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HETEROSIS FOR BODYWEIGHT IN NATIVE BY EXOTIC INBRED CHICKEN CROSSES

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Target Audience: Poultry farmers, breeders, researchers and teacher

ABSTRACT

Inbred lines derived from the native and exotic chicken were compared with their F_1 and backcross populations for body weight. The experimental birds were raised on deep litter pens from hatch to 20 weeks of age. Significant heterosis was obtained in body weight to 20 weeks, the magnitude was higher in the reciprocal (native x exotic) than the main (exotic x native) crosses. The backcrosses also exhibited significant heterosis and the magnitude was higher in the native than the exotic back crosses. An analysis of the genetic basis for bodyweight heterosis indicated that while complete dominance of allelic genes influenced the heterosis observed in the native backcrosses, 2-3 loci parental epistasis involving complementary genes were responsible for the heterosis observed in the exotic backcrosses. It is suggested that the genetic gap between the native and exotic chicken could be appreciably reduced by intercrossing the main and reciprocal backcrosses in the next generation. Crisscrossing and selection should follow this

Key words: Native, exotic chicken; heterosis; genetic basis.

DESCRIPTION OF PROBLEM

Nigeria has depended much on importation of parent stock and day old chicks for the sustenance of her poultry industry. The problem associated with importation is that huge foreign reserve is depleted in the process. Besides, the imported stock will not perform well in the tropical environment because of poor acclimatization. Considering these problems, it is imperative to improve on the performance of our native chicken. One way of achieving a rapid improvement in the productive potential of the native chicken is by judicious crossbreeding with exotic stocks (1). In a crossbreeding experiment involving the native and exotic parent stock of Gold link, Omeje and Nwosu (2) reported substantial heterosis in body weight and egg production traits. Similarly, Nwosu and Asuquo (3) observed in a three way crossbreeding experiment that the native chicken was significantly improved compared with two way cross. In view of the

influence which body size has on egg production and post lay value of the chicken, it is important to improve this trait in the native chicken. The research reported here was a crossbreeding experiment involving the inbred lines of the native and exotic chicken with the following specific objectives.

1. To estimate the F_1 heterosis for body weight and the residual heterosis from the backcrosses.
2. To determine the mode of gene action responsible for the heterosis exhibited.
3. To suggest ways of improving further on the body size of the native chicken based on the results obtained

MATERIALS AND METHODS

The birds used for this study were inbred lines generated from the within strain mating of two exotic (H and N Brown Nick and Black Olympia) and the native chicken maintained at the poultry breeding research unit of the Department of Animal science, Enugu State University of Science and Technology, Enugu. Two distinct lines were chosen from the progenies of each exotic strain namely Pure White (PW) and Pure Brown (PBr) from H and N Brown Nick (strain I) and Pure Black (PBL) and Barred (Brr) from Black Olympia (strain 11). The inbred lines of the native chicken (strain III) were maintained as two replicate groups (LC_1 and LC_2). At 28 weeks of age, 4 cocks and 40 hens from each exotic line (PW, PBr, PBL, and Brr) were reciprocally mated to 8 cocks and 80 hens each from the two replicate groups of the native chicken (LC_1 and LC_2) to generate eight F_1 crossbred populations with a total of 670 chicks. The mating arrangement is shown in Figure I. Similarly, at 28 weeks, 30 hens from each crossbred group were backcrossed to their male parents to obtain eight backcross progeny groups as illustrated in Figure 1. Mating was at random on floor pens with a mating ratio of 1 cock to 10 hens. A total number of 700 backcross chicks were produced.. The birds in each group were brooded for 8 weeks and raised on deep litter floors to sexual maturity by adhering to standard management procedures described by (4). Chick mash diet which on analysis yielded 19% CP and 2,685 Kcal ME/Kg was provided during the brooding period while growers mash containing 16% CP and 2642 Kcal ME/Kg was provided during the growing period. Both feed and water were provided ad libitum. The male and female sexes were separated at 6 weeks of age when the combs and wattles became prominent.

The body weight of each group was measured on 4 weekly interval till 20 weeks of age.

