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Combining Abilities of Carcass Traits among Pure and Crossbred Meat Type Chickens

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Abstract: Two hundred and ninety five cocks and two hundred and ninety nine hens were selected from a diallel combination of four breeds of chickens; [Anak Titan (A), Alpha (B), Giriraja (G) and Normal indigenous (N) chickens] at 12 weeks of age in a broiler improvement program for carcass analysis. The following data were collected in percentages: economically important traits = Live weight (g), Plucked weight, Eviscerated weight, Carcass yield, Abdominal fat percentage, Breast yield, Thigh yield, Drumstick yield; survival organs = Wing yield, Internal organ, Empty gizzard yield, Heart yield, Lung yield, Kidney yield, Liver yield. Analyses of variance of carcass traits show that sire and dam genotype significantly ($p<0.05$) affected carcass traits. Anak Titan sires and dams performed best in economically important traits, while N and B performed better in survival organs. Sex had significant ($p<0.05$) effect only on live weight with cocks having higher values of 979.55±56.62 and hens 879.6±34.18. Results of diallel analysis to test for general and specific combining abilities of breeds on traits showed that additive genetic effects were important in determining economically important traits, indicative that improvement can be achieved by selection. Dominance effects were important in control of survival organs, indicative of improvement by crossbreeding. Estimates of GCA for carcass traits show that Anak Titan had highest general combining ability for most of the carcass parameters while the least values were found among Alpha chickens. Estimates of SCA for carcass parameters showed AN cross generally had highest SCA for most of the carcass traits. Least SCA values for carcass parameters were generally recorded for AB crosses. It is recommended that an improvement process that involves all the breeds should be adapted using reciprocal recurrent selection or modifications of it.

Key words: Poultry breeds, carcass traits, combining ability

INTRODUCTION

The Nigerian indigenous chicken has been described as small bodied slow growing, poor feed converters and poor meat animals (Nwosu and Asuquo, 1985). This is as a result of long-term natural selection for fitness in a harsh tropical and disease prevalent-environment. The local birds in Nigeria are a major source of raw materials from which sustainable protein supply can be developed within the nation, makes them a focal point for researchers as 90% of the 150 million chicken in Nigeria are the local varieties which contribute 90% and 72% of the egg and meat consumption (Nwanta *et al*., 2006). Series of reports on the characterisation of the local chickens revealed that they could be classified based on the occurrence of some major genes such as dwarf gene (Dw), naked neck gene (Na) and Frizzling gene (Fr) (Ikeobi *et al*., 1996, Adebambo *et al*., 1999). Large variations were also reported to exist among the birds in growth and egg laying performance (Peters, 2000). These findings have led to the conclusion that the indigenous birds have a great potential for meaningful genetic improvement for growth and therefore contribution to the protein dearth in the country (Ikeobi *et al*., 1996; Adebambo *et al*., 1996; Peters, 2000). With growing interest in quality breeding, leanness of carcass cuts and quality of broiler market; monitoring changes in body weight and linear body parameters over time does not suffice for a broiler improvement program without inclusion of carcass traits. Genetic progress in broiler industry is rated in measures of change in body growth and carcass conformation.

Genetic progress can be attained either by selection or crossbreeding. Crossbreeding of the indigenous stock with exotic commercial birds will take advantage of artificial selection for productivity in the exotic birds and natural selection for hardiness in the indigenous birds. A good combining ability resulting from a choice of the best performing crossbred could lead to the production of birds that will be better in growth rate, efficiency of feed conversion, reproductive and carcass traits without sacrificing adaptation to the local environment, thereby resulting in reduced cost of production.

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Test for good combining abilities is developed by generating a diallel cross, which is a set of possible combination between several genotypes and general populations and analysis of data from such crosses (Hayman, 1954). The General Combining Ability (GCA) is defined as the average performance of a line (strain or breed) in hybrid combination with other lines. The variation in GCA is due to additive genetic variance. The Specific Combining Ability (SCA) refers to a cross produced by a pair of lines. It indicates cases where certain combinations (crosses) do relatively better or worse than would be expected on the basis of the average performance (GCA) of the two lines involved in producing that combination. Such crosses will therefore be selected for improvement or against as having individual cross advantage or disadvantage. The variation in SCA is due to non additive genetic variance; heterosis, dominance, over-dominance and epistasis, (Singh and Kumar, 1994).

