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Effect of feathering genes on growth performance of F_2 backcrosses and comparison of F_1 and F_2 crosses of Abor Acre broiler breeder x native chickens in humid tropical environment

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Abstract

This study was conducted to evaluate growth performance, brooding and rearing mortalities of F_2 main and reciprocal backcross progenies of Abor Acre broiler breeder x native chicken crosses and to compare their F_1 and F_2 backcross progenies. The base population used in the study consisted of mature (~ 48 weeks) male and female native chickens and exotic (Abor Acre) broiler breeder parent stock. The native chicken varieties were made up of normal feather, naked neck and frizzle genotypes. These birds were mated to the Abor Acre broiler parent stocks in main and reciprocal fashion generating F_1 main and reciprocal crossbreds. Females of these F_1 hybrids were then mated back to the broiler breeder cock to generate F_2 main and reciprocal backcross progenies that were evaluated in the present study. Data analyzed include body weight (BWT) and linear body parameters (LBPs), average feed intake (AFI), feed conversion ratio (FCR), brooding and rearing mortalities. Comparisons between genetic groups for these parameters were done by means of analysis of variance (ANOVA) technique. Results indicated improved growth performance and feed conversion ratios in the F_2 reciprocal backcross groups compared to their F_2 main backcross counterparts. The F_2 individuals in both crosses were superior to F_1 crossbred populations. Chick mortality rates were higher in main and reciprocal backcross groups involving the naked neck genotype compared to other plumage types. It was concluded that backcrossing the F_1 individuals to the exotic broiler breeder cocks increased the genetic profile of the backcross lines resulting in enhanced growth performance of progenies. Crossbreeding of exotic and local chicken varieties generated progenies that had higher genetic potentials for growth relative to the local strains and better adaptability relative to the exotic breed. However, incubation and brooding strategies capable of minimizing mortalities at embryonic, brooding and rearing phases should be explored and integrated in local chicken improvement programmes involving the use of these plumage reducing genes for optimal results.

Key words: Broiler breeder stock, local chickens, feathering genes, crossbreeding, growth traits, mortality.

Introduction

Poultry production in the tropics is constrained by a number of adverse factors such as unfavourable climatic conditions (Ali *et al.,* 2000; Islam and Nishibori, 2009), poor genetic profile of native chicken stock (Alexander, 2001; Mengasha *et al.,* 2008; Ogbu, 2012), poor nutrition as well as disease challenges. Improved local poultry is necessary to realizing a national poultry industry that is economically viable and self-sustaining. Many modern family poultry production schemes have benefited from such poultry improvement efforts. Indigenous poultry genes are needed in any genuine " poultry breed formation" aimed at developing suitable breed or strain of chicken that have productive adaptability in terms of egg and meat traits in a native production environment (Nwachukwu *et al.,* 2006a,b).

The local poultry population possesses a number of genotypes that exhibit major gene effects such as silky feather (H/H;h/h), naked neck (Na/Na; Na/na), dwarfing gene(d/w) and frizzle (F/F; F/f) (Merat, 1990; Islam and Nishibori, 2009; Oke, 2011). The naked neck and frizzle genotypes in particular are noted for varying degrees of feathering, adaptability and performance characteristics (Warnoto and Triadi, 2009; Fasill *et al.,* 2010). There is a consensus among researchers that the major genes of naked neck and frizzle confer adaptive and productive advantages on individual birds possessing them (Horst, 1988; Merat, 1990; Khatun *et al.,*2005; Islam and Nishibori, 2009). It is also believed that these genes could favourably influence overall population value in most quantitative traits when in high frequency (Horst, 1988).

Earlier reports had shown that crossbreeding the naked neck and frizzle chickens with exotic breeds yielded individuals that are higher than the pure natives in productive performance while retaining their adaptive potentials (Iraqi *et al.,* 2005; Mekki *et al.,* 2005). Favourable effects of crossbreeding the local chicken with exotic egg-type chickens have been demonstrated by Omeje and Nwosu, 1988; Udeh and Omeje, 2005; Udeh, 2010. Crossbreeding produce individuals of higher genetic potential for fitness and/or productive performance (hybrid vigour) relative to either of the parents or the mean of both parents (Iraqi *et al.,* 2005; Mekki *et al.,* 2005; Udeh and Omeje, 2005). The observed improvement in crossbred individuals have been attributed to complementary gene effects and favourable non-additive genetic effects e.g. dominance effect, sex-linked influence, maternal effects and 'parent-of-origin specific expression' etc (de Koning *et al.,* 2002; Deeb and Lamont, 2002; Ikeobi *et al.,* 2002; Kerje *et al.,* 2003; Tuiskula-Haavisto *et al.,* 2004; Hannan *et al.,* 2007).