Data analysis: The bodyweight data were transformed to logarithms and analysed on age by age basis for the inbreds, F1 crossbred and the backcrosses. For the inbred progeny data, a simple analysis of variance in a completely randomized design using unequal cell replicate model as given

by Winer (5) was used to test the effect of strains and lines within strains on the trait.

Figure 1: The Crossbreeding procedure involving the native and exotic inbred lines.

Generation Po	Strain I			Strain III			Strain II	
Inbred lines	PW [1]	PBr [2]		LC_1 [3]	LC [4]		PBL [5]	Brr [6]
F_1 (Crossbred)	1x 3 [7]	3x1 [8]	3x2 [9]	2x3 [10]	4x5 [11]	5x4 [12]	6x4 [13]	4x6 [14]
Backcrosses	1x8 [15]	3x7 [16]	2x9 [17]	3x10 [18]	5x11 [19]	4x12 [20]	4x13 [21]	6x14 [22]

Po: Base population.
PW: Pure white
PBr: Pure brown
PBL: Pure black
Brr: Barred
LC_1: Local chicken replicate I
LC_2: Local chicken replicate II

The statistical model used was as follows:- $Xijk = U + gi + Lij + eijk$ where

Xijk = K_{th} observation on body weight in the j_{th} line (j=1,2,..... 6) within the i_{th} strain (i =1,2,3).
U = the estimate of the overall population mean.
gi = effect of i_{th} strain on the trait (bodyweight)
Lij = random variable (bodyweight) due to the effect of the line within the i_{th} strain.
eijk = k_{th} error or offspring effect or individual chick differences.

For the F_1 crossbred and the backcrosses, data were analysed by means of a one way analysis of variance in a completely randomized design involving unequal subclass numbers as given by Winer (5) with breeding groups as the main source of variation. Duncan's multiple range test (6) was used to compare means when ANOVA showed significant effect.

Estimation of heterosis: Heterosis among the F_1 chicks were estimated as the mean crossbred deviation expressed in percentage of mid parent performance. Backcross heterosis was computed from the average additive merit E (BX) expected of each backcross as outlined by (2) and stated below.

$E(BX_1)$ = P + ½ [P_1 – P] for backcross to P_1 Parent.

$E(BX_2)$ = P + ½ [P_2 – P] for a backcross to P_2 parent

Heterosis = BX_1 - $E(BX_1)$ = heterosis by the BX_1 backcross.

Or = $BX_2 - E(BX_2)$ = heterosis by the BX_2 backcross.

A simple t test was used to compare the crossbred data with their midparent for significance of heterotic performance using the procedure outlined by (7) and adopted by (8).

Genetic analysis of heterosis:

The backcross heterosis relative to F_1 performance was computed and the results fitted against the complete dominance and parental epistasis model postulated by Sheridan (9). In this model (Table I) the F_1 heterosis relative to itself is 100% whether it is complete dominance or epistatic gene action that is operating. The relative

Table 1: Comparison of percentage heterosis expected under various mating Schemes for the dominance and parental epistasis models with complementary loci (8)*

Mating schemes	Dominance Hypothesis	Parental 2 loci	Epistasis 3 Loci
Purebred	0.0	0.0	0.0
F_1	100.0	100.00	100.0
F_2 (or two breed synthetic)	50.0	12. 50	-15.6
Backcross	50.0	25.0	12.5
Three way cross	100.0	50.0	25.0
Four way cross	100.0	0.0	- 50.0
Rotational cross (2 breeds)	66.7	44.4	29.6
Rotational cross (3 breeds)	85.7	40.8	21.0

* The percentage values are relative to F_1

Source: Sheridan (9)

performance of the backcross group was compared with the figure expected of the family or mating type under any of the gene actions. If a particular result was of the same or nearly the same magnitude with the corresponding

predicted value in this model, then it will be taken that the experimental data fitted well with the particular model of gene action responsible for heterosis

