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General Combining Ability for Growth Traits in F_1 Crosses of Native Chickens of Nigeria in the Savanna Region

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ABSTRACT

Nine genetic groups of native chickens of Nigeria were generated from a 3 x 3 diallel mating involving the normal feathered (NF), frizzle feathered (FF) and naked neck (Na) local birds. A total of 97, 75 and 73 straight bred chicks were hatched for the respective genetic groups. Correspondingly, 132,151 and 153 chicks resulted from various crosses (normal and reciprocal) of the parental birds. Body weights were taken at hatch and subsequently at 4, 8, 12, 16 and 20 weeks of age. Heterosis were calculated and general combining ability (GCA) were computed based on the pedigree of the birds. Body weight varied significantly ($p<0.05$) among the genetic groups at the various ages of measurement. Crossbreeding improved body weight in the crossbred over the parental genotypes. Heterosis for body weight at 20 weeks of age were positive and ranged from 1.93 in the Na birds to 12.18 in the NF birds. General combining ability (GCA) were 1058.97, 1044.01 and 1123.04 in the NF, FF and Na genotypes respectively. Consequently, variability was least in the Na genetic group signifying a higher selection pressure on these birds in the savanna region of Nigeria. The FF birds had a good hybrid ability and a greater gene variation for BW than the NF and Na genotypes. The study noted that that using the Na males against the FF females will give a greater advantage for body weight at 20 weeks of age in the savanna region of Nigeria. It is therefore recommended that Na males be crossed with FF females in developing table birds for this region from the available local stock.

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Despite the role of the Nigerian local chicken in stabilizing the rural households and contributing its quota to meeting the protein need of both urban, and peri-urban dwellers, they have been rated to be poor in terms of meat and egg output. This has been attributed to the poor genetic base or genetic handicap of these birds. Researchers have consistently pointed to selection and cross breeding as plausible ways of circumventing this handicap and improving the productivity of the local birds. The underlying assumption here is that cross breeding leads to highbrid vigour (heterosis) in the F_1 while selection increases the frequencies of the desirable genes in the population. Theoretically, hybrid vigor is inversely proportional to the extent of genetic similarities between parental populations [1] and it is expected to be proportional to the extent of heterozygocity of crosses [2]. It has been reported that crossbreeding results in alteration of the genetic variance and allows combining the valuable traits of parent lines in their progeny [3]. These authors further reported that an objective evaluation of the value of a given strain and its exact place in combinations is performed on the basis of diallel cross experiments. A diallel cross gives the possible set of combinations between different genotypes.

The combining ability analyses help to identify desirable combiners that may be utilized to exploit heterosis [4]. Gardner et al. [5] referred to the general combining ability (GCA) as the average performance of a line, strain or genotype in hybrid combinations with other lines. The variation in GCA is attributable to additive genetic variance. Many reports showed that GCA and therefore

additive variations were generally more important than dominance in determining body weight at different ages [4,6-8]. It is common knowledge in animal breeding that the phenotypic value of an animal is the sum of its genetic makeup and the environmental effect. While many researchers have reported on the performance of the Nigerian local chickens in hybrid combinations elsewhere, there is a dearth of information on this performance in the savanna region of Nigeria. The current study is therefore designed to provide baseline information on the GCA of three genetic groups of the Nigerian local chickens in the savanna ecology with the aim of identifying desirable combiners for choice of meat type chickens in this region.

Materials and Methods

The experiment was carried in Makurdi – Nigeria. Makuirdi is located within the savanna region of the country. The experimental birds were generated from a controlled breeding population of parent stock involving three genetic groups of Nigeria local chickens in a diallel mating arrangement as shown in (Table 1). The parent stock were sourced from local markets within and around Makurdi. They were kept for an adaptation period of four weeks. Birds with signs of ill health were isolated and treated. All birds were vaccinated against the common endemic diseases in the region. At the end of the adaptation period, the birds were distributed randomly into breeding pens with a mating ratio of 1:10 male to female respectively. Eggs were collected and identified according to sire lines, incubated and hatched artificially using the electric incubator. The day-old chicks were properly identified by colour marking, using indelible dyes and brooded under standard conditions on deep litter for eight weeks. Compounded chick and grower mash containing 18% crude protein and 2800Kcal/kg metabolizable energy, and 15% crude protein and 2670Kcal/kg metabolizable energy were feed *ad libitum* during the brooding and rearing phases respectively. There was no restriction to water intake throughout the experimental period. Routine vaccination was carried out as recommended for the environment. Progressive increase in body weight in the genetic group was evaluated 4-weekly to 20 weeks of age of the birds using a digital weigh scale. Daily weight gain was calculated using the procedure described by Msofffe et al. [9].

