



Heterosis and Combining Ability for Body Weight and Morphometric Traits in a Diallel Cross of Funaab Alpha Chickens

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ABSTRACT

This study was carried out to evaluate heterosis and combining ability for growth traits in a diallel cross of two strains of FUNAAB Alpha chickens. Sixty hens comprising thirty white plumage and thirty black plumage colour aged between 17-18 weeks were used. The experiment which lasted for 5 months, considered such growth traits as: Body weight (BW), Body length (BL), Chest Girth (CG), Shank length (SL), Shank circumference (SC), Comb height (CH) and Comb length (CL). The study was based on heterosis and diallel cross of growth traits, (Hatch to 20 weeks of age). Data obtained were subjected to statistical analysis using IBM SPSS (Version 20, 2016). The result indicated that significant disparity ($P < 0.05$) existed between White plumage and Black plumage chickens in all characters studied. White FUNAAB Alpha was 12.46% heavier than the Black FUNAAB Alpha. In the main cross of $W_{\text{♂}} \times B_{\text{♀}}$ and reciprocal cross of $B_{\text{♂}} \times W_{\text{♀}}$, the reciprocal ($B_{\text{♂}} \times W_{\text{♀}}$) cross was 6.82% heavier than the $W_{\text{♂}} \times B_{\text{♀}}$ at day old, although at 20 weeks of age, the $W_{\text{♂}} \times B_{\text{♀}}$ cross was 1.77% heavier than the $B_{\text{♂}} \times W_{\text{♀}}$ cross for body weight. The result of heterosis percentage revealed that heterosis estimates for body weight at hatch, 4 and 8 weeks of age was positive and higher in the black FUNAAB Alpha male x white FUNAAB Alpha female ($B_{\text{♂}} \times W_{\text{♀}}$). The main cross ($W_{\text{♂}} \times B_{\text{♀}}$) had superior heterosis for body length at hatch, 12 to 20 weeks of age.

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INTRODUCTION

Poultry improvement is genetically based on at least two different approaches and these are selection and crossbreeding (Adebambo *et al.*, 2011). Crossbreeding as a tool permits manipulating genetic variation in order to modify populations in such a manner that attempts to boost desired phenotype. The primary essence of crossing is to produce higher crosses to increase the performance of the developed local chickens and to combine diverse traits in which the breeds crossed were valuable for egg production and growth traits (Saadey *et al.*, 2008; Soliman *et al.*, 2016). The poultry industry is known to be the biggest when it comes to livestock species and thus produces more than thirty percent of animal protein (Adebambo *et al.* 1996; Olori, 1992). They exist within the poultry population, and are extensively found under scavenging systems in most rural regions (Muchadeyi *et al.*, 2007; Osei-Amponsah *et al.*, 2010). Local chickens are generally strong and cope well through epidemics and in various harsh environmental conditions (Addisu, 2012). In the last three decades the Nigerian local chickens have been improved through crossbreeding with exotic breeds. These exotic breeds play vital role in the improvement of economic characters in local chicken strains (Mohamed, 2003). Fayeye, (2014) reported that crossbreeding results in increased heterosis in traits that are low in heritability. Poultry breeding using diallel crossing ensures a comprehensive genetic basis for production of new strains or breeds and to discover superior crossbreeds (Aly *et al.*, 2015). High positive heterosis percentages for body weight at different ages among crossbreeds can be evaluated to determine best performing parents and mid parents (Mandour *et al.*, 1996). The objective of this study was to evaluate heterosis/combining ability of different growth traits (body weight and body morphometric) from a complete diallel cross involving 2 strains of FUNAAB Alpha Chickens.

MATERIALS AND METHODS

Experimental Location and Study Period

This experiment was conducted at the Poultry Unit of the Teaching and Research farm of Rivers State University, Nkpolu Oroworukwo, Port Harcourt, Rivers State. The average rainfall in Port Harcourt is 200.45mm (Uko and Tamunobereton-Ari, 2013). The study lasted for a period of 20 weeks, between June 2017 and October, 2017.

Experimental Birds

The birds used for this study were FUNAAB Alpha Strain. The FUNAAB Alpha birds are genetically improved Nigerian local chickens developed at Federal University of Agriculture Abeokuta (FUNAAB) Ogun State by a PEARL Project. These birds were developed after generations of intensive selection within normal feather Nigerian local chickens and later

crossbreeding with indigenous chickens of India (Adebambo, 2015). Sixty FUNAAB Alpha improved Nigerian local chickens comprising thirty (30) black and thirty (30) white plumage hens between 17 and 18 weeks of age were sourced from the Poultry Unit of the Federal University of Agriculture (FUNAAB) Abeokuta, Ogun State. The birds were randomly allocated into 6 replicate deep litter pens/strain for two weeks acclimatization and later assigned into individual cages in a three tier battery cage at 19 weeks of age.