There is need to explore appropriate poultry breeding strategies to sustainably manage the environmental constraints on domestic fowl with regards to production of prime products of egg and meat in Nigeria and elsewhere. Incorporating the naked neck and frizzle gene in exotic meat type birds produced better growth rate, and feed efficiency relative to the native birds and liveability relative to the exotic breed/strain (El-Safty, 2006). An earlier report

(Nwachukwu *et al.,* 2006a, b) demonstrated improved growth performance and egg production traits of main and reciprocal F_1 progenies of crosses between normal feather, naked neck and frizzle local chickens with an exotic meat type chicken. The present study therefore was aimed at evaluating the growth performance, brooding and rearing mortalities of F_2 main and reciprocal backcross progenies of Abor Acre broiler breeder x Local chicken F_1 crosses and a comparison of F_1 and F_2 crosses of the different plumage types investigated.

Materials and Methods

This study was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia state, Nigeria. Umudike is located within the humid rainforest zone of South Eastern Nigeria and has an annual rainfall range of 1700-2100 mm. The minimum and maximum daily temperatures range of 18.0-23.0°C and 26.0-36.0°C, respectively and a relative humidity range of 57.0-91.0% depending on the season of the year (Meteorological Station, National Roots Crop Research Institute, Umudike, unpublished). The area is aptly described as warm-wet or hot-humid tropics.

Experimental birds –The Base population

The base population utilized in the study consisted of mature (~ 48 weeks) male and female native chickens and exotic Abor Acre broiler breeders (E). The native chickens were made up of three varieties namely normal feather (NF), naked neck (Na), and frizzle (F) obtained from a local chicken population maintained at the Poultry Unit of the University Teaching and Research Farm while the Abor Acre broiler breeder stock was procured from a reputable hatchery in Owerri in Imo state, Nigeria. The details of management of breeding stock, and production and management of F_1 crossbred populations were as described by Nwachukwu *et al.* (2006a, b).

Management of F_2 main and reciprocal backcross progenies

At 40 weeks of age all surviving females of main and reciprocal F_1 hybrid birds were backcrossed to the exotic Abor Acre broiler breeder cocks using artificial insemination technique as described by Lake *et al.,* (1985). The breeding groups were: Ex(ExNF), Ex(ExNa), and Ex(ExF) as main backcrosses and Ex(NFxE), Ex(NaxE), and Ex(FxE) as reciprocal backcrosses. Eggs from these crosses were collected twice daily, identified properly and set in a locally fabricated incubator to hatch. Eggs were set weekly and 3 hatches involving 280 chicks (45 Ex(ExNF), 41 Ex(ExNa), and 48 Ex(ExF), 50 Ex(NFxE), 48 Ex(NaxE), and 48 Ex(FxE)) were obtained. The chicks were brooded and reared in batches on deep litter pens according to their genetic group. The birds were fed a commercial starter mash (23% CP, 2875 kcalME/kg) and water was served *ad libitum* from 0-6 weeks of age. Vaccination and prophylactic medication against common poultry diseases in the area were administered to ensure optimal health of the birds. During the rearing phase (7-18 weeks), the birds were fed a grower diet (16% CP, 2675 kcal ME/kg) and water was provided *ad libitum*. All cockerels were separated at 12 weeks to ensure efficient culling of males.

Data Collection and Statistical Analyses

The following parameters were measured from hatch to 12 weeks of age on equal number of birds/batch/genetic group: hatch weight (BWT_0), weekly body weight (BWT), daily feed intake (feed given minus left over after 24 hour divided by number of birds in a group), brooding mortality (number of mortality during the brooding phase, 0-6 weeks), rearing mortality (number of mortality from 7-12 weeks), linear body parameters (LBPs) for both sexes at 12 weeks of age namely, body length (BL) as distance from base of comb to base of tail around the uropigeal gland, wing length (WL) as distance from the beginning of the humerus to the 3rd digit on the left wing of each bird, keel length (KL) as distance from the beginning to the end of the keel bone or metasternum, shank length (SL) as distance between the hock joint and the tarso metatarsus or digit-3, and breast width (BW) as the width of the breast at the region of widest expansion of the breast while the bird was placed in a dorso-ventral position. All LBPs were measured with a Tailor's tape and recorded in centimeters. Feed conversion ratio (FCR) was calculated during brooding and rearing phases as gramme feed consumed per gramme weight gain on weekly basis. Data collected were subjected to Analysis of Variance (ANOVA) technique in Randomized Complete Block Design (RCBD) to test for effect of genetic group. Hatches were the blocking factor. Significant means were detected using the Duncan's New Multiple Range Test (Steel and Torrie, 1980).