Table 1: Diallel mating arrangement for generating of experimental (F_1) birds.

a, a (1, 1)	a, b (1, 2)	a, c (1, 3)
b, a (2, 1)	b, b (2, 2)	b, c (2, 3)
c, a (3, 1)	c, b (3, 2)	c, c (3, 3)

Note; a = normal feathered genotype, b = frizzle feathered genotype, c = naked neck genotype

Purebred crosses (diagonal) = 1, 1; 2, 2 and 3, 3

Main crosses (above diagonal) = 1, 2; 1, 3 and 2, 3

Reciprocal crosses (below diagonal) = 2, 1; 3, 1; and 3, 2

$$Dailygrowthrate = \frac{W_2 - W_1}{N}$$

Where: W_1 is the initial weight.

W_2 is the final weight.

N is the number of days (between W2 and W1).

Statistical Analysis

The general linear model procedure of SAS [10] statistical analysis software was used to evaluate the effect of genetic group on body weight gain. Paired comparison was carried out using the Duncan's multiple range test [11]. The model used was used:

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

Where

Y_{ij} = individual observation

μ = Overall group mean

a_i = fixed effect of i^{th} genetic group

e_{ij} = Residual error.

Heterosis for body weight in the genetic groups was computed as described by Fairll [12].

$$Heterosis\ (\%) = \{AB - \tfrac{1}{2}(AA + BB)\} \times 100$$

Where:

AB = phenotypic value of the F_1 crossbred (hybrid)

AA = phenotypic value of the F_1 parent (male)

BB = phenotypic value of the F_1 parent (female)

The general combining ability (GCA) for body weight in the genetic groups was calculated using [13] procedure

Results and Discussion

The least square means of body weight from 4 to 20 weeks of age is presented in (Table 2). Body weights varied significantly between the genetic groups from the 4^{th} to the 20^{th} week of age. Results of crossbreeding revealed that the introgression of the frizzling gene into the Na genotype significantly $p< 0.05$) improved body weight at 4 weeks of age in the cross bred genotype over the individual parental genotypes. Similarly, crossbreeding the NF with the FF and Na genotypes resulted in significant ($p <0.05$) improvement in body weight at 4 weeks of age in the respective crosses over the parental straight bred genotypes. At 12 weeks of age and subsequently, the naked neck genotype showed a significantly ($p<0.05$) higher

body weight when compared to its contemporaries. This is suggestive that full plumage cover and the associated stressing factors characteristic of the tropical environment could have set in between the 8th and 12th week of age. The naked neck birds tend to cope better with this challenge than the other two genotypes of the native chickens of the savanna region of Nigeria. In all the genetic groups, cross breeding resulted in significant ($p<0.05$) improvement in body weight over the straight bred genotypes.

Table 2: Least square means + sem of body weight (g) at various ages of the genetic groups.

