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Diallel Cross Analysis for Growth Traits in Improved Normal Feathered and Naked Necked Nigerian Indigenous Chickens

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Abstract - This study was carried out to evaluate the crossbreeding effect on the growth traits of normal feathered and naked necked improved Nigerian indigenous chicken FUNAAB alpha. One hundred (100) experimental birds aged forty (40) weeks, comprising 20 cocks and 80 hens were used. The birds were arranged in four (4) genetic groups GG1, (NF X NF), GG2 (NN x NN), GG3 (NN X NF) and GG4 (NF X NN) with each genetic group having 5 sires and 20 dams, (a mating ratio of one cock to 4 hens). Mating was carried out using artificial insemination to produce one hundred chicks. The traits monitored were body weight (BW), body length (BL), chest girth (CG), wing length (WL), leg length (LL), shank length (SL), and shank circumference (SC). The data obtained from these traits at hatch, week 4, week 8, week 12 and week 16 were subjected to multivariate analysis of variance. The results indicated that there were significant (P<0.05) differences in body weight among the four genetic groups. At hatch NF X NN had the highest body weight (42.60g) as compared to 37.69, 36.96 and 38.22 for NF X NF, NN X NN and NN X NF respectively. A similar trend was observed at weeks 4, 8 and 16 with NF X NN cross having a higher body weight than the other genetic groups. No significant (P>0.05) variation was noticed in body weight among the four genetic groups at 12 weeks of age, only numerical differences existed. The heterosis estimates for body weight from day old to 16 weeks of age were positive and higher in the main cross (NFXNN) than in the reciprocal cross (NNXNF). A similar trend was noticed in all the other traits. The results showed that the main cross (NFXNN) had strong and positive additive effect at all ages (2.25, 34.10, 67.08, 16.93 and 52.44) while the reciprocal cross (NN X NF) had weak and negative additive effect at all ages (-1.49, -10.13, -36.94, and -0.92) except for week 12 that was positive 0.62. It was observed further that the reciprocal effects for body weight at week 8 and 16 were strong and high 67.58 and 67.06. The result showed that the specific combining abilities for body weight and body length were all positive for the main (NF X NN) cross but negative in the reciprocate (NN X NF) cross for all ages. In view of the performance in body weight, chest girth and body length in this experiment, the combination of normal feathered and naked necked genes as sires and dams, respectively, is recommended to bring about genetic improvement in all the studied traits.

Keywords: Diallel Cross, Naked Neck, Genetic Group, Growth Traits, Normal Feather.

I. INTRODUCTION

In tropical and sub-tropical countries malnutrition is a common phenomenon as a result of rapid growth in population without a corresponding increase in food production especially those rich in animal protein. The greatest source of animal protein consumption by man is noted to be from poultry (Food and Agriculture Organization, 2000; Permin and Pederson, 2010). Hence, man's need in animal protein requirements would be met in their increased production (Mengesha, 2011). Within the poultry population, chicken is the most predominantly distributed across sub-Saharan Africa. Pym *et al.,* (2006) noted that in most developing countries, (which Nigeria is a part). The poultry industries operate in two ways, one using improved birds of exalted performance genes in a specialized production of meat and eggs while the other non-improved indigenous multipurpose low performing birds.

Typically, the size of the local bird is small and its growth rate is not as fast as the genetically developed exotic counterpart (Peters, 2000). These indigenous chickens are generally known to possess some economic important inherent traits. Such traits include those associated with hardiness and adaptability to the harsh/adverse climate and sociocultural milieu they are found (Kitalyi, 1999). The growth performance of indigenous chicken in the tropics is reported to be affected by major genes

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(Horst (1997). Ibe (1993) noted that the naked neck gene and the frizzled feather gene are important genes (major) associated with the indigenous chicken. Alleles of these traits have been found to be dominant over the wild-type (normal feather) which is expressed phenotypically in its recessive form. Reports from different authors have shown variations in quantitative traits of economic importance as a result of these genes. For instance, Gunn (2008) found a better feed conversion in the naked neck compared to their normal feathered counterparts. Olawunmi *et al.,* (2008) also reported existence of morphological differences between the frizzled feathered and naked necked chickens.

