# Heterosis and combining ability for body weight and feed conversion in four genetic groups of native chicken

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**ABSTRACT:** Combining ability analysis for body weight and feed conversion in four genetic groups of native chicken were carried out in full diallel cross. Heterosis effects were observed for body weight from 0-16 weeks of age. The highest heterosis was in the BxC cross followed by that in crosses CxB, CxA, and AxB. Two out of 12 crosses exhibited heterosis for body weight at 16 weeks of age. The lowest heterosis was exhibit in the cross AC. In the period of age 8-12 weeks, three out of 12 crosses (BxC, CxB, and DxC) showed negative heterosis for feed conversion but in the period of age 12-16 weeks, there were no crosses showed a positive heterosis. The variances due to general and specific combining abilities have significant effect on 8 and 16 week body weight. Variance due to general combining ability was significant for body weight at 8 and 16 weeks of age indicated that body weight at the said ages are influenced by additive genetic variance. At 8 weeks of age, CxD cross was significantly lower than AxD, BxC, BxD crosses. While on 16 week body weight, BC cross was significantly different from the AxD and CxD crosses. No significant effect of general combining ability for feed conversion was observed but the specific combining ability effect was significant in the period of age 8-12 and 12-16 weeks.

**Key words:** combining ability, body weight, feed conversion, native chicken

## INTRODUCTION

Native chickens play an important role household food supply in rural area and recently have been raised in semi-intensive systems with more efficient output per bird. In many developing countries, the local gene pool still provides the basis for the poultry sector. The genetic resource base of the indigenous chickens could form the basis for genetic improvement and diversification to produce breeds adapted to local conditions. However, breeding programs for local chicken will be difficult to set-up because of the competition with commercial breeding companies which have access to technology advantages and economics of scale (Hoffmann, 2005).

Crossbreeding is one of the tools for exploiting genetic variation. The main purpose of crossing in chicken is to produce superior crosses (i.e. make use of hybrid vigor), to improve fitness and fertility traits and to combine different characteristics in which the crossed breeds were valuable (Willham and Pollak, 1985; Hanafi and Iraqi, 2001). The basic principle behind crossbreeding is the phenomenon of heterosis. Heterosis is manifested when the progeny produced by mating two populations of diverse genotype show better performance than either of the parents.

The common genetic design used for estimating component of genetic variance in an inbreeding population is the diallel cross, which is the set of all possible mating among a given number of genotype (Carpena *et al*., 1993). Crossing each line to several others provide an additional measure in the mean performance each line in all its crosses. This mean performance of a line, when expressed as a deviation from the mean of all crosses, is called general combining ability (GCA) and when the cross might deviate from this expected to a greater or lesser extent, that so called specific combining ability (SCA) of two lines in combination. While there are few works on the effect of crossing native with commercial broiler stocks, no information is available on estimate the heterosis and combining ability on body weight and feed conversion through diallel crossing of the various genetic groups of native chickens, hence, this study.

## MATERIALS AND METHODS

Four genetic groups of Philippine native chickens, vis A-Paraokan, B-Banaba, C-Camarines, and D-Bolinao were mated in a full diallel fashion including the reciprocals. A total of 362 experimental chicks were available for this research.

Data obtained were analyzed using Completely Randomized Design and estimates of combining ability variance were analyzed using diallel analysis according to Griffing Method 1. The GCA and SCA were tested for its significant by the "t" test. The SAS GLM and diallel analysis of Burrow and Coors (1993) were using to analyze progenies data, GCA, and SCA. Mean data were used to estimate heterosis over mid parent and better parent according to Rai (1979).

## RESULTS AND DISCUSSION

### *Estimate of Heterosis for Body Weight*

A heterosis effect in crosses of several lines refers to a superiority of a particular cross over the average of two parents. Estimate percent heterosis for body weight and feed conversion in different stage of growth are presented in Table 1.