Parental Genotype (Code)			4 Weeks Weight.	8weeks Weight.	12 Weeks Weight.	16 Weeks Weight.	20 Weeks Weight.
Purebred Cross							
Male	Female	F1 Genotype (Code)					
NF (a)	NF (a)	aa	89.19 ± 0.45^{b}	273.16 ± 1.54^{cb}	479.73 ± 1.54^{g}	686.33 ± 3.70^{g}	921.14 ± 4.62^{f}
FF (b)	FF (b)	bb	91.01 ± 0.52^{a}	274.63 ± 1.64^{b}	488.20 ± 4.68^{gf}	710.44 ± 5.25^{f}	966.98 ± 9.14^{e}
Na (c)	Na (c)	cc	89.14 ± 0.69^{b}	270.92 ± 2.53^{cb}	540.24 ± 7.98^{d}	771.67 ± 9.70^{d}	1047.45 ± 13.88^{c}
Normal Cross							
NF (a)	FF (b)	ab	86.31 ± 0.54^{d}	267.78 ± 3.68^{dc}	620.22 ± 9.99^{b}	819.14 ± 9.39^{b}	1040.52 ± 12.34^{c}
NF (a)	Na (c)	ac	83.57 ± 0.69^{e}	264.11 ± 3.19^{d}	639.49 ± 7.94^{a}	842.29 ± 5.88^{a}	1088.20 ± 12.21^{b}
FF (b)	Na (c)	bc	91.87± 0.78^{a}	283.50 ± 2.41^{a}	526.81 ± 7.84^{e}	734.41 ± 7.38^{e}	1040.49 ± 13.06^{c}
Reciprocal Cross							
FF (b)	NF (a)	ba	87.18 ± 0.51^{dc}	268.57 ± 3.52^{dc}	608.15 ± 10.13^{c}	821.59 ± 8.83^{b}	1047.45 ± 13.47^{c}
Na (c)	NF (a)	ca	80.91 ± 0.87^{f}	257.16 ± 3.01^{e}	500.53 ± 7.11^{f}	793.95 ± 5.84^{c}	1017.63 ± 10.79d
Na (c)	FF (b)	cb	88.29 ± 0.91^{cb}	270.13 ± 1.92^{cb}	623.18 ± 7.10^{b}	817.42 ± 6.71^{b}	1121.78 ± 9.94^{a}

Note: a,b,c…Least square means in the same column with different superscripts differ significantly ($P < 0.05$). NF (a) = Normal feathered, FF (b) = Frizzle feathered genotype, Na (c) = Naked neck genotype

Purebred crosses (F_1 genotypes) = aa, ab, bb, and cc

Main crosses (F_1 genotypes) = ab; ac and bc

Reciprocal crosses (F_1 genotypes) = ba; ca; and cb

(Table 3) presents the percent heterosis for body weight at hatch and 20 weeks of age in the genetic groups. Heterosis were positive and ranged from 2.13 to 12.19 per cent. The low heterosis for body weight in the F_1 crosses involving the Na genotype may be a further confirmation of less genetic variability between the genetic groups and a dominating role of non-additive genes in the expression of this trait. General combining ability (GCA) was computed in the genetic groups (Table 4) at 20 weeks of age using the diallel analysis. Twenty weeks of age is selected as the baseline for the calculation of GCA because the birds approach sexual maturity at this age and therefore may not be marketed below this age. GCA was lower (1044.01) in the FF genotype than in the NF (1058.97) and naked neck (1123.24) birds. It can therefore be inferred that the FF genotype has a good hybrid ability and a greater gene variation for BW than the NF and Na genotypes. Consequently, the FF genotype has a comparative inferior performance as an individual whole (not in hybrid combination) for body weight than the other two genetic groups at 20 weeks of age. Selection pressure was higher in the Na birds in the savanna region of Nigeria leading to a comparative higher GCA and reduced variation than in the

other genotypes. The consequence of this, is that there is a greater potential for improvement in body weight in the FF birds than in the NF and Na birds. Therefore, using the Na males against the FF females will give a greater advantage for body weight at 20 weeks of age in the savanna region of Nigeria. It is therefore recommended that Na males be crossed with FF females in developing table birds for this region from the available local stock.

Table 3: Heterosis for body weights at hatch and 20 weeks of age in the genetic groups.

Genotype	Mean hatch wt. (g) of pure breed	Mean 20 weeks wt.(g) of pure breed	Mean hatch wt. (g) of crosses	Mean 20 weeks wt. (g) of pure breed	Mean advantage of crossbred at 20 wk wt.(g)	Percent heterosis for wt.(g) at 20 weeks
NF	26.84	921.14	25.98	1033.37	112.23	12.18
FF	27.08	966.98	27.55	1064.36	97.38	10.07
Na	28.81	1047.45	27.36	1067.71	20.26	1.93

Note: NF = Normal feathered, FF = Frizzle feathered genotype, Na = Naked neck genotype

Table 4: General combining ability (GCA) for body weights at various ages in the genetic groups.

Genotype	GCA
NF	1058.97
FF	1044.01
Na	1123.04

NF-Normal feathered genotype. FF- Frizzle feathered genotype. Na- Naked neck genotype

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