Breeding of the indigenous chicken in Nigeria so far has not been vastly applied on a large scale. Two Institution-based research has profitably developed some registered breeds, these include the breeding programme initiated in 1985 at the National Animal Production Research Institute, Zaria that resulted to the Shika Brown (egg-type) breed, and the PEARL Project which was launched at Federal University of Agriculture, Abeokuta, Nigeria. This Project has culminated in the improvement and development of a duly registered improved locally adapted Nigerian chicken breed known as FUNAAB Alpha Chicken. The FUNAAB Alpha Chicken has different strains with respect to their feather pattern. These are the normal feathered, the naked necked and the frizzle feathered. The general objective of the study was to evaluate crossbreeding effect on growth traits in two strains of FUNAAB Alpha Chickens Normal Feathered (NF) and Naked Necked (NN).

II. MATERIALS AND METHODS

The Study Site

The study was carried out at the poultry unit of the Teaching and Research Farm of the Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Nigeria. It lies between longitude $7^{0}00^{1}$E and latitude $4^{0}47^{1}$N with average monthly temperature of 22.54-31.03C and relative humidity of 69.08 -112.47% respectively and an average rainfall of 200.45m (Uko and Tamunobereton – Ari, 2013).

Time Frame of Study

The duration of this study was 16weeks and entailed the establishment of a diallel mating scheme between two strains of Nigerian indigenous chickens (normal feathered and naked necked strains) and investigation of the crossbreeding effect on growth traits from hatch to sixteen weeks of age.

Experimental Birds and Management

Breeding Stock

A total of 100 birds, comprising 80 hens and 20 cocks aged 40 weeks, were randomly selected from first generation of purebred naked necked ((NN x NN) and purebred normal feathered (NF x NF) Nigerian indigenous chicken population maintained at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Science, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt. These foundation flocks were obtained from the Poultry Breeding Unit of the Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria. They were the improved locally adapted indigenous chicken breeds developed after about twelve years of selective breeding for productive traits (body weight and egg production) using Nigerian indigenous chicken from south-west Nigeria and Fulani ecotype (Adebambo, 2015).

The studied birds for the cocks were chosen based on their semen quality and the hens on their short term egg production performance. The birds were housed in battery cages with each bird per cage. A breeders diet of 16% crude protein and 2500kcal/kg metabolizable energy at 130g/bird/day were fed to the birds. Water was given unrestricted.

Establishment of Genetic Groups for Diallel Mating

Selected cocks and hens were randomly allocated into four genetic groups as indicated in Table 3.1. Each genetic group had 5 sires and 20 dams (a mating ratio of 1 cock to four hens). Mating was achieved using artificial insemination. The insemination was carried out using a micro-pipette set at 0.2µl. Insemination was done two times per week, for a period of four weeks.

Table 3.1: Mating system used for the study

Group	Birds (Cock ♂ x Hen ♀)
GG1	Normal Feathered x Normal Feathered (NF x NF)
GG2	Naked Necked x Naked Necked (NN x NN)
GG3	Naked Necked x Normal Feathered l (NN x NF)
GG4	Normal Feathered x Naked Necked (NF x NN)

Management of Chicks

One hundred chicks were hatched. Each genetic group was brooded in separate brooding pen for four weeks and separated thereafter into five replicate pens. Chicks were fed formulated diets as recommended by Oleforuh-Okoleh *et al*., (2017). The gross and proximate composition of the diets is shown in Table 3.2.

Table 3.2: Gross and Proximate Composition of Experimental Diets

Ingredient	Feed Type	
	Chicks' Mash	Growers' Mash
Maize	55.70	44.40
Soybean meal	18.00	9.50
Palm kernel cake	11.60	26.60
Wheat bran	7.35	14.70
Fish meal	2.50	0.00
Bone meal	3.00	3.00
Limestone	1.00	1.00
Salt	0.35	0.35
Lysine	0.10	0.10
Dl-Methionine	0.15	0.10
Premix	0.25	0.25
Total	100.00	100.00
Calculated CP(%)	18.20	16.09
Metabolizable energy (Kcal/kg)	2804.00	2604.30

Data Collection

Individual body weight and morphometric traits of 100 chicks generated from the diallel cross of two strains (normal feathered (NF) and naked necked (NN)) were recorded at the end of every four weeks period from hatch to 16 weeks of age. The chicks were identified according to their pedigree by wing banding them from hatch till eight weeks of age.