Results and Discussion

The performance parameters (BWT, FI, and FCR) of the main and reciprocal F_2 backcross progenies from 0-12 weeks of age are presented in Table 1. Among the main backcross groups, BWT_0 differed significantly with progenies of Ex(ExNa) having the highest hatch weight of 26.92 ± 0.40 g followed closely by those of Ex(ExNF) 24.19 ± 0.54 g and the least value of 23.71 ± 0.40 g for Ex(ExF). However, the F_2 reciprocal backcross genotypes were statistically similar to each other in BWT_O but significantly heavier than their main backcross counterparts. Table 1 revealed further that these reciprocal backcross groups had significantly higher body weight at all age periods than their main backcross counterparts with the Ex(FxE) individuals overcoming the initial low hatch weight and achieving the highest BWT_{12}. This observation seem to indicate that the reciprocal backcross groups in general were better adapted to the production environment while the Ex(FxE) individuals in particular exhibited the best thermoflexibility and highest favourable non-additive gene effects on body weight. It could also be inferred that the complimentary effect of the exotic sire and hybrid native dam in the reciprocal backcross groups nicked better than that of exotic sire and native dam in the main backcross groups with reference to body weight. A similar superior performance of reciprocal groups to main crossbred groups was reported among F_1 progenies by Nwachukwu *et al.* (2006a) and in a

Table 1:Performance of F_2 main and F_2 reciprocal backcross progenies of Abor Acre x native chicken crosses

	Genetic group					
	Main backcrosses			Reciprocal backcrosses		
Parameter	Ex(ExNF)	Ex(ExNa)	Ex(ExF)	Ex(NFxE)	Ex(NaxE)	Ex(FxE)
BWT_0 (g)	$24.19(0.50)^{bc}$	$26.42(0.54)^{b}$	$23.71(0.40)^{c}$	$30.48(0.38)^{a}$	$30.00(0.43)^{a}$	$31.33(0.47)^{a}$
BWT_3 (g)	$98.63(3.54)^{c}$	$98.58(5.15)^{c}$	$104.14(4.73)^{c}$	$220.04(5.70)^{a}$	$172.22(13.51)^{b}$	$218.80(16.55)^{a}$
AFI_3 (g)	$22.69(0.79)^{b}$	$19.98(0.11)^{c}$	$17.17(0.52)^{d}$	$24.82(0.89)^{ab}$	$22.77(0.75)^{b}$	$27.18(1.52)^{a}$
FCR_3	$4.08(0.22)^{a}$	$3.40(0.09)^{b}$	$2.72(0.29)^{c}$	$2.63(0.14)^{c}$	$3.69(0.34)^{ab}$	$2.14(1.47)^{c}$
BWT_6 (g)	$354.39(24.79)^{bc}$	$294.44(20.58)^{cd}$	$242.08(11.34)^{d}$	$598.45(12.41)^{a}$	$421.86(5.26)^{b}$	$642.87(32.43)^{a}$
AFI_6 (g)	$36.50(1.26)^{bc}$	$33.50(1.30)^{c}$	$25.47(0.53)^{d}$	$54.21(1.39)^{a}$	$37.63(0.57)^{b}$	$54.06(1.47)^{a}$
FCR_6	$2.95(0.41)^{ab}$	$3.12(0.13)^{a}$	$3.28(0.25)^{a}$	$2.33(0.16)^{b}$	$2.90(0.06)^{ab}$	$2.29(0.09)^{b}$
BWT_9 (g)	$638.13(41.26)^{b}$	$623.67(53.52)^{b}$	$430.64(42.72)^{c}$	$1274.40(26.54)^{a}$	$745.00(41.60)^{b}$	$1238.07(52.59)^{a}$
AFI_9 (g)	$55.69(1.48)^{bc}$	$53.02(1.99)^{cd}$	$45.79(2.16)^{d}$	$78.39(3.11)^{a}$	$46.85(3.08)^{d}$	$61.77(2.22)^{b}$
FCR_9	$3.39^{a}(0.28)$	$2.93^{bc}(0.23)$	$4.25^{a}(0.95)$	$1.89^{c}(0.02)$	$3.39^{a}(0.47)$	$2.69^{bc}(0.48)$
BWT_{12} (g)	$1014.38(71.90)^{bc}$	$956.11(69.54)^{c}$	$645.00(34.51)^{d}$	$1752.23(42.49)^{b}$	$1223.13(74.60)^{b}$	$1976.67(97.60)^{a}$
AFI_{12} (g)	$60.80(1.04)^{c}$	$59.02(1.79)^{c}$	$54.06(3.51)^{c}$	$103.79(1.65)^{a}$	$73.48(4.35)^{b}$	$100.91(0.84)^{a}$
FCR_{12}	3.53(0.56)	2.85(0.10)	3.91(0.67)	3.70(0.20)	3.34(0.50)	2.70(0.42)