The aim of this research was to study general and specific combining abilities existing in carcass traits of pure and crossbred meat type chickens produced from four parental populations, - Giriraja (G), Anak (A), Nigerian improved indigenous poultry chicken, alpha (B) and the local (N) as a preliminary broiler lines evaluation prior to selection in a national broiler improvement program.

MATERIALS AND METHODS

The experimental birds comprise of 5191 chicks produced from a combination of four breeds of chickens maintained at the Poultry Breeding Unit of the University Teaching and Research farm, University of Agriculture, Alabata road, Abeokuta, Nigeria; latitude 7°10`N and longitude 3°2`E in. The area has a tropical climate with a mean annual rainfall of about 1037 mm. The mean monthly ambient temperature ranges from 28°C in December to 36°C in February with a yearly average of 34°C. Relative humidity ranges from 60% in January to 94% in August with a yearly average of about 82%. The vegetation represents an inter-phase between the tropical rainforest and the derived savannah.The chicken breeds include 45 Anak Titan: Israeli type commercial broiler (A), 58 Giriraja: Indian type dual purpose chicken (G), 75 Nigerian normal indigenous chicken (N), 61 Alpha: Nigerian developed improved indigenous for higher egg production (B) as diallel crosses, that is, both straight and reciprocal crosses generated over 2 year period 2006-2008. Eggs were collected daily for ten days from the breeder chickens maintained in battry cages with a period of one-week break between mating cocks. All the eggs were pedigreed before incubation. Hatched chicks from each strain or genotype were properly identified and wing tagged. All necessary vaccination and medication were supplied as at when due. Breeders were fed on a diet containing 11.704 MJ/kg metabolizable energy and 16% crude protein. The chicks were fed *ad libitum* on a broiler starter diet that supplied 23% crude protein and 12.122 MJ/kg metabolizable energy from 0-4 weeks of age. Thereafter, they were fed on a broiler finisher diet that supplied 20.5% crude protein and 12.958 MJ/kg metabolizable energy from 5-12 weeks. Clean water was supplied *ad libitum* throughout the experimental period.

Data collection

Carcass data: The chicks were wing-tagged along sire lines and weighed using a 0.01 kg sensitive scale. The birds were reared together, but differences in the parameters due to sex, season and other factors were noted. Skeletal dimensions were taken on weekly basis till the chicks reached 12 weeks of age. At termination of experiment twenty birds each were randomly selected, half of which were male and the other female from each cross at 12 weeks of age. They were dissected for carcass analysis at exactly the 12th week of age. Feed was withdrawn for 12 h from the birds so as to empty their crop and thus reduce the variability in body weight due to intestinal content. Individual carcass data were taken for each bird as follows.

Economically important traits:

- Live weight
- Plucked weight this was weight of the carcass after feather plucking (Salami *et al*., 2004).
- Eviscerated weight was measured after removal of the head and the intestine (Aduku and Olukosi, 2000).
- Carcass yield (%) was calculated as the percentage by weight of the carcass of the living bird before slaughter (Hahn and Spindler, 2002).
- Abdominal fat percentage. This was defined as the weight of abdominal leaf fat and the fat surrounding the gizzard and the lower intestine (Abdulameer Al Saffar, 2004).
- Percentage of cut. Percentage by weight of the individual part of the carcass (Hahn and Spindler, 2002):
  - a. Breast yield (%)
  - b. Thigh yield (%)
  - c. Drumstick yield (%)

Survival organs:

  - d. Wing yield (%)
- Organ yields in percentage
  - a. Internal organ (%)
  - b. Empty gizzard yield (%)
  - c. Heart yield (%)
  - d. Lung yield (%)
  - e. Kidney yield (%)
  - f. Liver yield (%)

All percentages were arcsine transformed to use as absolute values using the formula:

$$\text{Absolute} = \sin^{-1} \sqrt{\%}$$

Genstat (1996).

