c}	10.15±0.10^{c}	9.31±0.08^{b}	15.52±0.09^{b}	35.08±0.30^{c}
FF×RIR	73	1070.75±37.29^{c}	21.97±0.17^{b}	24.03±0.22^{b}	11.52±0.12^{a}	9.90±0.10^{a}	14.55±0.15^{c}	35.57±0.36^{b}
NF×RIR	72	925.35±43.74^{f}	20.77±0.29^{d}	22.38±0.35^{e}	10.00±0.18^{d}	8.67±0.15^{c}	14.59±0.28^{c}	34.02±0.40^{c}
NN×RIR	75	1444.20±45.26^{a}	23.70±0.18^{a}	25.65±0.29^{a}	11.37±0.14^{a}	9.67±0.17^{a}	17.55±0.18^{a}	38.12±0.32^{a}
Sex								
Male	480	1134.33±18.91^{a}	21.80±0.13^{a}	24.09±0.13^{a}	10.72±0.07^{a}	9.16±0.06^{a}	15.20±0.12^{a}	35.74±0.16^{a}
Female	478	925.48±13.24^{b}	20.31±0.10^{b}	22.46±0.10^{b}	9.81±0.06^{b}	8.37±0.06^{b}	13.97±0.10^{b}	33.54±0.16^{b}

^{abcdef}Means along the same column at each subclass with different superscripts are significantly ($p<0.05$) different, N: Number of observation, BDW: Body weight, BDL: Body length, CG: Chest girth, KL: Keel length, WL: Wing length, FE: Fulani ecotype, FF: Frizzle feather, NF: Normal feather, NN: Naked neck, RIR: Rhode Island Red, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red frizzle feather crossbred, RIR×NF: Rhode Island Red normal feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, NN×RIR: Naked necked Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, FE×RIR: Fulani ecotype Rhode Island Red and FF×RIR: Frizzle feather Rhode Island Red crossbred

measurements of individuals in each genotype as growth of the birds advanced are expected and also agreed with the reports of Adedeji *et al.*[15] that age is a major indicator of growth and physiological development. The significant genotype effects in the body weight measurements among the chicken genotypes corroborated with the earlier reports of studies[6,9,16,17]. The variation in the values of linear body measurements in all the pure and the crosses can also be associated to different genetic backgrounds of

Table 6: Least square mean values and standard errors of growth traits of pure, straight and reciprocal F_1 chickens as affected by genotypes and sex at 20 weeks of age

Parameters	N	BDW (g)	BDL (cm)	CG (cm)	KL (cm)	Shank (cm)	Thigh (cm)	WL (cm)
Genotype								
FE	75	1361.53±37.24^{c}	21.94±0.31^{f}	23.40±0.19^{g}	10.69±0.11^{h}	10.19±0.16^{c}	15.18±0.20^{d}	35.15±0.28^{f}
FF	76	1164.70±33.26^{e}	22.50±0.19^{e}	24.50±0.23^{f}	11.04±0.14^{g}	8.40±0.11^{g}	15.14±0.23^{d}	36.10±0.40^{d}
NF	76	1081.08±43.36^{f}	20.28±0.21^{h}	22.19±0.19	9.90±0.10^{ih}	8.99±0.17^{f}	13.47±0.20^{e}	34.67±0.40^{g}
NN	71	1349.73±50.61^{c}	23.87±0.21^{d}	26.07±0.22^{d}	11.16±0.18^{d}	10.08±0.30^{d}	16.60±0.30^{c}	37.07±0.33^{b}
RIR	68	1504.25±57.90^{ab}	26.65±0.20^{b}	28.30±0.27^{b}	13.00±0.13^{a}	10.67±0.03^{b}	17.30±0.21^{b}	36.95±0.12^{c}
RIR×FE	77	1423.33±43.04^{b}	22.67±0.25^{e}	25.03±0.24^{e}	11.41±0.14^{e}	8.67±0.14^{f}	16.42±0.20^{c}	36.84±0.48^{c}
RIR×FF	76	1142.50±24.57^{e}	22.50±0.08^{e}	24.45±0.23^{f}	10.90±0.04^{g}	9.60±0.06^{e}	15.15±0.26^{d}	35.50±0.08^{f}
RIR×NF	75	1224.00±34.19^{d}	21.75±0.17^{f}	24.25±0.23^{f}	11.00±0.11^{g}	8.00±0.14^{h}	14.87±0.26^{f}	36.12±0.34^{g}
RIR×NN	73	1478.73±75.00^{ab}	23.82±0.38^{d}	25.52±0.44^{e}	11.60±0.22^{d}	9.47±0.18^{e}	16.52±0.31^{c}	35.85±0.50^{e}
FE×RIR	71	1383.55±31.25^{c}	25.30±0.16^{c}	26.80±0.27^{c}	12.05±0.16^{b}	10.50±0.10^{b}	16.92±0.13^{c}	37.62±0.41^{b}
FF×RIR	73	1122.90±63.25^{e}	23.10±0.31^{e}	25.00±0.39^{e}	11.90±0.11^{e}	9.43±0.12^{e}	15.05±0.26^{d}	36.30±0.37^{d}
NF×RIR	72	1172.85±57.88^{e}	22.88±0.42^{e}	25.07±0.46^{e}	11.16±0.23^{f}	9.68±0.22^{e}	16.89±0.39^{c}	35.87±0.45^{e}
NN×RIR	75	1548.75±71.66^{a}	27.60±0.28^{a}	29.50±0.38^{a}	12.22±0.18^{b}	10.89±0.18^{a}	18.58±0.23^{a}	38.20±0.61^{a}
Sex								
Male	480	1520.63±22.29^{a}	24.32±0.15^{a}	26.31±0.15^{a}	11.86±0.07^{a}	10.10±0.07^{a}	17.05±0.11^{a}	37.38±0.14^{a}
Female	478	1154.87±19.14^{b}	22.71±0.14^{b}	24.61±0.16^{b}	11.06±0.07^{b}	9.13±0.07^{b}	15.19±0.11^{b}	35.56±0.16^{b}