$^{a-e}$Means on the same row with different superscripts are significantly different ($P < 0.05$), BWT_x ,AFI_x, FCR_x: body weight, Av. feed intake, and feed conversion ratio for the x^{th} week, respectively, SEM in parenthesis.

preliminary report by Udeh (2010) for crosses between inbred lines of native chickens crossed with Lohman Brown and Olympia Black exotic egg type chickens. These workers attributed favourable non additive genetic effects and maternal influence as the sources of the superiority of the reciprocal crossbred groups. This is particularly so because dam- of-origin effect has been reported to exert lasting influence on body weight and other quantitative traits in poultry (Deeb and Lamont, 2002).The attainment of mean body weight of above 1.2 kg by reciprocal backcross groups by 9 weeks of age and a body weight of above 1.9 kg by 12 weeks clearly showed that these birds are potential heavy- type birds which could be selected and further improved as meat- type chicken exhibiting fast growth like their broiler breeder parent and grandparent.

It was evident that the reciprocal backcross groups consumed more feed across the age periods compared to their main backcross counterparts and this could be as a result of their higher body weights. The values for FCR indicate that the reciprocal backcross groups were also more efficient in the conversion of feed consumed to body tissues. For instance, FCR_3 ranged from 2.14 ± 1.47 to 3.69 ± 0.34 in reciprocal backcross groups but from 2.72 ± 0.27 to 4.08 ± 0.22 in main backcross groups. The same trend was observed across the age periods. Thus, confirming earlier report that fast growing birds are more feed efficient than slow growing ones (Cahaner and Leenstra, 1992). Among the reciprocal backcross groups, Ex(FxE) hybrids which had the highest overall BWTs also had the least FCR- an indication of efficient feed utilization which also suggest that these frizzled birds achieved better adaptation to their local production environment. Frizzle birds are believed to achieve greater thermoregulation than normal feathered and naked neck individuals due to greater body surface area exposed to the atmosphere, which enhances convection heat loss (Cahaner, 2000). It is therefore likely that this genotype would be suitable for meat production in a hot and humid environment like in the study area.

Table 2 showed that body weight and linear body parameters (LBPs) varied significantly within crosses and between genetic groups.

As shown in Table 2, the reciprocal backcross cockerels and pullets weighed significantly higher than those of main backcross individuals at 12 weeks of age. The reciprocal backcross hybrid cockerels had overall longer BL, WL, KL, BW, and SL than their main backcross counterparts. The same was observed for BL and BW in pullets, but not for other LBPs which were similar for main and reciprocal backcross pullets. The higher values for LBPs in reciprocal backcross individuals were in tandem with the higher body weight values observed in this group at all age periods and suggest better body development and possible higher meat yield in these genetically crossbred groups. The LBPs have been reported to be good indicators of body growth and are positively correlated with body weight at mature age periods (Adeleke *et al.,* 2011; Ojedapo *et al.,* 2012). They are variously used as predictors of body weight (Udeh *et al.,* 2011; Ige *et al.,*

Table 2: Body weight and linear body parameters of F_2 main and F_2 reciprocal backcross cockerels and pullets of Abor Acre broiler x native chicken crosses at 12 weeks of age

