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Effects of Heterosis and Direction of Crossing on Production Performance of F_1 Offspring of Dominant Black Strain and Fulani Ecotype Chickens.

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ABSTRACT

The objectives of this study were to determine the mode of gene action of determinants of performance (i.e. positive or negative heterosis) in F_1 chickens produced by mating Fulani Ecotype (FE) and Dominant Black strain (DB) chickens, and whether the direction of crossing (DBxFE or FExDB) influenced the mode of gene action.
Analysis of all F_1 data irrespective of cross direction (combined) showed that the effect of percentage heterosis was positive but weak for Weight Gain (WG) = 0.04, Feed Intake (FI) = 3.83, Body Weight at First egg (BWF) = 0.76, Egg Weight (EW) = 11.28, and 0 for Egg Number (EN) and Mortality (M) during the laying period. The combined heterotic effects were negative for Hen Day Production (HDP), Feed efficiency (FEf), Age at Sexual Maturity (ASM), and mortality from day old to 21 weeks of age (-0.16, -4.33, -9.15 and -67.74% respectively). Positive but low heterosis was obtained for BWF (0.76), and EW (11.28) and WG, FEf, EN, ASM, HDP and M showed negative heterosis (-100.00 to -0.28) in the DBXFE cross bred. The mean performance of the FEXDB showed positive heterosis ranging from 1.08 to 100% in WG, FI, BWF, EW, EN, HDP and M during the laying period, while negative heterosis; -67.74, -4.54 and -8.22 was observed for M (0-21days), FEf and ASM. The reciprocal effects showed F_1 FEXDB were superior in ASM, BWF and EW, while F_1 DBxFE were superior in EN, HDP and M.

Key words: Exotic laying strain, Fulani Ecotype chicken, Heterosis, Reciprocal ` effects.

INTRODUCTION

Genetic improvement of livestock has made, and will continue to make major contributions to agricultural development, food security, sustainability and livelihood. In addition to making commercialization of poultry possible and has led to improved varieties of exotic breeds with good performance, high egg production rate and ability to convert low quality feed into high quality protein within a shorter period as in the case of broilers (Ayorinde, 1995). In the developing countries, crossbreeding is usually a progamme aimed at upgrading indigenous stocks using exotic breeds from the developed worlds (Branckaert *et al*., 2000). Crossbreeding improves the heterozygosity of non-additive genes leading to heterosis (Keambou *et al*., 2007); it can also increase the frequency of dominant alleles contributing to a quantitative trait by combining those that are unique to each of the hybridized parents, and additional mechanisms of hybrid vigour. Crossbreeding also constitutes an important tool for the exploitation of genetic variation and hybrid vigour via the combination of the different characteristics of each breed (Willham and Pollak, 1985; Hanafi and Iraqi, 2001) and for the exploitation of sex-linked effects associated to particular combinations between breeds or lines.

The poultry industry has a history of using breed crosses and more recently strain crosses, mainly to take advantage of heterosis. Heterosis is the deviation between the cross and mid-parent means (Falconer, 1989) and is well predicted when the traits are measured in the offspring. It is the average performance of progeny relative to their genetically distinct parent and has been used extensively in the poultry industry to measure performance and maximize production (Williams *et al.,* 2002). Developing countries have indigenous chickens with diverse uses and benefits, among which are household food supply and income generation especially among the peasant farmers (Sonaiya, 2002). The Nigerian indigenous chickens are thought to be suitable for the development of layer strains for the tropical environment since they posses some inherent advantages which include good fertility and hatchability, flavour, colour and texture of meat and egg that is preferred by local consumers, high degree of adaptability to prevailing conditions, high genetic variance in their performance, hardiness, disease tolerance, ease of rearing and ability to breed naturally (Omeje and Nwosu, 1983; Nwosu *et al*., 1985 ; Ikeobi *et al.,* 1996; Adebambo *et al*., 1999; Peters 2000; Adedeji *et al.,* 2008 and Adebambo *et al* ., 2009).

Crossbreeding of local stocks with exotic commercial stocks will take advantage of systematic scientific selection for productivity in the exotic birds and natural selection for hardiness in the indigenous birds. The Fulani Ecotype chicken is among the indigenous chickens found in Nigeria, is typical to the Fulani tribe and has been reported to be of better performance in most economic traits than other indigenous local chickens in Nigeria (Alaba, 1990; Atteh, 1990; Olori, 1992; Tiamiyu, 1999; Odetunde, 2007, Sola-Ojo and Ayorinde, 2009) when raised under identical condition and measured contemporaneously. The economic significance of laying hens justifies and encourages the study of inheritance of egg production and the relationship with variables associated with these traits as the knowledge acquired can inform the instruments for poultry improvement.