Selection of parents and diallel cross

Six sires each from the white and black FUNAAB Alpha strains were selected from the population based on their evaluated semen quality traits. From the existing population, sixty hens were selected based on their body weight and egg production.

Diallel cross: The selected birds were allocated randomly into four breeding groups as follows: WW ($W_{\text{♂}} \times W_{\text{♀}}$), BB ($B_{\text{♂}} \times B_{\text{♀}}$), WB ($W_{\text{♂}} \times B_{\text{♀}}$), and BW ($B_{\text{♂}} \times W_{\text{♀}}$) respectively. Each breeding group consisted of three sires and fifteen dams making a total of 72 chickens all together. For the mating procedure, artificial insemination method was used to inseminate the dams in this study. A ratio of one sire to five dams in each group was used and this was replicated three times. The insemination was carried out using a micro-pipette set at 0.2 μ . At the beginning of the experiment, semen was collected from the selected sire and inseminated into the oviduct of the dams in each breeding group. This was done thrice weekly to ensure high fertility.

Data Collection

This study was designed such that data was obtained on growth traits

Body weight and Morphometric Traits

Body weight and morphometric traits were measured and obtained from the progeny at intervals of 4 weeks (from hatch to 20 weeks of age). The variables among others measured include;

- (a) Body weight: The body weight of each bird was taken with the use of an electronic weighing scale in grams.
- (b) Chest Girth: This was measured as the width between two shoulder joints around the chest.
- (c) Body length: This was measured as the length between the lower ends of the rostrum maxillae (beak) to the caudal tail (coccygeal bone) without feathers from body surface.

The body measurements were done using the description of (Teguia *et al.*, 2008; Yakubu, 2011).

Data Analysis

Data were analyzed for variation between the crosses and within crosses (between progeny) using the multivariate analysis of general linear model procedure with genotype (WW, BB, WB, and BW) and Age (Hatch, 4, 8, 12, 16, and 20) as main effects. Interactions of these effects were also analyzed. Significant means at $P < 0.05$ were separated using LSD.

Genetic parameter estimate

$$\text{Heterosis \% for cross } (W \times B) = \left\{ \frac{(W \times B) - \frac{\{(WW+BB)\}}{2}}{\{(WW+BB)\}} \right\} / \{(WW+BB)\} / 2 \times 100\}$$

General Combining Ability (GCA): The general combining ability (GCA) values were calculated as the deviation of a specific genotype means from the overall mean for a trait estimated for the 4 diallel crosses. This implies that the GCA for $(W \times W) = \{1/3 * [(WW) + (W \times B) + (B \times W)] - 1/4 * [(WW) + (BB) + (W \times B) + (B \times W)]\}$.

RESULTS AND DISCUSSION

Results in Table 1 showed that at different weeks of age, body weight differed significantly ($P < 0.05$) among

the four genetic groups. The white FUNAAB Alpha strain had heavier day old weight in comparison with the black FUNAAB Alpha strain. In all crosses with white FUNAAB Alpha was used as a dam, heavier body weights at hatch and other age periods were noticed. The white FUNAAB Alpha ($W \times W$ parent genotype) was heavier (42.93g) than the Black FUNAAB Alpha parental genotype (37.80g) at day old. In the main cross of $W \text{♂} \times B \text{♀}$ and reciprocal cross of $B \text{♂} \times W \text{♀}$, the reciprocal ($B \text{♂} \times W \text{♀}$) cross was 6.82% heavier than the $W \text{♂} \times B \text{♀}$ at day old, although at 20 weeks of age, the $W \text{♂} \times B \text{♀}$ cross was 1.77% heavier than the $B \text{♂} \times W \text{♀}$ cross all for body weight. In all the growth traits studied, the White FUNAAB Alpha strain had better and higher significance than the Black FUNAAB Alpha strain. This may indicate that the underlying carotenoid pigmentation for white colour could possibly be linked with genes that favour the development of the various traits (Body weight, body length, etc) studied (Evans and Sheldon, 2015). Body length at different weeks of age was significantly different ($P < 0.05$) among the four genetic groups, with the white FUNAAB Alpha (12.20cm) having a superior value than the black FUNAAB Alpha (11.77cm), although the main cross ($W \text{♂} \times B \text{♀}$) had higher value of 12.26cm than the reciprocal cross ($B \text{♂} \times W \text{♀}$) with value of 12.24cm.