	Genetic group					
	Main backcrosses			Reciprocal backcrosses		
Parameter	Ex(ExNF)	Ex(ExNa)	Ex(ExF)	Ex(NFxE)	Ex(NaxE)	Ex(FxE)
Cockerels						
BWT_{12} (g)	1324.58(80.41)^{c}	1295.83(125.81)^{c}	1131.67(101.76)^{c}	1883.67(92.87)^{a}	1438.33(89.87)^{bc}	1675.83(79.84)^{ab}
BL (cm)	37.03(0.57)^{bc}	36.07(1.14)^{cd}	34.30(1.54)^{d}	40.63(0.56)^{a}	37.08(0.85)^{bc}	39.20(0.63)^{ab}
WL(cm)	21.80(0.55)^{ab}	20.50(0.90)^{bc}	20.32(1.17)^{c}	22.81(0.41)^{a}	22.52(0.69)^{ab}	22.65(0.28)^{a}
KL (cm)	13.41(0.48)^{c}	14.33(0.54)^{bc}	20.32(0.36)^{c}	22.81(0.30)^{a}	22.52(0.28)^{ab}	22.65(0.36)^{a}
SL (cm)	8.46(0.27)^{ab}	7.63(0.14)^{c}	7.82(0.16)^{bc}	8.82(0.14)^{a}	8.86(0.21)^{a}	9.12(0.17)^{a}
BW (cm)	11.53(0.52)^{bc}	10.95(0.75)^{bc}	9.90(0.34 ^{c}	13.67(1.85)^{a}	10.97(0.57)^{bc}	12.02(0.78)^{ab}
Pullets						
BWT_{12} (g)	1072.50(88.26)^{cd}	1118.33(85.10)^{cd}	916.67(55.48)^{d}	1578.00(81.19)^{a}	1250.00(45.09)^{bc}	1513.33(46.67)^{a}
BL (cm)	35.88(1.33)^{ab}	33.80(0.72)^{bc}	31.57(0.46)^{c}	38.50(0.71)^{a}	35.70(1.16)^{ab}	38.93(1.22)^{a}
WL(cm)	20.08(1.15)^{ab}	18.97(1.23)^{bc}	17.97(1.07)^{c}	21.94(0.50)^{a}	21.03(0.28)^{ab}	22.27(0.43)^{a}
KL (cm)	13.05(0.74)^{b}	13.70(0.76)^{ab}	13.17(0.60)^{b}	15.60(0.48)^{a}	15.03(0.54)^{ab}	14.43(0.15)^{ab}
SL (cm)	7.45(0.48)^{b}	7.43(0.19)^{b}	7.60(0.20)^{b}	8.30(0.22)^{ab}	8.30(0.25)^{ab}	8.77(0.09)^{a}
BW (cm)	9.43(0.52)^{c}	9.90(0.95)^{c}	9.30(0.44)^{c}	12.62(0.64)^{a}	9.87(0.62)^{bc}	11.73(0.13)^{ab}

a-e: Means on the same row with different superscripts are significantly different ($P < 0.05$), BWT_x: body weight for the x^{th} week, SEM in parenthesis.

2012; Ojo *et al.,* 2014). Table 2 also showed some evidence of sexual dimorphism between cockerels and pullets in all the genetic groups for the growth parameters studied. Cockerels generally exceeded pullets in 12 weeks body weight (BWT_{12}) and in all the LBPs investigated. Evidence of differential growth of males and females is widely reported in avian species and in most farm animals (Kalita *et al.,* 2004; Ogah *et al.,* 2005). Sexual dimorphism is believed to be the result of differential internal and external milieu of males and females such as differential levels of male and female hormone secretion, and dominance of males over females when both are reared together (Kalita *et al.,* 2004; Ogah *et al.,* 2005).

Table 3 presents comparative performance of F_1 main cross and F_2 main backcross progenies of the three genotypes while Table 4 showed similar comparison between the F_1 reciprocal and F_2 reciprocal backcross individuals.

The F_2 main backcross groups surpassed their F_1 main crossbred counterparts (except ExF) in BWT at the various age periods except at BWT_0 (see Table 3). AF1 and FCR did not follow a definite trend within and between these groups. The superior growth performance of F_2 main backcross progenies showed increased genetic potential for growth in this group due to increased exotic blood in the backcross group to 75 % compared to 50 % in the F_1 main cross groups. Backcrossing F_1 hybrids to their superior parent breed is a widely employed mating scheme in breed formation and in genetic upgrading of farm animals and poultry. The results in Table 4 showed clearly that F_2 reciprocal backcross groups surpassed their F_1 reciprocal counterparts in BWT across the age periods except at hatch. The F_2 reciprocal backcross birds had higher values of AFI and FCR indicating that these groups consumed more feed and were less efficient in feed utilization. These results were expected since heavy birds at older age beyond 8 weeks tend to grow slowly, convert feed more into fat and less to muscles.