Statistic and genetic analyses

Analyses of variance of growth traits: A mixed model was set up to test effects of sire genotype, dam genotype and sex using the general linear models procedure of the Statistical Analysis System program (SAS, 1999). Sires and dams which were all represented in all the seasons were considered random effects with dams nested within sires, while sex was taken as fixed effects. The same program was used to correct for effects of batch, sex and season by covariant relationship. The following model was used for weekly analysis of all growth traits.

Model:

$$Y_{ijkl} = \mu + S_i + D_j + X_k + SD_{ij} + SX_{ik} + DX_{jk} + g_{ijkl}$$

Where,

- Y_{ijkl} = Observed value of dependent variable
- μ = Overall mean
- S_i = Effect due to i^{th} sire (i = Anak titan, Giriraja, Local, Alpha)
- D_j = Effect due to j^{th} dam (j = Anak titan, Giriraja, Local, Alpha)
- X_k = Effect due to kth sex (k = male, female)
- SD_{ij} = Effect of the interaction of sire and dam genotype
- Sx_{ik} = Effect of interaction of sire genotype and sex
- Dx_{jk} = Effect of interaction of dam genotype and sex
- g_{ijkl} = Random residual error normally distributed with zero mean variance $*^2_e$.

Diallel analysis: In order to estimate general and specific combining abilities and specific combining ability, a diallel analysis was set up after adjusting for effects of batch and sex according to the method of Hayman (1954) using Genstat (1996) and Dial98 package (Ukai, 2002).

A diallel table was set up as follows:

$$\begin{array}{llll}
x_{11} & x_{12} & x_{13} & x_{14}\ldots\ldots \\
x_{21} & x_{22} & x_{23} & x_{24}\ldots\ldots \\
x_{31} & x_{32} & x_{33} & x_{34}\ldots\ldots \\
x_{41} & x_{42} & x_{43} & x_{44}\ldots\ldots \\
\cdot & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & \cdot
\end{array}$$

$$x_{i.} = x_{i1} + x_{i2} + x_{i3} + x_{i4}\ldots.$$

$$x_{.j} = x_{1j} + x_{2j} + x_{3j} + x_{4j}\ldots.$$

$$x.. = x_{1.} + x_{2.} + x_{3.} + x_{4.} + \ldots. + x_{.1} + x_{.2} + x_{.3} + x_{.4} + \ldots.$$

$$= \sum\sum_{ij} x_{ij} = x_{11} + x_{12} + x_{13} + \ldots. + x_{44}\ldots.$$

The following model was used:

$$Y_{rs} = \mu + j_r + j_s + j_{rs} + k_r - k_s + k_{rs}$$

Where,

- μ = Grand mean
- j_r = Mean deviation from the grand mean due to r^{th} parent
- j_s = Mean deviation from the grand mean due to s^{th} parent
- j_{rs} = Remaining discrepancies in the rs^{th} reciprocal sum
- k_r = Differences between the effect of the r^{th} parental line used as male parent and as female parent
- k_s = Differences between the effect of the s^{th} parental line used as male parent and as female parent
- k_{rs} = Remaining discrepancies in the rs^{th} reciprocal difference

An extension of the model by fitting constants for dominance difference between parental mean and progeny mean and for deviation from this due to specific parents can be made.

The constant j_{rs} can be subdivided into three constants:

- l = Mean dominance deviation (b1)
- l_r = Further dominance deviation due to r^{th} parent (b2)
- l_{rs} = Remaining discrepancy in the rs^{th} reciprocal sum (b3)

The extended statistical model was of the following form:

$$Y_{rs} = \mu + j_r + j_s + l + l_r + l_s + k_r - k_s + k_{rs}$$

Test of significance for overall differences among various classes of effects was done with error mean square (M_e').