Data were collected on the following growth traits.

a) Body Weight: Each birds body weight was taken using an electronic balance (Jadesola weighing scale LT 30 KA 30kg/1g) with a sensitivity of 0.01g. The weighing was done at monthly intervals.
b) Body Morphometric Traits: Body morphometric traits were measured using a flexible measuring tape as described by Gueye *et al.,* (1998), and Fayeye *et al.,* (2006).
The measurements were:

i) Body Length (BL): This was measured as the length between the tip of the beak and the pygostyle bone from the body surface.
ii) Chest Girth (CG): This was measured as the circumference of the body under the wings around the chest region.
iii) Wing Length (WL): This was measured as the distance from the shoulder joint to the extreme terminal phalanx.
iv) Leg Length (LL): It was measured as the distance between the hock joint and the pelvic joint.
v) Shank Length (SL): This was measured as the distance between the hock and the metatarsal pad.
vi) Shank Circumference (SC): it was measured as the circumference of the middle of the shank.

Data Analysis

The statistical tool used in the analysis was IBM, SPSS (version 22, 2013). All the growth traits measured were analysed using the multivariate analysis in general linear model with strain types (NF and NN) and age (0, 4, 8, 12, and 16 weeks) as main effects. Significant means at P<0.05 were separated using Duncan multiples range test, Duncan, (1990). The linear model used for the study is as follows:

$$X_{ijk=\mu+S_i+A_j+SA_{ij}+E_{ijk}}$$

Were X_{ijk} = observation made on the kth individual bird belonging to the ith strain monitored during the jth age period (1,4,8,12,16 weeks).

μ = Overall population mean

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S_i = Effect of the ith strain on the parameter or trait monitored (i = 1, 2…..7)
A_j = effect of the jth age of the birds (j = Day old, 4, 8, 12, 16)
SA_{ij} = Interaction between strain and age effects
E_{ijk} = Random error
Calculation formula

(1) Heterosis was estimated according to Fairfull (1990) using the following formula;

a. Heterosis % for the cross (NF X NN) = $\frac{[\{0.5(NF \times NN) - MP\}}{MP} \times 100$

b. Heterosis % for cross (NN X NF) = $\frac{[\{0.5(NN \times NF) - MP\}}{MP} \times 100$

c. Overall Heterosis % = $\frac{mean\ of\ F_{1-MP}}{MP} \times 100$

Where: F_1 = first filial generation [NF x NN and NN x NF]
MP = mid parent value = mean of parents [NF x NF and NN x NN]

(2) Direct Additive Effect (that is line group sire differences)

a. For Normal feathered = ½ {(NF X NF) + (NF X NN)} – ⅓ {(NF X NF) + (NN X NN) + (NN X NF)}

b. For Naked necked = ½ {(NN X NN) + (NN X NF)} – ⅓ {(NN X NN) + (NF X NF) + (NF X NN)}

c. Reciprocal cross effect (NF X NN) and (NN X NF) = [(NF X NN) - (NN X NF)] / 2

III. RESULTS

Genetic group and Age Effect on Body Measurements

The genetic group and age effect on body measurements is presented in Table 1. The results obtained indicated that there was significant (P<0.05) difference in body weight among the four genetics groups. At hatch NF x NN had the highest body weight (42.60) as compared to (37.67, 36.96 and 38.22) for NF x NF, NN x NN and NN x NF respectively. A similar trend was observed at weeks 4, 8 and 16 with NF x NN cross having a higher body weight than the other genetic groups. No significant (P>0.05) variation was noticed in body weight among the four genetic groups at 12 weeks of age, only numerical difference existed.

For body length, the NF x NN cross showed significant (P<0.05) difference from the other genetic groups. NF x NN was 5.37% longer than NN x NF, 5.45% than NN x NN and 3.68% than NF x NF at hatch. This indicates that NF x NN cross had a superior length and as such the combination of the genes of NF x NN cross gave the best bonding for growth amongst all the crosses. Furthermore, substantial (P<0.05) difference in body length of 2.99, 4.91, 3.52cm and 2.27, 2.63, 2.18cm were found between NF x NN and NN x NF, NN x NN, NF x NF for weeks 4 and 8 respectively. Weeks 12 and 16 recorded no significant (P>0.05) variation in body length among the four genetic groups.