The F_1 reciprocal crossbred groups which are progenies of local cock x exotic dam (50 % local blood: 50 % exotic blood) and the F_2 reciprocal backcross groups (75 % exotic blood: 25 % local blood) both groups showed impressive growth performance within their respective groups. This study revealed that backcrossing the F_1 reciprocal groups to exotic sire improved the overall growth performance of the resulting F_2 hybrids. It is proper to note that superior FCR for the reciprocal F_1 crossbred groups in week 12 could be due to the effect of small body size gene derived from the native sire. It has been reported that the local chicken is endowed with the genetic potential for feed efficiency due to lower maintenance requirement (Ogbu and Omeje, 2010). Generally, birds of lighter body weight require less feed resources for maintenance and production. The F_2 reciprocal crossbred group achieved overall higher BWT_{12} and consumed more feed except the naked neck (Ex(NaxE) group. It is evident in this study that these F_2 reciprocal groups with 75% exotic blood resembled their Abor Acre broiler breeder parents requiring more feed to sustain their heavier body weight.

Table 3: Performance of F_1 main cross and F_2 main backcross progenies of Abor Acre x native chicken crosses

	Genetic group					
	F1 main crosses			F2 main backcrosses		
Parameter	ExNF	ExNa	ExF	Ex(ExNF)	Ex(ExNa)	Ex(ExF)
BWT_0 (g)	26.45(0.35)^a	26.00(0.26)^a	26.50(0.73)^a	24.19(0.50)^{ab}	26.42(0.54)^a	23.71(0.40)^b
BWT_3 (g)	76.56(2.42)^c	79.31(2.22)^c	115.00(6.04)^a	98.63(3.54)^b	98.58(5.15)^b	104.14(4.73)^{ab}
AFI_3 (g)	19.11(0.86)^b	17.52(0.83)^c	16.76(0.41)^c	22.69(0.79)^a	19.98(0.11)^b	17.17(0.52)^c
FCR_3	3.57(0.02)^b	3.35(0.02)^b	3.06(0.19)^{bc}	4.08(0.22)^a	3.40(0.09)^b	2.72(0.29)^c
BWT_6 (g)	208.81(10.78)^c	212.13(9.55)^c	347.08(18.15)^a	354.39(24.79^a	294.44(20.58)^b	242.08(11.34)^b
AFI_6 (g)	28.16(1.28)^b	27.85(0.87^b)	25.00(1.02)^c	36.50(1.26)^a	33.50(1.30)^a	25.47(0.53)^c
FCR_6	4.01(0.08)^a	3.35(0.12)^b	3.27(0.19)^b	2.95(0.41)^b	3.12(0.13)^b	3.28(0.25)^b
BWT_9 (g)	375.05(23.34)^c	340.00(9.06)^c	552.67(27.40)^a	638.13(41.26)^a	623.67(53.52)^a	430.64(42.72)^{bc}
AFI_9 (g)	46.86(1.62)^b	45.88(1.77)^b	43.89(1.60)^b	55.69(1.48)^a	53.02(1.99)^a	45.79(2.16)^b
FCR_9	3.36(0.17)^{ab}	3.32(0.14)^{ab}	3.10(0.21)^{ab}	3.39(0.28)^{ab}	3.93(0.23)^b	4.25(0.95)^a
BWT_{12} (g)	508.60(29.85)^c	519.43(35.46)	609.58(16.86)^b	1014.38(71.90)^a	956.11(69.54)^a	645.00(34.51)^b
AFI_{12} (g)	57.94(1.28)^{ab}	57.17(1.29)^{ab}	57.03(1.41)^{ab}	60.80(1.04)^a	59.02(1.79)^{ab}	54.06(3.51)^b
FCR_{12}	2.55(0.19)^b	2.54(0.11)^b	2.21(0.22)^b	3.53(0.56)^a	2.85(0.10)^{ab}	3.91(0.67)^a

$^{a-e}$Means on the same row with different superscripts are significantly different ($P < 0.05$), BWT_x, AFI_x, FCR_x: body weight, Av. feed intake and feed conversion ratio for the x^{th} week, respectively, SEM in parenthesis.

Table 4: Growth performance of F_1 Reciprocal cross and F_2 Reciprocal backcross progenies of Abor Acre x native chicken crosses