The various effects were estimated as follows:

$$\mu = 1/p^2\ X..$$

Where

- μ = Population mean
- P = Number of lines for crossing
- X = Grand total

General combining ability effects of crosses was calculated as:

$$g_i = 1/2p\ (X_{i.} + X_{.i}) - 1/p^2\ X..$$

Specific combining ability effects of crosses was calculated as:

$$s_{ij} = ½\ (X_{ij} + X_{ji}) - 1/2p\ (X_{i.} + X_{.i} + X_{j.} + X_{.j}) + 1/2pX..$$

RESULTS AND DISCUSSION

None of the birds accumulated abdominal fat throughout the study period.

Sire, dam and sex effects on carcass traits: Sire and dam genotypes had significant effect on carcass

Table 1: Means of carcass traits as affected by sire, dam and sex

Effects	N	Live weight (g)	Bled weight (%)	Pluck weight (%)	Eviscerated weight (%)	Breast weight (%)	Wing weight (%)	Drumstick weight (%)
Sire								
Anak	115	1130.96±110.05[a]	1.29±0.02	1.1±0.02[b]	0.85±0.02[a]	0.23±0.01[a]	0.14±0.006	0.15±0.01[a]
Giriraja	131	925.22±38.36[b]	1.31±0.01	1.08±0.03[b]	0.78±0.01[b]	0.21±0.01[ab]	0.14±0.004	0.15±0.01[ab]
Alpha	115	939.65±41.96[b]	1.31±0.007	1.1±0.008[b]	0.83±0.02[ab]	0.2±0.01[ab]	0.12±0.003	0.13±0.003[b]
Normal	112	678.67±25.55[c]	1.32±0.01	1.15±0.02[a]	0.82±0.03[ab]	0.2±0.01[b]	0.14±0.01	0.14±0.01[ab]
Dam								
Anak	106	1069.25±90.93[a]	1.31±0.01	1.1±0.02[ab]	0.80±0.02	0.2±0.01	0.13±0.01[ab]	0.15±0.01
Giriraja	114	1112.75±100.82[a]	1.33±0.02	1.1±0.05[b]	0.84±0.02	0.21±0.01	0.12±0.003[b]	0.13±0.01
Alpha	120	924.92±48.53[b]	1.3±0.02	1.1±0.01[ab]	0.79±0.01	0.2±0.01	0.13±0.004[ab]	0.14±0.01
Normal	133	769.04±29.48[c]	1.3±0.01	1.12±0.01[a]	0.81±0.02	0.23±0.01	0.14±0.01[a]	0.14±0.01
Sex								
Male	294	979.55±56.62[a]	1.3±0.01	1.1±0.01	0.82±0.01	0.21±0.01	0.14±0.003	0.15±0.004[a]
Female	299	879.6±34.18[b]	1.31±0.01	1.1±0.02	0.81±0.02	0.21±0.01	0.13±0.01	0.14±0.004[b]

Means in the same columns with different superscripts are significantly different ($p<0.05$)

Table 2: Means of carcass traits as affected by sire, dam and sex

Effects	N	Thigh weight (%)	Empty gizzard weight (%)	Liver weight (%)	Lung weight (%)	Internal organ weight (%)	Heart weight (%)
Sire							
Anak	115	0.15±0.01	0.04±0.003[b]	0.03±0.002	0.01±0.001	0.09±0.01[c]	0.01±0.001
Giriraja	131	0.14±0.01	0.05±0.002[a]	0.03±0.001	0.01±0.001	0.1±0.004[bc]	0.01±0.0003
Alpha	115	0.14±0.004	0.05±0.002[a]	0.03±0.001	0.01±0.0003	0.13±0.01[a]	0.01±0.0003
Normal	112	0.14±0.01	0.05±0.003[a]	0.03±0.004	0.01±0.002	0.11±0.01[b]	0.01±0.0005
Dam							
Anak	106	0.14±0.01	0.04±0.003[b]	0.03±0.001	0.01±0.001	0.08±0.01[b]	0.01±0.0004
Giriraja	114	0.13±0.004	0.04±0.002[b]	0.03±0.001	0.01±0.001	0.09±0.01[b]	0.01±0.0004
Alpha	120	0.15±0.01	0.05±0.003[a]	0.03±0.002	0.01±0.001	0.12±0.01[a]	0.01±0.0004
Normal	133	0.15±0.01	0.05±0.002[a]	0.03±0.002	0.01±0.001	0.11±0.01[a]	0.01±0.0004
Sex							
Male	294	0.14±0.004	0.04±0.002	0.03±0.002	0.01±0.0004	0.1±0.01	0.01±0.0003
Female	299	0.14±0.01	0.05±0.002	0.03±0.001	0.01±0.001	0.11±0.01	0.01±0.0003