RESULTS AND DISCUSSION

Body weight development

Figure 2 shows the profile of growth performance of inbred lines of two exotic and the native chickens used for the crossbreding while the growth performance of the F1 crossbred groups are presented in Figure 3. The body weight trends among the inbred lines of each exotic were similar at day old, 8, and 16 weeks of age. Significant differences ($P<0.01$) were obtained during the 4, 12 and 20 weekly periods. The two replicate groups of the native chicken were similar in bodysize from hatch to 20 weeks of age (Figure 2). The body sizes of the F_1 crossbred groups at the first 8 weeks of life were mostly influenced by the body size and egg size of the dam (Figure 3). The influence of the dams egg size on body size at the first eight weeks had earlier been established (10, 11, 12). With the recession of the maternal influence, some of the main crosses ($PWXLC_1$ and PBL X LC_2) compared with the reciprocal crosses (LC_1 X PW; LC_1 X PBr; LC_2 X PBL and LC_2 X Br) in bodyweight from 8 to 20 weeks of age (Figure 3). Figure 4 shows the profile of 20th week growth performance of backcross progeny groups of exotic and native inbred chicken. The main and reciprocal backcrosses did not present any definite trend in body weight superiority over each other at the first 8 weeks of life probably due to the leveling effect of equal maternal egg size of the F_1 pullets used in reproducing the backcross chicks (Figure 4). A similar trend was reported by Nwosu and Omeje (13) in native and exotic backcrosses. However, from 12 to 20 weeks of age, the main backcrosses asserted their superiority in body weight over the reciprocal back crosses (Figure 4). The apparent superiority of the main backcrosses were due to the acquisition of additional growth loci by the dominant exotic genes which is the hallmark of the grading up process by the exotic sire while the reciprocal backcrosses with additional loci predominated by 'null' genes were forced to positions behind the main backcrosses at 20 weeks (Figure 4).

Heterosis in body weight.

Table 2 presents the heterosis exhibited by F_1 crossbred groups in body weight from hatch to 20 weeks of age. Highly significant ($P<0.01$) heterosis were obtained by the F_1 crossbred groups in most of the age periods. This would imply that significant improvement in the body size of the native chicken could be achieved by reciprocal mating of the native and exotic chicken. The reciprocal crosses exhibited higher heterosis than the main crosses in most of the periods probably because they benefited from the superior maternal environment and from the reciprocal cross effect (14).

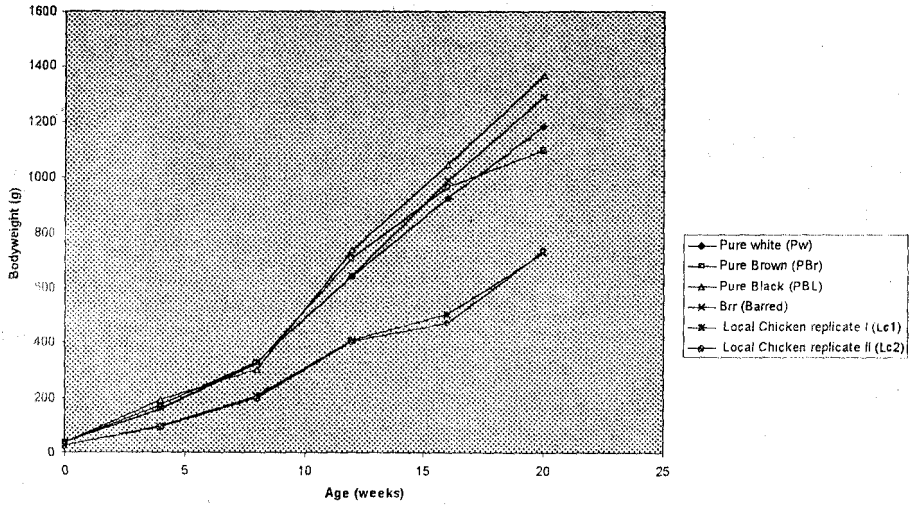

Fig.2 Profiles of growth performance of inbred lines of two exotic and native chickens used for the crossbreeding