**Table 1.** Estimate percent heterosis for body weight and feed conversion in different stage of growth

| | Body Weight (weeks) | | | | | Feed Conversion (weeks) | | | |
|---|---|---|---|---|---|---|---|---|---|
| Crosses | 0 | 4 | 8 | 12 | 16 | 0-4 | 4-8 | 8-12 | 12-16 |
| A x B | 12.06 | 11.25 | 5.04 | 2.04 | 6.08 | -5.41 | -5.57 | 6.82 | -21.17 |
| A x C | 1.33 | 6.77 | 5.08 | -3.11 | -0.77 | 0.69 | -4.69 | 9.95 | -8.60 |
| A xD | 4.76 | 2.11 | -5.66 | -4.59 | -0.39 | 0 | -5.24 | 14.38 | -13.49 |
| B x C | 2.08 | 12.12 | 15.12 | 7.06 | 9.96 | 0.69 | -3.39 | -6.02 | -14.21 |
| B x D | 3.55 | 4.71 | 4.07 | 4.11 | 5.34 | 1.69 | -9.59 | 6.34 | -9.34 |
| C x D | -10.37 | -6.84 | -7.57 | -1.31 | 2.22 | 12.31 | -4.69 | 3.80 | -8.97 |
| B x A | 5.75 | 4.21 | 2.94 | 0.24 | 4.92 | 0.45 | -0.96 | 6.82 | -23.34 |
| C x A | 1.57 | 0.31 | 6.08 | 0.01 | 7.04 | 13.16 | -0.39 | 2.69 | -20.17 |
| D x A | -1.3 | -0.99 | 1.37 | -1.11 | 1.24 | -2.54 | -10.67 | 5.01 | -11.82 |
| C x B | 6.02 | 4.71 | 9.88 | 3.79 | 7.60 | 16.78 | -1.40 | -6.84 | -21.62 |
| D x B | 3.55 | -2.79 | -0.01 | -0.67 | 0.62 | 4.22 | -6.27 | 10.24 | -9.34 |
| D x C | -8.71 | -10.74 | -13.49 | -4.93 | 0.06 | 15.77 | 10.32 | -4.11 | -13.57 |

At one-day of age, the heterosis of body weight was evident in all crosses except CxD and DxC. The highest heterosis was observed in AxB cross (12,96%) while the lowest was noted in CxD cross (-10.37%).

At 4 weeks of age, no positive heterosis was noted in crosses CxD, DxA, DxB, and DxC. The maximum heterosis was found in BxC cross (12.12%). The evidence of heterosis at 8 weeks of age was observed in all crosses except in AxD, DxB, and DxC crosses. At this age, heterosis ranged from -13.49% (DxC) to 15.12% (BxC). The results suggest that in Philippine native chicken the expression of heterosis is variable and depends on the particular cross.

At 12 weeks of age, six crosses showed the heterosis effects and generally the percentage of heterosis decrease at this age. At 16 weeks of age, 12 crosses exhibited heterosis where the BxC cross was the highest (9.96%) and the AxC cross was the lowest (-0,77).

Theoretically, the magnitude of heterosis is universally related to the degree of genetic resemblance between the parental populations (Willham and Pollak, 1985), and is proportional to the degree of heterozygosity of the crosses. There was no trend of heterosis found in the current study, and this finding is in agreement with Verma and Chaudhary (1980) that heterosis of body weight is found vary over time.

### *Estimate of Heterosis for Feed Conversion*

Estimate of heterosis for feed conversion in a diallel cross showed that heterosis effect is not expressed in all ages but in particular ages. Kanavikar *et al*. (1978) and Jain et al. (1981) stated that heterosis for some traits are affected by age during early growth.

Usually, crosses show a performance equal or better than their parental pure lines but this study found that the heterosis effect in period of age 12-16 weeks is negative, which implies that there is pressure of some other factor that is unknown and which therefore can not be eliminated by experimental design (intangible variation). Falconer (1993) stated that the intangible variations that may be caused by the external environment are those connected with metabolic process.

### *Estimate of Combining Ability Variance for Body Weight*

Analyses of variance and the variance component for combining ability (GCA and SCA) are presented in Table 2.

**Table 2.** Analysis of variance and variance components for periodic body weight of four genetic groups of native chickens

| Source of Variation | Periodic Body Weight | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0-week | | 4-week | | 8-week | | 12-week | | 16-week | |
| | df | MS | df | MS | df | MS | df | MS | df | MS |
| GCA | 3 | 2.43 | 3 | 2383.49 | 3 | 9645.17* | 3 | 10897.86 | 3 | 23273.56* |
| SCA | 6 | 11.41 | 6 | 631.07 | 6 | 3844.31* | 6 | 3982.04 | 6 | 11276.69** |
| Reciprocal | 6 | 3.10 | 6 | 311.74 | 6 | 1565.11 | 6 | 2418.92 | 6 | 6076.74* |
| Remainder | 45 | 6.07 | 45 | 346.39 | 45 | 1666.91 | 45 | 2198.36 | 45 | 2749.05 |
| | Variance Components[1] | | | | | | | | | |
| $\sigma_g^2$ | | -0.27 (00) | | 55.45 (12.56% | | 186.51 (8.57%) | | 220.41 (8.10%) | | 395.40 (8.15%) |
| | | 0.82 (13.12%) | | 43.80 (9.93%) | | 334. 98 (15.40%) | | 274.41 (10.09%) | | 1311.94(26.93%) |
| $\sigma_r^2$ | | -0.37 (00) | | -4.33 (00) | | -12.73 (00) | | 27.57 (1.01%) | | 415.96 (8.54%) |
| | | 1.30 (96.96%) | | 346.39 (78.49%) | | 1666.91 (76.61%) | | 2198.36 (80.89%) | | 2749.05 (56.42%) |