Table 1 Mean SE for growth traits at different studied ages from the diallel crossing of White and Black FUNAAB Alpha strains

Trait	GG	Growth traits at different ages (weeks)						P-Value		
		Day Old	4	8	12	16	20	Strain	Age	S x A
BW	WW	42.93 ^b	187.86 ^a	578.07 ^b	991.50 ^a	1021.14 ^a	1024.14 ^a	0.000	0.000	0.005
	WB	41.00 ^c	169.70 ^c	548.67 ^d	833.40 ^b	844.10 ^b	848.10 ^b			
	BB	37.80 ^d	151.60 ^d	567.11 ^c	750.78 ^d	767.56 ^d	771.33 ^d			
	BW	44.00 ^a	184.70 ^b	612.80 ^a	819.00 ^c	828.60 ^c	833.10 ^c			
BL	WW	12.20 ^c	21.82 ^a	29.89 ^a	37.72 ^b	38.14 ^b	38.51 ^b	0.000	0.000	0.076
	WB	12.26 ^a	20.77 ^c	28.59 ^c	38.95 ^a	39.30 ^a	39.62 ^a			
	BB	11.77 ^d	20.03 ^d	29.00 ^b	33.23 ^d	33.57 ^d	33.76 ^d			
	BW	12.24 ^b	21.50 ^b	29.36 ^b	37.30 ^c	37.65 ^c	37.89 ^c			
CG	WW	9.92 ^b	15.61 ^a	22.47 ^a	29.29 ^b	29.73 ^{ab}	29.86 ^b	0.000	0.000	0.271
	WB	10.15 ^a	15.08 ^c	22.20 ^c	30.41 ^a	30.79 ^a	30.90 ^a			
	BB	9.35 ^d	14.76 ^d	22.40 ^{ab}	26.26 ^d	26.62 ^c	26.71 ^d			
	BW	9.82 ^c	15.25 ^b	22.26 ^b	29.12 ^c	29.52 ^b	29.60 ^c			
SL	WW	2.24 ^c	3.95 ^b	6.09 ^{ab}	7.54 ^b	7.75 ^a	7.84 ^{ab}	0.022	0.000	0.93
	WB	2.28 ^a	3.90 ^c	5.67 ^c	7.61 ^a	7.75 ^a	7.86 ^a			
	BB	2.20 ^d	3.59 ^d	6.02 ^b	6.84 ^d	7.02 ^c	7.12 ^c			
	BW	2.26 ^b	4.03 ^a	6.17 ^a	7.42 ^c	7.65 ^b	7.74 ^b			
SC	WW	1.85 ^c	2.76 ^b	3.54 ^b	7.02 ^a	4.44 ^b	4.48 ^b	0.315	0.000	0.787
	WB	2.05 ^a	2.65 ^c	3.64 ^a	4.44 ^b	4.52 ^a	4.60 ^a			
	BB	1.79 ^d	2.46 ^d	3.48 ^c	3.94 ^d	4.02 ^c	4.07 ^d			
	BW	1.94 ^b	2.86 ^a	3.45 ^d	4.02 ^c	4.08 ^{bc}	4.12 ^c			
CL	WW	0.000	1.14 ^b	2.53 ^a	3.63 ^a	3.70 ^a	3.79 ^a	0.000	0.000	0.787
	WB	0.000	1.15 ^a	2.27 ^b	3.06 ^b	3.17 ^{ab}	3.28 ^b			
	BB	0.000	0.93 ^d	2.08 ^{bc}	2.37 ^c	2.47 ^c	2.66 ^c			
	BW	0.000	1.07 ^c	2.07 ^c	3.06 ^b	3.16 ^b	3.27 ^{ab}			
CH	WW	0.000	0.25 ^a	1.02 ^a	1.79 ^a	1.89 ^a	1.99 ^a	0.000	0.000	0.630
	WB	0.000	0.21 ^c	0.80 ^c	1.44 ^c	1.54 ^c	1.71 ^b			
	BB	0.000	0.19 ^d	0.82 ^{bc}	1.13 ^d	1.30 ^d	1.51 ^c			
	BW	0.000	0.24 ^b	0.85 ^b	1.51 ^b	1.61 ^b	1.73 ^{ab}			

GG = Genotype group, BW = Body weight, BL = Body length, CG = Chest girth, SL = Shank length, SC = Shank circumference, CL = Comb length, CH = Comb height, WW = White White, WB = White Black, BB = Black Black, BW = Black White, S x A = Interaction of Strain and Age

Heterosis estimate for body weight and morphometric traits are presented in Table 2. The result shows that heterosis estimates for body weight at hatch, 4 and 8 weeks of age was positive and higher in the black FUNAAB Alpha male x white FUNAAB Alpha female ($B♂ \times W♀$). At 12 – 20 weeks of age, negative

heterosis was obtained. Negative heterosis was obtained at 4 – 20 weeks of age for the main cross ($W♂ \times B♀$). The main cross ($W♂ \times B♀$) had superior heterosis for body length at hatch, 12 to 20 weeks of age.