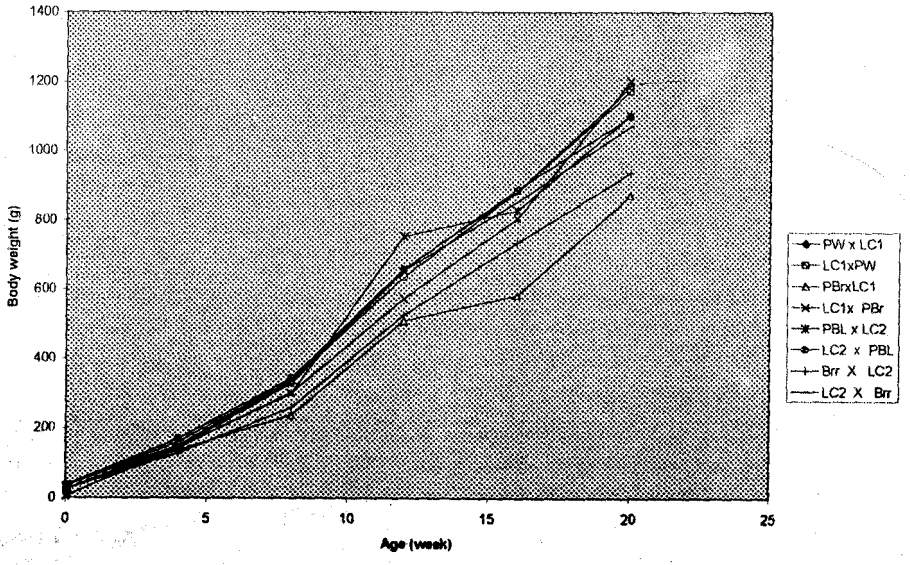

Fig. 3 The 20th week post hatch body weight of the cross between exotic and native inbred lines of chicken.

Table 2: The mean + SE of percent heterosis in body weight of the F_1 crosses between inbred lines of the exotic and native chickens.

	Crossbred groups							
Age	$PWXLC_1$,	LC_1XPW	$PBrXLC_1$,	LC_1XPBr	$PBLXLC_2$,	LC_2XPBL	$BrrXLC_2$	LC_2XBrr
Day old	–15.87** ± 0.37	12.74** ± 0.57	-16.15** ± 0.50	20.67* ± 0.96	-13.34** ±0.62	16.72** ±0.68	-11.90** ±0.63	19.97** ±0.89
WK 4	9.98** ± 2.91	25,98** +2.55	23,17** ±2.67	25.43** + 3.37	3.13NS +3.08	35.27** ± 4.20	13.84** ±2.18	18.10** ±7.69
WK 8	24.64** ± 2.03	29.95** ±3.33	9.43** ± .62	24.39** + 2.63	15.92** ± 1.32	43.71** ±4.08	2.92NS + 3.78	29.23** ± 3.21
WK 12	25.60** ± 3.71	20.44** 3.70	-8.75* +4.80	4.49ns +2.65	32.50** +5.07	22.05** ±4.84	7.27* +6.69	24.12** ±3.21
WK 16	24.01** ± 4.01	25.46** ±4.80	-17.96** ±3.03	15.31** +3.26	9.88** ±1.24	19.65** +3.71	3.48nNS ±2.48	17.18** ±2.07
WK 20	15.63** ± 2.09	25.34** ±3.62	-0.75NS + 1.37	30.08** ± 4.03	3.84NS + 4.12	15.85** ±3.00	-2.56NS ±3.03	7.12** ± 3.92