Exploring the potential of Fulani ecotype chicken through crossbreeding is very important as it can highlight effective methods for improving its productivity. The present study was designed to study the heterotic effects of crossing the exotic Dominant Black strain with the indigenous Fulani Ecotype chicken, and comparing the reciprocal crosses to determine differences in heterosis resulting from the direction of crossing. Knowledge of whether and to what extent heterosis occurs in the current crosses will assist the breeder in formulating breeding policies by suggesting modes of action of the quantitative traits under study, and the extent to which first crossing may be used to create animals that tend towards the performance of the superior parent for each trait of interest, or indeed exceeds the performance of the superior parent in cases of super-dominance or over-dominance in hybrids.

MATERIALS AND METHODS

Origin and Management of Parental Genotypes

Two hundred and fifty day old Dominant Black strain parent stock were obtained from S and D Farm located at Abeokuta, Ogun State in South West Nigeria and a total of 175 day old Fulani Ecotype chicks produced from an existing flock at the Teaching and Research farm, University of Ilorin were used for this study. The chicks were wing tagged, weighed and randomly distributed to separate brooding pens at day old. All the necessary vaccinations and medications were administered as recommended by MVM (1986). The birds were fed recommended diets from day old to point of lay (NRC, 1994). During this period, data collection included weekly body weight, feed intake and mortality rate from day old to point of lay. Feed efficiency was calculated as percentage of the amount of weight gain relative to feed intake over a period.

Fifty pullets (18 weeks old) from each strain were selected and kept in individual battery cages for evaluation of laying performance from point of lay to 100 days. The following traits were recorded: Age at Sexual Maturity (i.e. age at first egg), egg number to 100 days of production from first egg, body weight at first egg, egg weight and mortality rate. Hen day production (HDP) was estimated as the percentage of eggs produced to number of hens in each strain. Mean values of all the traits were calculated per strain and used as the parental mean in estimating heterosis.

Mating Design and Production of F_1 crosses.

At 36 weeks of age, 143 Dominant Black strain (15 males and 128 females) and 100 Fulani Ecotype (12 males and 88 females) chickens were randomly selected and allowed to mate naturally in separate pens at a mating ratio of 1 male to 8 females (27 males : 216 females). The mating groups were:

A. DBxDB (9 DB males and 72 DB females)
B. DBxFE (6 DB males and 48 FE females)
C. FExDB (7 FE males and 56 DB females)
D. FExFE (5 FE males and 40 FE females)

Eggs were collected from each group on daily basis, labelled according to the group and kept at room temperature over a 10 day period prior to incubation. The eggs were taken to a commercial hatchery-Nefraday Farm, Lasoju, Kwara State, Nigeria for incubation and hatching. On arrival, the eggs were allowed to rest, fumigated with 17g potassium permanganate and 100ml of 20% formalin before incubation. The eggs were candled for fertility on the 18th day of incubation. Three hours before candling, and before transfer of eggs from Setter to Hatcher, 1% formalin was sprayed in the hatchery room to disinfect the compartment. Following hatching, the chicks were weighed, wing banded, grouped according to genotype and distributed to brooding pens. The birds were fed recommended diets (NRC, 1994) from day old to the point of sexual maturity and given the necessary vaccinations and medications, data collected were feed intake, weight gain, feed efficiency and mortality. At 18 weeks of age, 50 pullets were moved to individual cages for evaluation of reproductive performance from point of lay to 100 days in lay. The experimental birds were of parental genotypes DBxDB, FExFE and their reciprocal crossbreds DBxFE and FExDB. Data collected during laying were: Age at sexual maturity, Body weight at first egg, Egg weight, Egg number, Hen day production and mortality. Heterosis among the crossbreds (DBxFE, FExDB) were estimated as the differences between the average parental means and means of crossbred offspring (Falconer, 1989):

$$H_{AB}(\%) = [(P_{F1} - (P_A+P_B)/2]\, x100] / (P_A+P_B)/2$$

Where:

H_{AB} (%) = Heterosis (in percentage of parental performances),

P_{F1} = Mean performances of F_1 reciprocal crossbreds,

P_A = Mean performance of parents A,

P_B = Mean performance of parents B.

% Heterosis DBxFE = DBxFE P(A+B) / P(A+B) X 100/1

% Heterosis FExDB = FExDB- P(A+B) / P(A+B) X 100/1

Reciprocal effects were calculated as the difference in performance between reciprocal F_1 types.

RE = P_{F1}(FExDB) P_{F1}(DBxFE).

Where:

RE = the reciprocal effect.