	Genetic group					
	F1 Reciprocal crosses			F2 Reciprocal backcrosses		
Parameter	NFxE	NaxE	FxE	Ex(NFxE)	Ex(NaxE)	Ex(FxE)
BWT_0 (g)	29.84(0.32)	30.83(0.59)	30.22(0.30)	30.48(0.38)	30.00(0.43)	31.33(0.47)
BWT_3 (g)	136.79(3.45)^c	148.50(7.92)^c	134.46(3.89)^c	220.04(5.70)^a	172.22(13.51)^b	218.80(16.55)^a
AFI_3 (g)	22.31(0.72)^b	22.52(0.51)^b	23.83(0.57)^b	24.82(0.89)^{ab}	22.77(0.75)^b	27.18(1.52)^a
FCR_3	2.09(0.07)^c	2.05(0.08)^c	2.05(0.15)^c	2.63(0.14)^b	3.69(0.34)^a	2.14(1.47)^b
BWT_6 (g)	357.97(9.54)^c	288.60(22.42)^c	360.29(10.30)^c	598.45(12.41)^a	421.86(5.26)^b	642.87(32.43)^b
AFI_6 (g)	45.00(1.17)^b	46.12(1.74)^b	48.43(1.24)^b	54.21(1.39)^a	37.63(0.57)^c	54.06(1.47)^a
FCR_6	3.32(0.18)^a	2.69(0.11)^b	1.88(0.08)^c	2.33(0.16)^b	2.90(0.06)^{ab}	2.29(0.09)^b
BWT_9 (g)	651.28(26.69)^c	615.80(37.08)^c	612.12(30.01)^c	1274.40(26.54)^a	745.00(41.60)^b	1238.00(52.59)^a
AFI_9 (g)	65.60(2.44)^{bc}	64.50(2.26)^{bc}	69.77(2.09)^b	78.39(3.11)^a	46.85(3.08)^d	61.77(2.22)^c
FCR_9	2.02^{cd}(0.20)	2.95^{ab}(0.11)	2.05^{cd}(0.24)	1.89^d(0.02)	3.39^a(0.47)	2.69^{bc}(0.48)
BWT_{12} (g)	1039.15(52.18)^c	910.88(67.15)^d	1141.88(42.28)^c	1752.23(42.49)^b	1223.13(74.60)^c	1976.67(97.60)^a
AFI_{12} (g)	72.03(3.03)^b	73.15^b(2.71)	74.74^b(2.53)	103.79^a(1.65)	73.48^b(4.35)	100.91^a(0.84)
FCR_{12}	1.96(0.36)^b	2.20(0.34)^b	2.45(0.20)^b	3.70(0.20)^a	3.34(0.50)^a	2.70(0.42)^{ab}

$^{a-e}$Means on the same row with different superscripts are significantly different ($P < 0.05$), BWT_x, AFI_x, FCR_x: body weight, Av. feed intake, and feed conversion ratio for the x^{th} week, respectively, SEM in parenthesis.

Table 5: Brooding and rearing mortality rates of F_2 main and F_2 reciprocal backcross progenies of Abor Acre x native chicken crosses

	Genetic group					
	Main backcrosses			Reciprocal backcrosses		
Parameter	Ex(ExNF)	Ex(ExNa)	Ex(ExF)	Ex(NFxE)	Ex(NaxE)	Ex(FxE)
Brooding (%)	5.78(0.21)^b	26.92(0.48)^a	6.46(5.89)^b	13.21(3.35)^{ab}	27.67(7.86)^a	13.42(3.89)^{ab}
Rearing (%)	11.68(3.83)^a	0.57(0.00)^c	6.46(5.89)^b	11.74(4.94)^a	12.85(8.20)^a	8.47(2.99)^b

$^{a-c}$Means on the same row with different superscripts are significantly different ($P < 0.05$), brooding: 0-6 wk of age; rearing: 7-12 wk of age.

Table 5 showed that there were significant differences in brooding and rearing mortalities within and between main and reciprocal backcross groups. For main backcross population, highest brooding mortality were recorded for progenies of the naked neck- Ex(ExNa) followed by those of frizzle feather- Ex(ExF) and normal feather- Ex(ExNF) whereas rearing mortality was significantly higher for Ex(ExNF) followed by Ex(ExF) and least for Ex(ExNa). A similar trend was observed in the reciprocal backcross groups during brooding and rearing phases (Table 5). During brooding, Ex(NaxE) chicks died most (27.67 ± 7.86%) compared to Ex(FxE) and Ex(NFxE) chicks which had mortality rates of 13.42 ± 3.89% and 13.21 ± 3.35%, respectively while during the rearing more of Ex(NFxE) birds died (11.74 ± 4.94%) compared to those of Ex(FxE) individuals (8.47 ± 2.99%). Between main and reciprocal backcross individuals, overall chick and pullet mortalities were generally higher for the reciprocal backcross group.