Note: NS: Not Significant *P< 0.05 *P< 0.01

Table 3 and Figure 5 show the heterosis recorded by the backcross progeny groups. The reciprocal backcrosses recorded higher heterosis than the main backcross groups because they had the advantage of lower additive merit than the main backcrosses. The lower additive merit was contributed by the smaller body size of the native dam. On the contrary, the main backcross groups had very low deviations because the larger body size of the exotic dam imposed huge additive effect for these groups to surmount before registering heterosis. With the dissipation of maternal effect at 8 weeks which corresponded with the attainment of maximum deviation in the reciprocal backcross groups, heterosis declined progressively toward the additive value (Figure 5). This tendency by the reciprocal backcross groups may be attributed to the preponderance of native recessive genes that manifested to 20 weeks of age. In the main backcross groups (especially MBX_1 and MBX_4) mean deviation increased progressively from 8 to 12 weeks, declined sharply by the 16th week before appreciating further above the additive merit value at 20 weeks. The heterotic trends of these groups may have been initially aided by the preponderant growth genes that constituted 75% of their total genome which acted until 12 weeks after which their action might have given way to epistatic effect which probably manifested from them onward giving way to negative deviations. As explained by (9) such a decline in residual heterosis in the backcross population would arise if some of the heterosis of the F_1 is due to parental epistasis involving complementary genes or if segregation has occurred in various genic combinations that acted additively in the F_1. The later situation may arise if additive epistatic combinations were present in either of the parental lines (15) The subsequent increase in heterosis observed especially in the MBX_1 and MBX_2 after 16 weeks (Figure 5) may indicate epistatic effect that originated through dominance x dominance or dominance x additive genes under 2 loci parental epistasis described by (16).

Genetic basis of heterosis in bodyweight:

Under the complete dominance hypothesis it is expected that both the F_2 and backcross generations should attain 50% of the F_1 heterosis because the hybrid condition is proportional to the degree of heterozygosity (17,9). The data in Table 4 indicate that most of the backcross groups obtained more than 100% of the F_1 heterosis especially at the first 8 weeks of life thereby departing grossly from this expectation. This means that maternal influence can play a larger role in the determination of heterosis especially at the first 8 weeks of life. The complete dominance and parental epistasis model (9) does not account for maternal, paternal or sex linked effects, all of which contribute to the phenotypic quantities used in the computation of heterosis and hence the backcross groups departure from the prediction under this model. The proportion of backcross heterosis relative to the F_1

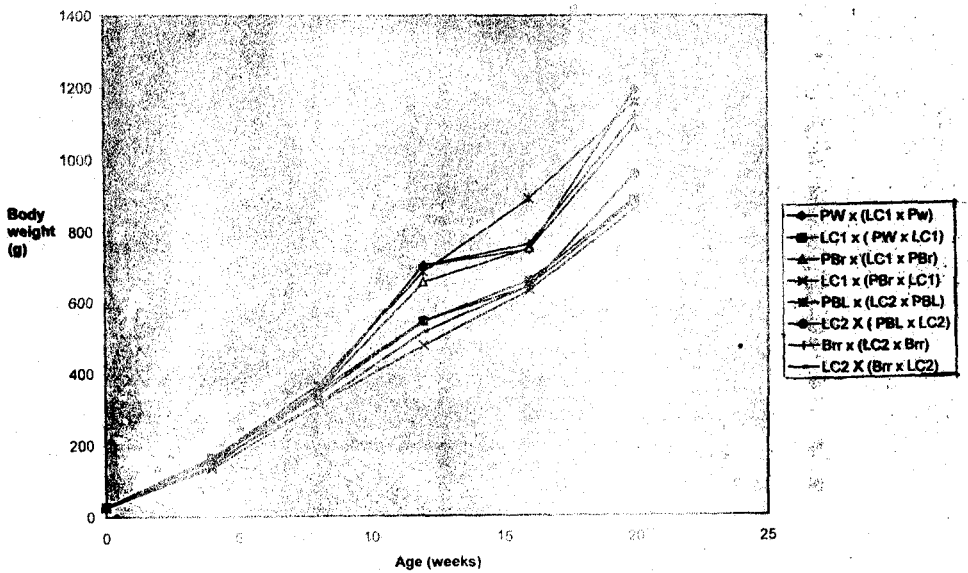

Fig. 4 Profiles of 20th week growth performance of backcross progeny groups of exotic and native chickens