Significant (P<0.05) variation also occurred among the four genetic groups for chest girth. NF x NN also had the highest value across the various weeks except for week 12 that had no significant (P>0.05) difference. NF x NN had the highest values of 8.93, 16.91, 23.86 and 32.75 for hatch, 4, 8 and 16 weeks respectively. In the chest girth NF x NN cross had the highest value of 8.93 while NF x NF had the lowest value of 7.54 whereas NN x NN and NF x NF had (7.61 and 7.93) respectively for hatch. At 4 weeks of age NF x NF and NN x NN had no difference whereas variation (6.68%) existed between NN x NF and NF x NN for chest girth. From table 4.1, NF x NN cross had a superior performance in all the growth traits studied.

Table 4.1 further revealed that significant (P<0.05) difference existed among the four genetic groups with NF x NN having the highest value (6.21) for wing length, this was closely followed by NN x NF, NF x NF and NN x NN (5.27, 5.22 and 4.86) respectively. Furthermore, in all the ages for WL NF x NN group had the highest significance, however hatch and week 4 were highly significant as compared to weeks 8 and 12. There was no significant (P<0.05) difference at week 16. It was further observed that at week 4, NF x NF had a value that was in between NN x NF and NN x NF while at week 12 had a value in between NF x NN and NN x NF, NN x NN. Table 3.4 reveal that high and significant genetic group difference (P<0.05) was noticed at hatch, 4 and 8 weeks of age for leg length and shank length. The results obtained showed that NF x NN cross had better result than NN x NN, NF x NF and NN x NF for the two age groups above respectively.

There was no significant (P>0.05) difference at weeks 12 and 16 respectively for leg length. There was significant (P<0.05) variation among the four

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genetic group with NF x NN having the highest value for hatch, weeks 4 and 8 respectively. Although, at 4 weeks, NF x NN and NN x NF competed favourably (5.80 and 5.58) as compared to NN x NN and NF x NF, with values of 5.07 and 5.00 respectively. Significant (P<0.05) difference for shank circumference was only recorded at hatch with the cross bred having higher values than the parental progenies. Non-significant (P>0.05) differences were noticed among the genetic groups at weeks 4, 8, 12 and 16.

Table 1: Genetic group and age effects on bodyweight, BL, CG and WL.

TRAIT	GG	AGE				
		Day old	4WEEKS	8WEEKS	12WEEKS	16WEEKS
BW(g)	NF x NF	37.69^{b}	230.71^{b}	618.64^{b}	992.25	1397.83^{b}
	NN x NN	37.96^{b}	213.04^{b}	635.87^{b}	1010.83	1434.65^{b}
	NN x NF	38.22^{b}	272.53^{b}	650.08^{b}	1038.85	1463.75^{b}
	NF x NN	42.60^{a}	315.00^{a}	785.25^{a}	1069.58	1615.88^{a}
	SEM	1.30	27.79	40.99	61.64	88.89
	P-value	0.000	0.001	0.001	0.602	0.053
BL(cm)	NF x NF	12.01^{ab}	21.54^{b}	32.87^{b}	37.52	40.89
	NN x NN	11.79^{b}	20.15^{b}	32.42^{b}	37.33	42.02
	NN x NF	11.87^{b}	22.07^{b}	32.78^{b}	37.24	41.45
	NF x NN	12.47^{a}	25.06^{a}	35.05^{a}	37.79	42.32
	SEM	0.27	0.01	0.73	0.81	1.15
	P-value	0.047	0.000	0.001	0.910	0.525
CG(cm)	NF x NF	7.54^{c}	14.79^{c}	22.14^{b}	26.27	30.38^{b}
	NN x NN	7.61^{c}	14.44^{bc}	21.99^{b}	25.95^{ab}	30.33^{a}
	NN x NF	7.93^{b}	15.78^{b}	23.12^{ab}	26.87	29.69^{b}
	NF x NN	8.93^{a}	16.91^{a}	23.86^{a}	26.49	32.75^{a}
	SEM	0.23	0.59	0.73	0.71	0.88
	P-value	0.000	0.000	0.027	0.539	0.002
WL(cm)	NF x NF	5.22^{b}	12.14^{bc}	17.77^{b}	21.34^{ab}	22.69
	NN x NN	4.86^{b}	11.51^{c}	17.56^{b}	20.62^{b}	21.82
	NN x NF	5.27^{b}	12.70^{b}	17.72^{b}	21.01^{b}	22.95
	NF x NN	6.21^{a}	13.70^{a}	18.87^{a}	22.33^{a}	22.50
	SEM	0.24	0.42	0.40	0.55	0.68
	P-value	0.000	0.000	0.041	0.016	0.847

ab Means on the same column (for each trait) followed by different superscript are significantly different at p-values indicated.