^{abcdef}Means along the same column at each subclass with different superscripts are significantly ($p<0.05$) different, N: Number of observation, BDW: Body weight, BDL: Body length, CG: Chest girth, KL: Keel length, WL: Wing length, FE: Fulani ecotype, FF: Frizzle feather, NF: Normal feather, NN: Naked neck, RIR: Rhode Island Red, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red frizzle feather crossbred, RIR×NF: Rhode Island Red normal feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, NN×RIR: Naked necked Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, FE×RIR: Fulani ecotype Rhode Island Red and FF×RIR: Frizzle feather Rhode Island Red crossbred

Table 7: Pooled least square mean values of feed intake, weight gain and feed conversion ratio of pure, straight and reciprocal F_1 chickens as affected by different genotype and sex

Parameters	N	Feed Intake (g)	Weight gain (g)	Feed conversion ratio
Genotypes				
FF	75	63.24 ±1.56^{b}	9.44±0.35^{d}	6.92±0.25^{bc}
RIR	76	99.59±1.22^{a}	15.06±0.48^{a}	8.97 ±0.44^{a}
FE	76	59.39±0.86^{bc}	12.42±0.67^{a}	7.83±0.35^{c}
NN	71	50.20 ±2.48^{d}	8.77±0.45^{de}	6.34±0.36^{bc}
NF	68	48.99±0.47^{e}	9.69±0.90^{d}	7.15±0.35^{b}
RIR×FE	77	51.47±0.22^{d}	8.88±0.67^{de}	7.11±0.45^{b}
RIR×FF	76	52.08±1.88^{cd}	9.29±0.44^{d}	6.19±0.34^{bc}
RIR×NN	75	47.12± 4.35^{e}	14.24±0.22^{ab}	4.32±0.66^{d}
RIR×NF	73	57.22± 2.78^{c}	12.48±0.48^{b}	9.45±0.78^{ab}
FE×RIR	71	56.47±2.33^{c}	8.52±0.44^{d}	8.34±0.04^{ab}
FF×RIR	73	64.53±0.67^{b}	11.66±0.88^{b}	7.14±0.45^{b}
NN×RIR	72	47.06±0.35^{f}	15.99±0.48^{a}	6.69±0.67^{e}
NF×RIR	75	48.68±0.78^{f}	8.16±0.69^{e}	7.56±0.48^{b}
Sex				
Male	480	60.09±0.99^{a}	12.47±0.45^{a}	10.09±0.23^{a}
Female	478	56.89±2.78^{b}	10.56±0.67^{b}	8.69±0.34^{b}