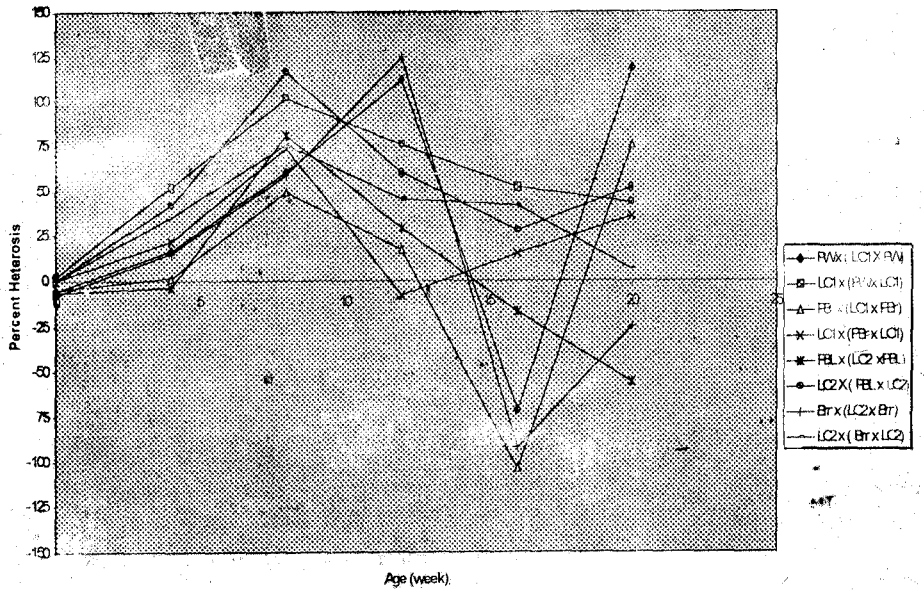

Fig. 5: Heterotic performance in body weight from day old to 20 weeks of age of the back cross progeny groups

Table 3: Mean and standard error for heterosis in body weight of the backcross progeny groups

Age	MBX_1,	RBX_1	MBX_2	RBX_2	MBX_3	RBX_3	MBX_4	RBX_4
Day old	-6.11* ±0.54	* 2.46 ±0.59	-5.33** +0.50	-0.27 ±0.67	-6.40** ±0.92	0.28 +0.78	-7.88** ±0.52	0.19 ±0.57
WK 4	15.99** + 4.96	51.97** ±6.12	1.70 ±3.17	21.55** ± 3.14	-3.55** ± 8. 66	41.33** ± 5.03	14.61* ± 7.72	34.71** ± 5.00
WK 8	60.19** ± 11.37	101.47** ±8.53	49.17** ±12.5	73.41** ± 7.25	80.80** ±14.18	116.69** ±7.65	58.38** ± 9.07	75.66** ±7.39
WK 12	112.44** ± 19.26	76.06** ±10.87	17.10 ±15.70	-7.99 ±19.42	29.13 ±22.03	60.45** ±16.36	125.01 ±22.52	45.46** ±12 92
WK 16	-71.09 ± 26.20	51.97* +22.21	-104.03** ±27.8	14.58 ±12.93	-17.36 +24.91	27.36 ±18.98	-91.94** ±20.02	41.94* ±18.75
WK 20	118.63** ± 28.29	43.38* ±21.91	75.63* ±32.8	35.79* ±15.04	-55.83 ±47.71	51.94- ±24.3	25.0 ±55.28	6.11 ± 23.87
Mean dev. (g)	38.34 ± 29.92	54.55 ±13.56	5.71 ±25.22	22.85 **±11.95**	4.47 ±18.91	49.68 ±15.94	12.20 ±30.94	34.01 ±11.33

* P< 0.05, ** P < 0.01

Note:

MBX_1 :	PW X (LC_1 X PW)	MBX_3:	PBLX(LC_2 XPBL)
RBX_1 :	LC_1 X (PW X LC_1)	RBX_3:	LC_2 X(PBL XLC_2)
MBX_2:	PBr X (LC_1 X PBr)	MBX_4:	Brr X (LC_2 X Brr)
RBX_2:	LC_1 X (PBr X LC_1)	RBX_4:	LC_2 (Brr X LC_2)

Table 4: Heterosis in body weight of the back cross progeny groups expressed as Percent that of the F_1*