SEM – Standard error of mean; BW – Body weight; BL – Body length; CG – Chest girth; WL – Wing length; LL – Leg length; SL – Shank Length; SC – Shank circumference; NF – Normal Feather; NN – Naked neck.

Table 2: Genetic group and age effects on bodyweight, LL, SL and SC.

TRAIT	GG	AGE				
		Day old	4WEEKS	8WEEKS	12WEEKS	16WEEKS
	NN x NN	4.56^{b}	9.05^{c}	16.96^{b}	20.30	22.20
	NN x NF	4.78^{b}	10.55^{b}	16.77^{b}	20.59	22.61
	NF x NN	5.87^{a}	12.35^{a}	18.03^{a}	20.06	22.35
	SEM	0.27	0.70	0.50	0.53	0.56
	P-value	0.000	0.000	0.041	0.733	0.847
SL(cm)	NF x NF	2.83^{b}	5.00^{b}	7.47^{b}	9.57	9.81
	NN x NN	2.77^{b}	5.07^{b}	7.30^{b}	9.58	10.10
	NN x NF	2.84^{b}	5.58^{a}	7.37^{b}	9.58	9.9000
	NF x NN	3.05^{a}	5.80^{a}	7.96^{a}	9.23	9.5000
	SEM	0.85	0.20	0.24	0.24	0.34

	P-value	0.007	0.000	0.027	0.360	0.337
SC(cm)	NF x NF	1.73[b]	3.39	3.79	4.58	4.7750
	NN x NN	1.76[b]	3.47	3.84	4.51	4.5913
	NN x NF	1.88[b]	3.40	3.76	4.51	4.8303
	NF x NN	1.92[a]	3.35	3.97	4.60	4.7360
	SEM	0.06	0.07	0.11	0.14	0.15
	P-value	0.001	0.370	0.173	0.834	0.381

abc Means on the same column (for each trait) followed by different superscript are significantly different at p-values indicated.
SEM – Standard error of mean; BW – Body weight; BL – Body length; CG – Chest girth; WL – Wing length; LL – Leg length; SL – Shank Length; SC – Shank circumference; NF – Normal Feather; NN – Naked neck.

Heterotic Effect

Table 2 presents heterosis percentage of body measurements at different ages from the diallel crossing of Normal feathered and Naked necked strains. The result showed that heterosis estimates for body weight from day old to 16 weeks of age were positive and higher in the main cross (NF x NN) but negative in the reciprocal cross (NN x NF). A similar trend was noticed in all the other traits. For body length the reciprocal cross recorded positive heterosis only in weeks 4 and 8, but was negative at other ages. For chest girth the NF x NN cross had positive heterosis in all the ages, a similar trend was noticed in the NN x NF cross except for week 16 were weak and negative heterotic effect was observed. Wing length had positive and high heterosis estimates with the main cross (NF x NN) higher than the reciprocal cross (NN x NF) at all ages. This differed from the leg length where a negative heterosis was recorded in the reciprocal cross at weeks 8 and 16 respectively. The shank length and shank circumference both recorded positive and negative heterosis for both crosses at varying ages.