P_{F1}(FExDB) = the mean performance of the F_1 from FE rooster and DB hen

P_{F1}(DBxFE) = the mean performance of the F_1 from DB rooster and FE hen.

RESULTS AND DISCUSSION

The results indicated negative and low heterosis for some of the performance traits measured (Table 1). Combined percentage heterosis was 0.04, 3.83, -4.33 -67.74 for weight gain, feed intake, feed efficiency, and mortality from day old to 21 weeks of age respectively. Heterosis for weight gain was -0.28, feed intake 3.61, feed efficiency -4.10, while 67.74 was obtained for mortality in DBxFE crossbred group from 0 to 21 weeks of age. In the FExDB group 1.08 was the percentage heterosis obtained for weight gain, 4.04 for feed intake, -4.54 for feed efficiency and -67.74 for mortality from day old to 21 weeks of age. The reciprocal effects of crossing Fulani Ecotype Chicken rooster and Dominant Black strain hen was +18.30 for weight gain, +8.00 for feed intake, -0.32, for feed efficiency and 0.00 for mortality (Table 1).

Table 1.Heterosis and Reciprocal Effect for Production Traits (0-21 Wks) in Dominant Black and Fulani Ecotype Chicken Crossbred

Parameters	Parental Mean	Crosses Mean	DBXFE	FEXDB	Heterosis (%)	Heterosis (%) DBxFE	Heterosis (%) FEXDB (FEvs.DB)	RE
W G (g)	1350.57 ±0.21	1355.95 ±0.28	1346.80 ±0.20	1365.10 ±0.21	0.04	-0.28	1.08	+18.30
F I (g)	1896.36 ±0.90	1969.00 ±1.12	1965.00 ±1.00	1973.00 ±1.01	3.83	3.61	4.04	+ 8.00
F Ef (%)	71.43	68.34	68.50	68.18	-4.33	-4.10	-4.54	- 0.32
M(%0-21wks)	6.2	2.00	2.00	2.00	-67.74	-67.74	-67.74	0.00

WG= Weight gain, FI= Feed Intake, FEf = Feed efficiency, M = Mortality.
DBxFE = Dominant Black Male and Fulani Ecotype Female
FExDB = Fulani Ecotype chicken Male and Dominant Black Female
H (%) = Heterosis General
H (%) DBXFE = Heterosis from Dominant Black rooster and Fulani Ecotype hen crossing
H (%) FEXDB = Heterosis from Fulani Ecotype rooster and Dominant Black hen crossings.
RE = Reciprocal effect on the FEXDB and DBXFE performances.

Table 2 indicated that combined percentage heterosis was -9.15, 0.76, 11.28, -0.16 and 0 for ASM, BWF, EW, HDP, EN, and M during the laying phase, respectively. In the DBxFE, ASM, BWF, EW, EN, HDP and mortality had heterosis values of 0.04, 11.39, -1.92, -1.70, 10.08 and -100, respectively. For the FEXDB cross bred, heterosis values were -8.22, 1.48, 11.17, 1.92, 1.39, and 100 for ASM, BWF, EW, EN, HDP and mortality, respectively. Reciprocal effects of crossing FE and DB were +3 for ASM, +20 for BWF, -0.10 for EW,+ 2 for EN, +1.60 for HDP and +0.04 for mortality.

Table 2: Heterosis and Reciprocal Effect for Early egg production traits (100 days) in Dominant Black and the Fulani Ecotype Chicken Crossbred

Parameters	Parental Mean	Crosses Mean	DBXFE Mean	FEXDB Mean	Heterosis (%) ALL	Heterosis (%) DBxFE	Heterosis (%) FExDB	RE
ASM (days)	161.25 ± 6.53	146.50 ±2.75	145.00 ±1.02	148.00 ±0.98	-9.15	-10.08	-8.22	+ 3.00
BWF (g)	1387.41 ±1.31	1398.00 ±1.50	1388.00 ±1.02	1408.00 ±0.98	0.76	0.04	1.48	+20.00
EW (g)	46.19 ± 3.42	51.40 ±1.25	51.45 ±2.50	51.35 ±1.20	11.28	11.39	11.17	- 0.10
EN	52.00 ± 0.28	52.00 ±0.01	51.00 ±0.01	53.00 ±0.00	0	-1.92	1.92	+ 2.00
HDP (%)	51.75 ± 13.67	51.67 ±1.25	50.87 ±0.35	52.47 ±1.75	-0.16	-1.70	1.39	+1.60
M (%)	0.02	0.02	0	0.04	0	-100	100	+0.04

EW = Egg weights, ASM= Age at Sexual Maturity, BWF = Body weight at first egg, M = Mortality
HDP= Hen Day Production, EN = Egg numbers, RE= Reciprocal effects.
DBxFE = Dominant Black Male and Fulani Ecotype Female
FExDB = Fulani Ecotype chicken Male and Dominant Black Female
H (%) = Heterosis General
H(%) DBXFE = Heterosis from Dominant Black rooster and Fulani Ecotype hen crossing
H(%) FEXDB = Heterosis from Fulani Ecotype rooster and Dominant Black hen crossings.
RE = Reciprocal effect on the FEXDB and DBXFE performances.