*P<0.05 **P<0.01

[1] Figures in parentheses indicate the percent contribution to total variance

Results showed significant GCA variance for body weight at 8 and 16 weeks of age. Since the GCA was used to designate the average performance of a line in hybrid combination (Falconer, 1983), therefore these results showed the importance of GCA with respect to body weight at 8 and 16 weeks of age.

Similarly, significant (P<0.05) SCA variance was noted at 8 week of age and was found to be highly significant (P<0.01) for 16 weeks of age. This indicated that specific mating combination had significantly different than the other.

Reciprocal effect for body weight was only noted at 16 week of age. It tends to show the importance of female role in crosses to determine the body weight of native chickens at 16 weeks of age. For other particular ages, reciprocal effects found to be insignificant. Kanavikar *et al*. (1978) reported non significant reciprocal effects for body weight at 8 weeks of age conform to the result obtained in this study.

The variance accounted for by GCA in day old chick weight was almost zero while in 4, 8,12, and 16 weeks of age were only 12.56, 8.57, 8.10, and 8.15%, respectively. These results indicated that the body weight traits are influence to a lesser degree by additive genetic variance. The variance accounted by SCA for body weight at 0, 4, 8, 12, and 16 weeks old were relatively higher in magnitude than that of the GCA, indicating that these body weight traits governed to a certain extent by non additive gene action.

The significant reciprocal effect accounted for 8.54% at 16 weeks of age indicated the presence of maternal effect and/or sex linkage for this trait. Jain and Chaudhary (1984) estimated a reciprocal variance of 3.97% on 5-month body weight, which in agreement with the result of this study.

From these results, it is evident for body weight 8 and 16 weeks of age, both GCA and SCA were important. Thus a breeding program which can harness the available additive as well as non additive genetic variances will be most appropriate for the population in question. For this purpose, reciprocal recurrent selection will be desirable. However, selection of different genetic groups following the subsequent crossing can also result in significant progress.

***GCA Effect.*** Slight differences on the individual GCA effect on four selected genetic groups of Philippine native chickens were noted. The GCA effect on day old body weight ranged from -0.14 (Bolinao group) to 0.18 (Camarines group). However, statistical analysis showed no significant differences (P>0.05) among the GCA constants. Similarly, at 4 and 12 weeks of age. It could also be noted that in those ages, Bolinao group (D-group) consistently showed negative values. These negative values tend to show that the additive genetic effect was less in D-group compared to other genetic groups considered. Jain and Chaudhary (1984) likewise found negative values for GCA of native chicken from Bangladesh (Desi) in all periods of growth.

At 8 and 16 weeks of age, the GCA effects on body weight were found to be significant (P<0.05). The Paraoakan (A-group) and Banaba (B-group) showed significantly higher GCA constants than Bolinao (D-group) at 8 weeks of age, while at 16 weeks of age, the B-group and D-group were significantly different. Result in this study collaborates with the findings of Mukherjee (1990) who likewise found significant GCA constants for body weight at certain ages. Hill and Nordskog (1958) and Goto and Nordskog (1959) reported variation in GCA effects among light-type male lines and heavy-type female lines. Since reciprocal crosses were not included, the general reciprocal effects were expected to be compounded with the GCA variances.

***SCA Effect.*** Estimate of SCA constants for body weight showed varying magnitude of differences in the estimate at all ages considered. No significance differences were found among genetic groups within 0, 4, and 12 weeks of ages. This finding indicated that the amounts of non additive genetic variance influencing the expression of these traits are more or less similar.

The non additive genetic variance accounted for a greater portion of the total variance than did additive genetic variation for 0, 8, 12 and 16 weeks of ages. The BxC cross consistently showed the highest SCA effect at 4, 8, 12, and 16 weeks of age. This result tend to suggest that the cross between Banaba male x Camarines female has promising results in improving body weight through genetic group crossing. On the contrary, the CxD cross showed zero estimates at all ages considered, indicating very limited potential for improving growth rate using this specific mating scheme.

### *Estimates of Combining Abilities Variance for Feed Conversion*

Analyses of variance and the variance component for periodic feed conversion of four genetic groups of native chickens are presented in Table 3.