Means in the same columns with different superscripts are significantly different ($p<0.05$)

parameters (Tables 1 and 2). This is in accordance with Karima and Fathy (2005) and Musa *et al*. (2006) who reported significant breed differences in live body weight and other carcass parameters. The exotic generally performed better on most economically important parameters while the Normal indigenous performed better in most maintenance organs, such as liver weight, empty gizzard weight, lung weight, internal organ weight and wing weight. This may be a reflection of long term natural selection of the indigenous chicken for fitness and adaptability genes, while the exotics are artificially selected for production genes.

Sex was only significant ($p<0.05$) on live weight and drumstick weight. This result differs from most reported results on sex effects on carcass traits (Musa *et al*., 2006), Bartov and Plavnik, (1998), Marks (1990) and Smith and Pesti, (1998), most likely as a result of the close genetic relationship among all the breeds. The effect of sex (Table 1 and 2) on means of carcass traits show that Cocks had the higher values for live weight, eviscerated weight, leg weight, head weight, liver weight, neck weight, lung weight, wing weight, drumstick weight, thigh weight and heart weight. This is in agreement with the findings of Musa *et al*. (2006) who found Males compared to females showed higher live weight, carcass weight, semi-eviscerated weight, eviscerated weight, breast muscle weight, liver weight and abdominal fat weight in the broiler breeds they used. The superior average male performance among the more economically important traits is as a result of sexual dimorphism caused by the faster growth and muscle laying activity of the male hormone.

GCA on carcass traits: Results of analysis carcass measurements (Table 3 and 4) show that both additive variance and dominance variance were significant ($p<0.05$) in determining carcass traits. GCA and SCA results (Tables 5 and 6) show that GCA values were generally higher than SCA values for the more economically important traits such as bled weight, pluck weight, eviscerated weight, drumstick weight, thigh weight and breast weight, while the reverse is the case for less economical traits like lung weight, wing weight, heart weight, internal organ weight, empty gizzard weight and liver weight. This means that additive gene effect is more important in the control of the economically important traits, therefore improvement will be by selection. This result might be as a result of long term selection pressure for the economically important traits, which has increased their heritability with time. The

Table 3: Hayman (1954) ANOVA for carcass parameters

	DF	Live weight	Bled weight	Pluck weight	Eviscerated weight	Breast weight	Wing weight	Drumstick weight
Rep	2	24940.0^{ns}	25660.0^{ns}	54619.0^{ns}	897.0000^{ns}	558.2813^{ns}	131.3438^{ns}	125.7031^{ns}
A	3	1014914.0**	951312.0**	430280.0**	392729.0000**	26098.3800**	7465.4690**	12274.3800**
B	6	180602.4**	170342.4**	91869.84*	86269.5200**	4858.3730**	933.1235**	1552.0190**
B1	1	7360.0690^{ns}	12580.73^{ns}	99946.63	3521.5310^{ns}	1529.0280^{ns}	39.5322^{ns}	96.2871^{ns}
B2	3	164310.3**	159353.9**	124327.9*	43382.2500^{ns}	2588.4050*	875.0959**	2096.7210**
B3	2	291661.8**	265705.9**	39144.35^{ns}	191974.4000**	9927.9980**	1466.9600**	1462.8320*
C	3	508740.2**	483237.3**	103442.8*	358607.6**	21066.3400**	3062.5890**	5205.5240**
D	3	745500.2**	700850.7**	140076.0**	445500.2**	19728.6200**	4202.1780**	5535.7010**
Error	30	16391.64	16296.53	29435.5400	16975.09	705.8089	170.4865	292.8496
Total	47							