Age	F1	MBX_1	RBX_1	MBX_2	RBX_2	MBX_3	RBX_3	MBX_4	RBX_4
Day Old	100.00	>100.00	>100.00	>100.00	-42.86	>100.00	59.57	>100.00	15.57
WK4	100.00	66.48	216.09	5.73	72.68	-13.98	162.72	72.32	171.24
WK8	100.00	83.99	141.60	263.50	393.52	104.65	151.13	139.27	180.49
WK12	100.00	96.37	65.19	-142.98	66.18	19.15	39.73	170.29	61.93
WK16	100.00	-39.70	29.02	-783.36	-109.79	-15.80	24.91	-121.82	55.57
WK20	100.00	63.16	23.10	59.17	28.00	-58.19	54.14	-142.86	34.91
Mean[1]	100.00	39.75	56.55	22.61	90.50	5.82	64.65	31.86	88.80

[1] Calculated from the mean deviations in Table 3.

Table 5: Summary of the back cross heterosis expressed as percent that of the F_1 to ascertain modes of gene action [1]

Mating Scheme (Type of cross)	Type of Heterosis	Complete Dominance		Parental (2.Loci)		Epistasis (3 loci)	
		Observed	Expected	Observed	Expected	Observed	Expected
F_1 crosses (combined)	HF_1	100.00	(100.00)	100.00	(100.00	100.00	(100.00)
Back crosses (BX)							
LC_1 x (PW X LC_1)	$HRBX_1$	56.55	(50)				
PW X (LC_1 X PW)	$HMBX_1$			39.75	(25)		
Combined	HBX_1	48.15					
LC_1 X (PBr X LC_1)	$HRBX_2$	90.50	(50)				
PBr X (LC_1 X PBr)	$HMBX_2$			22.61	(25)		
Combined	HBX_2	56.56					
LC_2 X (PBL X LC_2)	$HRBX_3$	64.65	(50)				
PBL X (LC_2 X PBL	$HMBX_3$					5.82	(12.50)
Combined.	HBX_3	35.25					
LC_2 X (Brr X LC_2)	$HRBX_4$	88.80	(50)				
Brr X (LC_2 X Brr)	$HMBX_4$			31.86	(25)		
Combined	HBX_4	60.30					

After Sheridan (9)

population varied during the period of 12 to 20 weeks but each were more or less than the 50% expected. Table 5 presents the summary of backcross heterosis expressed as the percentage of the F_1 and averaged over six age periods to ascertain the mode of gene action. It will be observed that the MBX_1, MBX_2, MBX_3 and MBX_4 obtained mean of 39.75, 22.61, 5.82 and 31.86 % respectively. This fitted these groups to 2-3 loci parental epistasis involving complementary genes. On the other hand, the reciprocal backcrosses (RBX_1, RBX_2, RBX_3 and RBX_4) recorded values of 56.25, 90.51, 64.65 and 88.80 % respectively thereby confirming that these groups performed under complete dominance of allelic gene postulated in this model. The net effect of the two backcrosses combined is that complete dominance and 2 loci parental epistasis were the operating gene action involved in the inheritance of body weight in the chicken. This observation agreed with the submission by Hill (18) that heterosis was made up of dominance and epistatic components together with additive inheritance.

CONCLUSION AND RECOMMENDATION

We can conclude from these results that

1. Substantial heterosis in body weight was achieved by reciprocal mating of the native and exotic chicken. The reciprocal crosses exhibited higher heterosis than the main crosses.
2. The main and reciprocal backcrosses exhibited significant heterosis in body weight at different ages, which was higher in the reciprocal, compared with the main backcross groups.
3. Whereas complete dominance was implicated in the heterosis observed in the reciprocal backcrosses, 2 – 3 loci parental epistasis involving complementary genes was noted as the operating gene action responsible for body weight heterosis in the main back crosses
4. Based on the summary of the findings, we recommend the intercrossing of the main and reciprocal backcross groups in the next generation. The intercross progeny groups should be crisscrossed before selection. It is hoped that the genetic gap between the body size and other egg production traits of the native and exotic chicken will be appreciably narrowed

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