**Table 3.** Analysis of variance and variance components for periodic feed conversion of four genetic groups of native chickens

| Source of Variation | Age Period (weeks) 0-4 df | MS | 4-8 df | MS | 8-12 df | MS | 12-16 df | MS |
|---|---|---|---|---|---|---|---|---|
| GCA | 3 | 0.23 | 3 | 0.12 | 3 | 0.09 | 3 | 0.11 |
| SCA | 6 | 0.07 | 6 | 0.06 | 6 | 0.14** | 6 | 2.05** |
| Reciprocal | 6 | 0.06 | 6 | 0.05 | 6 | 0.05* | 6 | 0.28 |
| Remainder | 30 | 0.07 | 30 | 0.05 | 30 | 0.02 | 30 | 0.12 |
| Variance Components[1] | | | | | | | | |
| $\sigma_g^2$ | 0.01 (8.22%) | | 0.003 (5.33%) | | -0.00 (00) | | -0.07 (00) | |
| | 0.001 (1.37%) | | 1.78 (0.0003) | | 0.02 (47.92%) | | 0.39 (84.26%) | |
| $\sigma_r^2$ | -0.00 (00) | | 0.0003 (0.53%) | | 0.01 (10.42%) | | 0.03 (5.74%) | |
| | 0.07 (93.15%) | | 0.05 (92.36%) | | 0.02 (47.75%) | | 0.12 (25.95%) | |

*P<0.05 **P<0.01

[1] Figures in parentheses indicate the percent contribution to total variance

The variance accounted for by GCA in the first two periods were only 8.22% and 5.33%, while the variances accounted for by GCA in the last two periods were zero estimated.

The variances accounted for by SCA in the last two periods were relatively higher in magnitude than those of GCA, indicating that these feed conversion are expected to be influenced by non additive gene action.

Reciprocal effects were significant in the period of age 8-12 weeks. Here, the reciprocal effect accounted for 10.42% of the total variance. Fairfull (1990) reported mean reciprocal differences of feed conversion as a percentage of mid-parent in meat type crosses, at 2% with interval 1 to 4%, while Jain and Chaudhary (1984) reported the reciprocal effects on feed conversion which ranged from 1 to 5%.

***GCA effect***. The individual effects of breeds were varied on feed conversion in period of age 0-4 weeks. The highest GCA effect was found in period D-group with 0.13 while the A-group showed zero estimates. However, the variation among genetic groups was too small to be considered significant. Similarly, in the remaining periods the GCA had no significant effect on feed convertion ratio. It appeared that the GCA effects in D-group tended to decline periodically as the bird got older. The B-group showed consistently zero estimates in the all periods while its effect on C-group was only in the first period of study. These results indicated that the additive genetic effects on feed conversion in Philippine native chickens are too small and the variability among them can be due to non additive genetic variance.

***SCA effect***. The SCA effect on feed conversion of native chickens showed differences among periods of age. In the first period of study (0-4 weeks) the SCA effect was highest in CxD cross (0.15) while AxB and AxD crosses showed zero estimates. However, the SCA effects among the crosses were too small to be considered significant. A similar trend was noted in the subsequent period (4-8 weeks). This finding implies that crosses have no effect on feed conversion in the said period of ages.
The SCA constants showed highly significant ($P<0.01$) effects in the age period 8-12 weeks. This effect was found between the BxD and BxC crosses. A similar trend was noted in the subsequent period (12-16 weeks). The BxD cross was significantly higher than AxB cross in the last period of study. The variances accounted for by the SCA for feed conversion in the period of age 8-12 and 12-16 weeks as percent contribution to the total variances were 47.92% and 84.26%, respectively. These results indicate that feed conversion is greatly influenced by non additive genetic variance.
Since SCA effects refer to the average inferiority or superiority of a cross relative to the average performance of the lines involved in that cross, than the BxD cross was superior over the other crosses in this study for feed conversion.

## CONCLUSIONS

Heterosis effects were exhibit in body weight and feed conversion of Philippine native chickens. Crosses between Banaba (B-group) and Camarines (C-group) showed significantly improve body weight of Philippine native chicken (highest percent of heterosis). In contrast, the progeny of mating with Bolinao (D-group) showed significant lower body weight improvement indicating that these mating combinations should be avoided in diallel crossing.

Variances accounted by GCA were significant for body weight at 8 and 16 weeks of age. The SCA was significant for 8 weeks body weight and highly significant at 16 weeks body weight and feed conversion 8-12 weeks and 12-16 weeks age periods. Reciprocal effects were observed for 16 weeks body weight and feed conversion in 12-16 weeks age period.

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