The higher mortality recorded among main (Ex(ExNa) and reciprocal Ex(NaxE)) backcross hybrid chicks carrying naked neck gene during the brooding phase is in agreement with the report of Horst (1989) and Peters *et al.* (2004). These workers reported decreased liveability of naked neck genotypes at both embryonic and immediate post-hatch stages of life. The Na gene has also been reported to be more lethal to chick embryos carrying double dose of the gene (homozygous NaNa) than when heterozygous (Nana) (Sidadolog, 1991). The higher mortality of naked neck and frizzle genotypes at the brooding phase compared to the rearing phase could be attributed to reduced vitality of embryos of these genotypes and the subsequently reduced liveability of the chicks resulting from them. Pullets of these genotypes had lesser mortality probably because of improved liveability at older age which is in consonance with the reports by Horst (1989).

Table 6 showed that F_1 main crossbred chicks of ExNa had equivalent mortality rates with F_2 main backcross chicks of Ex(ExNa) and these were significantly higher than those of main cross ExF chicks which in turn was higher than those of F_2 main backcross Ex(ExF) and Ex(ExNF) chicks, respectively. During the brooding phase, main crossbred ExNa chicks still had overall highest mortality of 27.66 ± 5.40 % followed by those of ExF (14.05 ± 0.81%) and ExNF (0.57 ± 0.01) while progenies of F_2 main backcrosses had mortality rates

Table 6: Brooding and rearing mortalities of F_1 main crosses and F_2 main backcross progeni Abor Acre x native chicken crosses

	Genetic group					
	F1 main crosses			F2 main backcrosses		
Parameter	ExNF	ExNa	ExF	Ex(ExNF)	Ex(ExNa)	Ex(
Brooding (%)	0.57(0.01)^{d}	27.66(5.40)^{a}	14.05(0.81)^{b}	5.78(0.21)^{c}	29.92(0.48)^{a}	6.46(
Rearing (%)	8.95(0.47)^{b}	14.99(1.73)^{a}	8.65(0.30)^{b}	9.68(1.83)^{b}	0.57(0.00)^{d}	6.46(

$^{a-d}$: Means on the same row with different superscripts are significantly different (P < 0.05), broodir wk of age; rearing: 7-18 wk of age.

Table 7: Brooding and rearing mortalities of F_1 Reciprocal and F_2 Reciprocal backcross progenies of Abor Acre x native chicken crosses

	Genetic group					
	F1 Reciprocal crosses			F2 Reciprocal backcrosses		
Parameter	NFxE	NaxE	FxE	Ex(NFxE)	Ex(NaxE)	Ex(FxE)
Brooding (%)	0.54(0.01)^{c}	27.36(7.40)^{a}	14.00(0.83)^{ab}	13.21(3.35)^{b}	27.67(12.86)^{a}	13.42(3.89)^{b}
Rearing (%)	8.45(0.42)^{b}	12.96(1.72)^{a}	9.65(0.32)^{b}	7.74(2.94)^{b}	6.85(2.20)^{bc}	4.47(1.99)^{c}

$^{a-d}$: Means on the same row with different superscripts are significantly different ($P < 0.05$), brooding: 0-6 wk of age; rearing: 7-18 wk of age.

5.78 ± 0.21 for Ex(ExNF), 6.46 ± 0.89 for Ex(ExF), and 29.92 ± 0.48 % for Ex(ExNa). The significantly higher juvenile mortality observed in progenies of crosses involving the naked neck gene corroborates our earlier report that the naked neck gene reduces liveability at juvenile stage of life.

The continued high mortality of ExNa (main cross) progenies during the rearing phase is surprising given that their main backcross counterparts had relatively mortality rates of less than 1.0 % during this period. It could be that other extraneous factor (s) unknown to the researchers may have affected the liveability of this genotype at this stage.

In Table 7, it was obvious that theF_1 reciprocal crossbred individuals had similar mortality trend with their F_2 reciprocal backcross counterparts during brooding. However, the mortality trend was less and somewhat different in the rearing phase. In both generations, the naked neck individuals (NaxE and Ex(NaxE)) still had the highest mortality rate like in the F_1 and F_2 main crosses considered above.

Conclusion

Backcrossing the F_1 hybrid chickens carrying the normal feather, naked neck and frizzle genes to their exotic broiler breeder sires increased the genetic profile of the crossbred native chicken lines and led to enhanced growth performance of the birds. The performance of the F_1 and F_2 reciprocal groups were superior to those of their main cross counterparts. However, chick mortality in main and reciprocal groups was generally higher in crosses bearing the naked neck genes especially during the brooding period. The situation calls for adoption of brooding and rearing strategies that minimize mortalities of chicks and pullets possessing the naked neck and frizzle genes if the local farmers and local poultry industry would benefit from the use of these tropically relevant major genes in indigenous chicken breed formation and development.

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