The positive heterosis values reported for WG and FI in the combined and FExDB genotypes indicate an advantage of the F_1 over the mean parental performance. DBXFE gained less weight than FExDB and the parental mean during the growing phase (Table 1). The positive but low heterotic values observed as shown in Table 1 indicate the superiority of F_1 in relation to the parental means. This can probably be attributed to complementation of the purebred parent genotypes in their F_1 offspring. Negative heterosis values were obtained for feed efficiency and mortality in the combined and the cross-bred genotypes which showed the superiority of the parental mean to the crosses in both genotypes. Positive reciprocal effects were obtained for feed intake and weight gain, while the reciprocal effect of crossing FE rooster and DB hen was negative for feed efficiency. Mortality during the growing phase indicated a negative heterosis for the F_1 in the study. Reciprocal effect of zero indicated that heterosis of survival does not differ with cross direction. Negative heterosis for weight gain in DBxFE was advantageous in as much as they also reached sexual maturity earlier than the parental and FExDB means by 16.25 and 3 days respectively. This is quite significant as high body weight and feed intake are not desirable traits in laying birds.

Negative heterosis obtained for age at sexual maturity (Table 2) is an advantage for the cross-breds as they reached sexual maturity earlier than the mid- parent ASM. Hen day production and egg number had negative heterosis for DBXFE, which indicates that the parental average was better in both traits. FEXDB had positive though low heterosis for egg number and hen day production, indicating an advantage of the F_1 over the mean parental performance for each of these traits. Heterosis obtained for other parameters (BWF, EW) was low but positive. Heterosis for mortality, indicated that DBxFE is more adapted to the study environment than the reverse cross (DBxFE). The reciprocal effect (RE) between the FE and DB crosses in this study revealed that the FExDB crosses were more proficient than the DBxFE in age at sexual maturity, body weight at first egg and egg weight, and less proficient in egg number, hen day production and feed efficiency.

Positive heterosis reported for body weight at first egg in this study corresponds with the findings of Singh *et al.* (1992), Fairfull *et al*. (1987) and El Salamony *et al*. (2002), but contrasts with the findings of Hoste (1989). Positive heterosis for body weight is not desirable in layers because it will reduce feed conversion by increasing the maintenance requirement (Fairfull and Gowe, 1986). The low heterotic values for egg weight in this study are consistent with the reports of Groene *et al.* (1998) and is an indication of a very low response in improvement of egg weight through cross breeding. The heterosis obtained for egg number in FE x DB contradicts the findings of Fairfull and Gowe (1986), who reported that heterosis for egg number is typically above 10%. It is however within the range of -3 to 40% reported by Sheridan,1986; Groene *et al*., 1998 and Fairfull *et al.,* 1987 for Leghorn chicken.

CONCLUSION

With the exception of mortality, low heterotic advantage exists in selective crossing of male DB x female FE or vice versa. Low heterotic values obtained indicate that the performances of the progeny are different from the mean performance of their parents but do not profoundly surpasses either (marked super-dominance/ -over-dominance/ -hybrid vigour). This suggests co-dominance of the underlying determinants of the assessed traits; and/or low levels of positive epistasis of trait determinants originating from either of the crossed parents or low measurable combined effects (synergism) of complementary dominant genes contributed by both parents.

The results indicate that the use of Fulani Ecotype chicken as the sire and the exotic Dominant Black breed as dam would provide maximum advantage with regards to ASM, BWF and EW traits studied, while desirable gains in EN, HDP and M would be favoured by adoption of the reverse cross (DBxFE). It may be possible to extract further gains in heterosis in the F_1 generation by firstly driving the genes in each parental background (particularly FE) to homozygosity before crossing. Equally, it should be possible to consolidate F_1 heterosis through further crossing (backcrossing or intercrossing) teamed with selection strategies to eliminate inferior genotypes and increase the frequency of the desirable alleles thereby producing an improved population with respect to performance.

It is unclear whether and to what extent crossing and the direction of crossing affects the expression of desirable traits of the FE such as hardiness, disease resistant, and gustatory qualities which were not examined here, but shall be the subject of a further study.Further studies will also investigate the genetic bases of differences in performance between parental lineages through research on advanced cross animals.

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