Table 2 Heterosis percentages of body weight and body morphometric for offspring at different studied ages from the diallel crossing of white (WW) and black (BB) FUNAAB Alpha Strain

Trait	GG ♂ x ♀	Growth traits at different ages (weeks)					
		Day old	4	8	12	16	20
BW	W x B	1.57	-0.02	-4.18	-4.33	-5.62	-5.53
	B x W	9.01	8.82	7.02	-5.99	-7.35	-6.54
BL	W x B	2.29	-0.74	0.03	9.76	9.61	9.64
	B x W	2.13	2.74	-0.29	5.14	5.01	4.86
CG	W x B	5.35	-0.69	-1.05	9.49	9.28	9.25
	B x W	1.92	0.42	-0.78	4.84	4.77	4.65
SL	W x B	2.70	3.45	-6.36	5.84	4.94	5.08
	B x W	1.80	6.89	1.89	3.19	3.59	3.48
SC	W x B	12.64	1.53	3.70	-18.98	6.86	7.60
	B x W	6.59	9.57	-1.71	-26.64	-3.55	-3.63
CL	W x B	0.00	11.1	-1.52	2.00	2.76	1.71
	B x W	0.00	-10.144	-10.19	2.00	2.43	1.39
CH	W x B	0.00	-4.54	-13.04	-1.37	-3.45	-2.29
	B x W	0.00	9.09	-7.61	3.42	0.94	-1.14

GG = Genotype group; BW = Body weight; BL = Body length; CG = Chest girth; SL = Shank length; SC = Shank circumference; CL = Comb length; CH = Comb height; $W♂ \times B♀$ = White male x Black female; $B♂ \times W♀$ = Black male x White female.

The result for estimates of general combining ability (GCA) is presented in Table 3. GCA estimates were all positive for body weight in $W♂ \times W♀$ for hatch, 4 to 20 weeks of age while they were all negative in $B♂ \times B♀$ cross in all the ages. Similar trend was noticed in body length except for week 4 (0.263) that was positive for

BB cross. Estimates of GCA for chest girth recorded positive estimates for $W♂ \times W♀$ cross except week 8 (-0.023) that was negative; however, all the ages for $B♂ \times B♀$ cross were negative. Similar observations were made with respect to Shank length, Shank circumference, comb length and comb height.

Table 3 General and specific combining abilities of growth traits at different ages from the diallel crossing of white and black FUNAAB Alpha strains.

Trait	GG	Growth traits at different ages (Weeks)					
		Day Old	4	8	12	16	20
BW	WW	1.211	7.288	3.183	32.630	32.596	32.612
	BB	-0.502	-4.799	-0.470	-47.610	-51.93	-51.658
BL	WW	0.112	0.333	0.07	1.190	1.198	1.228
	BB	-0.028	0.263	-0.226	-0.306	-0.325	-0.355
CG	WW	0.153	0.138	-0.023	0.836	0.848	0.853
	BB	-0.036	-0.145	-0.046	-0.173	-0.188	-0.197
SL	WW	0.015	0.093	-0.011	0.171	0.174	0.173
	BB	0.001	-0.027	-0.033	-0.062	-0.068	-0.06
SC	WW	0.039	0.074	0.016	0.305	0.081	0.083
	BB	0.019	-0.026	-0.004	-0.722	-0.059	-0.054
CL	WW	0.000	0.048	0.053	0.220	0.218	0.196
	BB	0.000	-0.022	-0.097	-0.200	-0.192	-0.010
CH	WW	0.000	0.011	0.018	0.113	0.095	0.091
	BB	0.000	-0.009	-0.596	-0.107	-0.102	-0.069

GG = Genotype group, BW = Body weight, BL = Body length, CG = Chest girth, SL = Shank length, SC = Shank circumference, CL = Comb length, CH = Comb height, WW = White x White, BB = Black x Black, WB = White x Black, BW = Black x White.

CONCLUSION AND RECOMMENDATION

The diallel analysis of the White and black FUNAAB Alpha strain showed that body weight was affected by genetic group. Crossing between white and black FUNAAB Alpha resulted in improved body weight at varying ages. The white FUNAAB Alpha gave the best estimate for heterosis and general combining ability. Therefore the use of white FUNAAB Alpha as dam and both sire parents provided the most balanced combination and improved body weight. It is therefore recommended for use as parent in other to exploit their vigour for body weight improvement.

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