Rep = Replication, A = Variation between the mean effects of each parental lines, B = Variation in the reciprocal sums not ascribable to (A), B1 = Mean dominance deviation, B2 = Further dominance deviation due to the rth parent, B3 = Remaining discrepancy in the rsth reciprocal sum, C = Average maternal effects of each parental line, D = Variation in the reciprocal differences not ascribable to (C), *p<0.05, **p<0.01, ***p<0.001, ^{ns}not significant

Table 4: Hayman (1954) ANOVA for carcass parameters

	DF	Thigh weight	Weight empty gizzard	Internal organ	Liver weight	Heart weight	Lung weight
Rep	2	265.0313^{ns}	19.8008^{ns}	14.0234^{ns}	27.0322^{ns}	1.1191^{ns}	0.7008^{ns}
A	3	11040.3800**	154.0449**	1243.8590**	259.3301**	19.1174**	46.9834**
B	6	1924.0230**	36.7870*	862.0557**	67.6254**	3.1866*	6.7044**
B1	1	33.6903^{ns}	1.4290^{ns}	142.5765^{ns}	44.9614^{ns}	0.1623^{ns}	1.1278^{ns}
B2	3	2157.2860**	29.1960^{ns}	1097.1530**	101.0929**	3.9512*	6.8667*
B3	2	2519.2960**	65.8524*	869.1494*	28.7563^{ns}	3.5519*	9.2492**
C	3	5212.9330**	71.5964**	2874.7260**	168.5862**	9.6061**	19.3654**
D	3	6325.1480**	52.9664*	1404.3740**	164.4694**	6.7323**	20.8568**
Error	30	229.4048	15.1383	179.4814	11.7684	0.9618	1.5520
Total	47						

Rep = Replication, A = Variation between the mean effects of each parental lines, B = Variation in the reciprocal sums not ascribable to (A), B1 = Mean dominance deviation, B2 = Further dominance deviation due to the rth parent, B3 = Remaining discrepancy in the rsth reciprocal sum, C = Average maternal effects of each parental line, D = Variation in the reciprocal differences not ascribable to (C), *p<0.05, **p<0.01, ***p<0.001, ^{ns}not significant

Table 5: General combining ability and specific combining ability for carcass traits

Parameters	Live weight	Bled weight	Pluck weight	Eviscerated weight	Breast weight	Wing weight	Drumstick weight
G-Anak	661.53±29.91	642.62±29.49	453.84±24.73	453.86±27.00	99.88±8.82	58.96±3.46	76.68±5.27
G-Giriraja	-281.81±10.17	-280.78±10.30	-99.38±18.84	-191.04±6.28	-43.20±2.04	-22.50±0.89	-27.83±0.81
G-normal	335.81±36.20	325.52±37.60	143.24±44.62	222.78±27.94	60.85±5.89	25.08±3.99	30.17±5.27
G-alpha	-715.53±14.38	-687.36±16.14	-497.70±24.39	-485.60±10.59	-117.54±2.24	-61.54±1.38	-79.02±1.52
S-ag	-520.95±42.55	-527.07±40.95	-359.63±32.37	-372.91±49.08	-57.24±8.37	-27.34±3.86	-26.68±5.90
S-an	668.37±26.43	622.79±27.89	-107.30±114.88	448.07±16.89	130.04±8.44	56.91±3.79	61.54±5.45
S-ab	-561.96±24.22	-548.85±19.34	-326.97±30.75	-359.86±3.39	-63.74±5.35	-36.36±3.29	-54.64±3.12
S-gn	185.51±67.31	186.06±66.47	350.65±71.33	125.85±49.61	32.51±9.07	14.83±2.91	32.04±5.93
S-gb	345.19±35.03	326.86±32.99	162.66±50.97	342.36±28.44	81.78±10.56	21.37±2.77	18.93±3.22
S-nb	-244.84±37.39	-228.03±37.94	-193.67±31.22	-224.52±29.64	-64.71±7.07	-19.99±2.08	-16.47±2.09