Table 3: Heterosis (%) of the body measurements at different ages from the diallel cross of Normal feathered and Naked necked strains

Trait	GG	AGE				
		DAYOLD	4	8	12	16
BW(g)	NF X NN	14.14	41.97	25.19	6.79	16.10
	NN X NF	2.41	22.83	3.64	3.73	6.36
	OVERALL	8.27	34.40	14.45	5.26	11.23
BL(cm)	NF X NN	4.79	20.22	7.42	0.34	1.75
	NN X NF	-0.25	5.88	0.49	-1.10	-0.04
	OVERALL	2.27	13.05	3.95	-0.37	0.86
CG(cm)	NF X NN	17.89	15.70	8.14	1.49	7.66
	NN X NF	4.69	7.97	8.41	2.87	-2.19
	OVERALL	11.29	11.84	9.27	2.18	2.73
WL(cm)	NF X NN	23.21	15.87	6.82	6.43	3.35
	NN X NF	4.76	7.40	0.31	0.14	3.12
	OVERALL	13.99	11.62	3.57	3.29	3.24
LL(cm)	NF X NN	25.29	28.25	6.40	0.88	3.61
	NN X NF	2.03	9.45	-1.03	0.83	-0.79
	OVERALL	13.66	18.84	2.68	0.86	1.41
SL(cm)	NF X NN	8.93	14.97	7.71	-3.55	-4.77
	NN X NF	1.43	10.60	-0.27	0.02	-0.55
	OVERALL	5.18	12.79	3.72	-1.77	-2.66
SC(cm)	NF X NN	10.03	-2.33	4.23	1.21	1.07
	NN X NF	7.74	-0.58	-1.44	-0.77	2.98
	OVERALL	8.88	-1.46	1.44	0.22	2.05

GG – Genetic group; BW – Body weight; BL – Body length; CG – Chest girth; WL – Wing length; LL – Leg length; SL – Shank length; SC – Shank circumference; NF – Normal feather; NN – Naked neck.

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IV. DISCUSSION

Genetic Groups Effect

Peters (2000) observed substantial changes in growth, reproductive traits, morphological and immune response in indigenous chickens. Adebambo, (2005), opined that these birds have special genes that could be useful in other regions of the word. Hence the need for their conservation to keep genetic variation in and between indigenous breeds. Several reports on the characterization of indigenous chickens have revealed that they could be classified based on the occurrence of some major genes, such as the naked-neck gene and dwarf gene, (Ikeobi *et al.,* 1996). According to Nwachukwu *et al.,* (2006), naked-neck and frizzle chickens have been found to be tolerant to thermal stress as compared with their normally feathered counterparts. The naked-neck and frizzle genes have been found to be associated with heat tolerance, and therefore in areas with high ambient temperature, chickens with these genes are superior to their normal feathered counterparts for feed efficiency (Garces *et al.,* 2001). Chickens with the naked-neck and frizzle genes have better adult bodyweights than their normal feathered counterparts (Fayeye *et al.,* 2006). Also, many investigators have confirmed the superiority of crossbreds over purebreds regarding growth traits in chicken (Nwachukwu *et al.,* 2006).

The range of body weight for hatch in this experiment was within that of 22.3 g to 39.9 g reported by Oke (2011) in three genotypes of Nigerian indigenous chickens and their crosses. It slightly differed from the range of 21.8 to 28.1 g recorded by Ndofor-Foleng *et al.* (2010) for light and heavy ecotype chickens with their main crosses. The significantly higher hatch bodyweight in NF x NN cross suggests that their gene may have the potential for rapid growth. At 4 weeks of age the body weight among the four genetic groups differed significantly and this result was contradicting that of Mahrous (2008) and Oke (2011), who had previously reported that there are no differences between the main and reciprocal crosses for bodyweight at this age. There was a consistency in higher weights of NF x NN and NN x NF genetic groups, and this was similar to the report of Mahrous *et al.* (2008) that the pair of NF x NN and NN x NF genes conferred fast-growing ability, either singly or in sets. Furthermore NF x NN genetic group maintained far superior performance of body weight at 8 weeks of age hence this was an indication of excellent individual and combining arrays for these major genes. The body weight of weeks 12 to 16 revealed that NF x NN out-performed all other groups. These observations agree with the findings of Mahrous (2008) and Oke (2011). This ascendancy may be as a result of efficiency of thermoregulation imparted by the two genes (Yunus and Cahaner, 1999).

The significant estimates obtained for reciprocal effect from hatch to the 16thweek of age for body length and chest girth imply that there was variation owing to sex-linked genes and maternal effect. The superior performance of NF x NN may be as a result of maternal effect of NN. In the entire experiment, when NN was used as dam and NF as sire the result was far better than NN x NN and NF x NF. This result was consistent with the positive estimates obtained when there was a cross between Venda (normal-feathered South Africa indigenous chicken) and naked-necks (Ndeyebo, 2011). Although, Cook *et al.* (1972) noted that the presence of substantial sex chromosomes in the homogametic male progeny in reciprocal crosses was maternal effect rather than sex linkage which is implicated in their difference.