^{abcde} Means along the same column at each subclass with different superscripts are significantly ($p<0.05$) different, N: Number of observation, RIR: Rhode Island Red, FE: Fulani ecotype, NN: Naked neck, NF: Normal feather, RIR×FE: Rhode Island Red Fulani ecotype crossbred, RIR×FF: Rhode Island Red Frizzled feather crossbred, RIR×NN: Rhode Island Red naked neck crossbred, RIR×NF: Rhode Island Red normal feather crossbred, FE×RIR: Fulani ecotype Rhode Island Red crossbred, FF×RIR: Frizzle feather Rhode Island Red crossbred, NN×RIR: Naked neck Rhode Island Red crossbred, NF×RIR: Normal feather Rhode Island Red crossbred, ED: Early dry, LD: Late dry, EW: Early wet and LW: Late wet

the chicken as reported by Keambou *et al.*[18]. The superiority in the body weight and other linear body measurements traits noted for crosses of NN×RIR chicken upon the pure and other crossbred counterparts suggested supported the earlier observations of previous studies[19-21] that crossbred chicken performed better than their purebred counterparts in respect to body weights and other linear measurements. It could be suggested that the improved local chicken has a good gene combining effects with the RIR (exotic) when a male line was used rather than female line. Sex significantly ($p<0.05$) affected all the body weight and other body parameters with most of the obtainable values for body weight and other linear measurement favored the male of the birds at all considered ages and these values consistently increases as the birds attaining ages for all the genotypes. The variations in the growth traits between the male and female birds across the genotypes might be associated to the fact that the muscle development occurs through the interaction of numerous factors, among which sex and hormonal factors are more significant and this favored the male as agreed with Akinbola *et al.*[4]. Males were superior in body weight and body conformations than their females' counterpart. This result affirmed with the findings of previous studies[17,19,22], who reported that male birds were better significantly in respect to body weights and other linear measurements than its counterpart female birds. This may have resulted from the presence of the androgen hormone in males compared to the females which gave the male birds to be more aggressive and dominant when feeding, especially when both sexes are reared together.

The pooled least square mean values of feed intakes, weight gain and feed conversion ratio as affected by different genotypes and sex are presented in Table 7. The results showed that genotype significantly affected ($p<0.05$) feed intake, weight gain and feed conversion ratio. The RIR chickens as expected consumed more feed (99.59 g) than other genetic groups while NN×RIR crossbred consumed lowest feed of value 47.06 g. However, NN×RIR birds had the highest weight gain (15.99 g) than its counterpart genotypes with least weight gain recorded for NF×RIR crossbred chickens. The value recorded for feed conversion ratio in RIR was significantly highest among the different genotypes involved while the lowest feed conversion ratio was observed in the crosses of NN×RIR birds. The results indicated that crosses involving NN×RIR consumed less feed with better weight gain coupled with best feed conversion ratio than other genetic groups considered. This agreed with the observations of[11,23,24] that combining genes of crosses of chickens×RIR birds consumed more feeds than other genotypes of birds involved in their studies. These authors affirmed that genetic constituents influenced the growth performance characteristics of chickens. This could be due to the heterosis effect, leading to improved performance traits in the progenies. Sex significantly ($p<0.05$) influenced the values obtained for feed intake, weight gain and feed conversion ratio with higher values observed in the male birds than its counterpart female birds, thus agreed with the earlier reports of Amin[19] that male consumed more feeds due to the aggressiveness and dominance because of the hormonal effects of androgen in male birds.

CONCLUSION

The study depicted that crossing between of NIC and RIR chickens exploits the advantages of heterotic effect on growth performance characteristics. It was observed that BDW and linear body measurements increased as the chickens attained ages in the thirteen genotypes produced which proved that these body measurements were directly proportional to age of the animals. The study also affirmed that growth traits and performance were affected by the genetic compositions of the animals involved. The crosses between naked neck and Rhode Island Red (NN×RIR) chickens that produced naked neck Rhode Island Red (NNRIR) crossbred chickens had superior growth traits coupled with its attributes to consume lesser feed and gain more weight than its counterpart genotypes. The male of all genotypes were better in terms of growth traits dues to the hormonal influence of androgen in the male birds. The findings further suggested that Nigerian indigenous chickens (NN, NF, FF and FE) could be used appropriately as sire and exotic chickens as dams was best suited for improving the local stocks for growth performance characteristics in the derived savanna environment of Nigeria.

SIGNIFICANCE STATEMENT

The potential of the local chickens cannot be overemphasized since indigenous chicken production is a widely known practice in tropical and sub-tropical countries as the chickens are kept majority by rural masses as a major source of protein and income but the genetic composition of these chickens was limited in respect of growth and other economic characters. Thus, these limiting factors can be improved through selection and mating methods. The study employed several mating methods as a means of exploring the genetic potential especially the growth performance traits and the results depicted that growth performance parameters were significantly varied among the genetic components with NNRIR having better growth performance characteristics than its counterpart genetic stocks.

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