G = General combining ability, S = Specific combining ability, a = Anak, g = Giriraja, b = Alpha improved indigenous, n = Normal indigenous

results of GCA (Tables 5 and 6) show that Anak Titan had the highest GCA resulting from high selection pressure, which reduced variation. On the other hand Giriraja and Alpha (improved indigenous) show generally negative GCA, which indicate the inferior performance of these breeds in their hybrid combination for body weight. Normal indigenous shows low but positive GCA, indicating good hybrid abilities and higher gene variations for carcass traits, indicative of room for improvement. Anak Titan and Normal indigenous will be good for an improvement program for economically important carcass traits.

SCA on carcass traits: The effect of SCA on carcass traits, which involves dominance, over dominance and epistasis, was not as significant as GCA (Tables 5 and 6). This is in agreement with the results obtained by Singh *et al*. (1983) who pointed out that in traits with high heritability, specific combining ability effects upon individual performance were relatively higher than its influence on family performance. This non-additive hereditary interaction may be an important source of variance among individuals without major influence upon family performance. Tables 5 and 6 show that non-additive gene effects were more important for the less

Table 6: General combining ability and specific combining ability for carcass traits

Parameters	Thigh weight	Internal organ weight	Empty gizzard	Heart weight	Liver weight	Lung weight
G-Anak	71.23±3.71	1.40±0.71	1.28±0.49	3.11±0.15	10.65±0.25	4.34±0.22
G-Giriraja	-20.55±0.69	23.72±2.41	2.82±0.80	-0.83±0.01	-2.56±0.44	-3.31±0.07
G-normal	27.77±4.77	3.38±1.69	6.76±1.20	0.93±0.17	4.30±0.54	2.84±0.30
G-alpha	-78.44±2.03	-28.51±1.76	-10.86±0.57	-3.21±0.18	-12.38±0.48	-3.87±0.14
S-ag	-42.43±3.38	-57.94±2.79	0.16±0.87	-0.84±0.38	-6.16±0.92	-3.13±0.50
S-an	69.99±4.49	35.14±3.38	6.39±1.17	2.90±0.10	1.16±0.61	3.61±0.42
S-ab	-56.94±4.78	14.68±4.44	-6.18±1.27	-2.70±0.38	-8.14±0.33	-3.14±0.53
S-gn	31.39±4.19	2.64±5.77	-0.20±0.60	1.10±0.14	12.85±1.58	1.91±0.40
S-gb	30.50±6.13	-7.98±5.19	10.39±0.20	1.07±0.18	-2.42±1.26	1.44±0.40
S-nb	-23.82±3.47	-5.45±3.65	-8.76±0.92	-0.93±0.50	-7.35±1.16	-2.29±0.46

G = General combining ability, S = Specific combining ability, a = Anak, g = Giriraja, b = Alpha improved indigenous, n = Normal indigenous

economically important traits or supply organs. Meaning individual specifics control these traits, this will most likely be as a result of non specific selection pressure for these organs. Observations on SCA results also show that A-N followed by G-B crosses had the best individual crossbred performance and therefore would be good crosses for improvement in carcass traits.

Conclusion and Recommendations: Combining abilities show that the chicken breeds all have different breed advantages for the traits observed in this study. It is therefore recommended that an improvement program that involves exploiting the trait advantages of the breeds should be used. Development of a Nigerian broiler line should therefore involve Anak Titan as a sire line due to good general combining ability for carcass traits, while individual performance of the Normal, Giriraja and Alpha-improved indigenous should be utilized in selecting a dam line. This will aid in development of lines that are each selected for a set of traits. The production animals will be hybrids in which all the desired traits are combined with a full exploitation of heterosis. The reciprocal recurrent selection or modifications of it will exploit the entire genetic variance, both additive (general combining ability) and non-additive (specific combining ability) due to heterosis, dominance, over-dominance and epistasis.

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