Heterotic Effect

The genetic origin of heterosis has been under deliberations nonetheless, dominance and epistasis are the primary genetic prototypes advocated to explain heterosis (Lippman and Zamir, 2007; Reif *et al*., 2006; Crow, 2000). According to Birchler *et al.*, (2003), there is yet a remarkable discordance between an extensive use of heterosis in variety development and our understanding of the basis of heterosis.

The molecular basis of heterosis as considered by many researchers in recent years, may be attributed to the increased gene expression level in the hybrid or to the altered regulation of gene expression in the hybrid either at the global level or for specific classes of genes (Leonardi *et al.*, 1991). Gibson & Weir, (2005), stated that two unlike alleles brought together in the hybrid may create a combined allelic expression pattern in the hybrids. On the alternative, at some loci, the interaction of alleles or a change in the spectrum of trans-acting factors makes gene expression in the hybrid to digress from simple additive allelic expression patterns of the parents. Romagnoli *et al.*, (1990), noted that phenotypic traits expressed by an organism are the results of the gene expression an entity take in a trait, it should be the result of over-expression of some genes, that is to say, the over-expression and under-expression of some genes lead to the expression of heterosis together.

The heterosis estimates obtained in this study fall within the range reported by Momoh and Nwosu (2008) in crossbreeding study involving two ecotypes of Nigerian local chickens. Estimates of the heterosis of chicks at day-old for both strains were low indicating that body weight and linear body measurements at these ages are to a very large extent a function of environmental factors. The low heterosis at younger ages also indicates less genetic variability relative to phenotypic variability among the chicks. The implication of this is that selection for trait of interest may not result in any appreciable improvement at an early age of the bird. Therefore, crossbreeding will bring about genetic improvement resulting from heterosis relative to selection only. It is however, important to state that this genetic improvement due to crossbreeding will only be permanent if selection is applied to the crossbred lines over many generations. The low heterosis estimates observed could be due to non-additive genetic effects such as dominance and epistasis. As from week 4, there was an increase in the observed heterosis. Therefore, heterosis estimates of the parameters increased to medium and high values. Moderate to high heterosis estimate is an indication that variability due to additive gene action is probably higher than the non- additive component and genetic progress can be made through selection. This then implies that a large proportion of the superiority of the parents will be retained in the offspring. Comparatively, heterosis in this study were slightly higher than the values obtained by Adeyinka *et al*., (2004) which ranged from 0.013± 0.08 for keel length to 0.32±0.22 for weight at day-old with the heterosis estimates for weights at various ages being moderate in a population of naked neck broiler chickens. Since highest heterosis were obtained at weeks 8 and 16 in this study, selection of broiler breeders can be carried out at these ages. This then implies that a large proportion of the superiority of the parents will be retained in the offspring.

V. CONCLUSION

The diallel analysis of normal feather and naked necked Nigerian indigenous chickens indicated that body weight was affected by genetic group. The NF x NN group had superior body weight compared with other genetic groups at almost all ages. Furthermore, the NF x NN gave the best estimates for heterosis and combining abilities. Therefore, the use of the NFas sire and the NN as dam provided the most suitable combination for the best improved body weight with a high body weight at 16 weeks of age. The use of NN as dam was also most suitable since sex-linked/maternal effect was significant.

Recommendation

In view of the performance in body weight, chest girth and body length, in this experiment, the combination of normal feather and naked neck genes as sires and dams, respectively, is recommended to bring about genetic improvement in all the studied traits.

Contribution to Knowledge

This work noted an improved performance of the genetic group NF x NN over the other genetic groups NN x NF, NN x NN and NF x NF using the diallel cross. Therefore, it brings to knowledge that in these two strains of Nigeria indigenous chicken, the normal feathered and the naked necked, diallel cross could be use to improve performance. It also brought to limelight that using NF as sire and NN as dam gave a better growth performance in body weight, body length and chest girth, therefore, this genetic group could be used for future generation performance improvement and commercial exploitation by researchers and farmers.

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