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RESEARCH PAPER

Heterosis and reciprocal effect for body weight and leather properties in hybrid goats

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ABSTRACT

Identification and evaluation of economically important traits in livestock is central to genetic improvement. The objective of this study was to evaluate heterosis and reciprocal effects for bodyweight and leather properties among progenies of pure and reciprocal crossing of West African Dwarf (WAD) and Red Sokoto (RS) goats. Bodyweights of 96 kids were recorded at birth, weaning and yearling. Skins collected from slaughtered goats at yearling were processed to leather using vegetable tanning approach. The leathers were subjected to physical analysis to determine Thickness, Percentage Elongation (PE), Surface Area, weight and grain properties comprising Load at Crack, Load at Tear, Distension at Crack and Distension at Tear. Heterotic effect for bodyweight was negative at birth (-8.99%) and weaning (-11.15%) but positive at yearling (6.64%). Specific heterosis for bodyweight at yearling was higher for progenies of WAD does serviced with RS bucks. General and specific heterosis were positive for all the leather traits except PE. Specific heterosis was higher when RS does were serviced with WAD bucks. Reciprocal effects for bodyweight reduces with increase in goats' age (Birth > Weaning > Yearling: 9.88 > 6.28 > 5.62).Reciprocal effects for grain properties were generally higher than other leather traits. This study concluded that WAD and RS goats are dissimilar in leather traits and bodyweight at different ages, and that choice of sire or dam for successful crossbreeding programme is trait dependent.
Keywords: Crossbreeding; Genotype; Hybrid; Traits; Vigour;

INTRODUCTION

Variation in phenotypic performance is the basis for selection for genetic improvement in livestock species. Variation exists among goat breeds in the expression of bio-economic traits like growth rate, market bodyweight, milk production and skin or leather quality. Red Sokoto goat is renowned for itsfast growth rate and leather quality, while the West African goat is reputed for its disease resistance, high kidding rate and low kidding interval (Wilson, 1991; Hamayun *et al.*, 2006). Crossbreeding is an important instrument for breeders to improve many traits in farm animals (Oseni *et al.*, 1997) and combine different characteristics of genetically different animals in the crossbred. The crossbred offspring have the tendency to be superior in some quantitative traits than either one or both parental lines. This is often referred to as hybrid vigor or sometimes positive heterosis (Baranwal *et al.*, 2012). According to Sheridan (1981), heterosis obtained through crossbreeding is directly proportional to the level of heterozygousity of the crosses, and its magnitude is inversely proportional to the degree of genetic resemblance between parental populations (Willams and Pollak, 1985). However, the crossbred progeny may not necessarily perform better than the parents (Ibe, 1998, Salako, 2012). Negative heterosis may sometimes be desirable for the crossbreds particularly in the traits like mortality and disease susceptibility, where merits are associated with lower values.

The common practice in crossbreeding programme is to select and cross a male breed of desirable trait with different (native) females breed, hence selection pressure is predominantly much on male (Wilkinson and Barbara, 1987). However, the choice of breed to serve as male or female in a crossbreeding program should rather be done objectively. Reciprocal effect is the deviation between crosses of two parental groups in which their roles were revised. It is useful in defining the extent of genetic dissimilarities between the combining breeds (Viana, 2007). It is a maternal effect and may also be due to possible difference in the combining aptitudes between males and females of the local and exotic breeds (Keambou *et al*, 2010). Reciprocal effects had been extensively reported in the crossbreeding of chicken (Yahaya *et al.,* 2009; Keambou *et al.,* 2010) and cattle (Baker *et al.,* 1986; Hossain *et al.,* 2002). There is a dearth of information on the heterosis and reciprocal effect for bio-economic traits in goat, particularly among Nigeria breeds. Thus, the aim of the present study was to evaluate crossbreeding potential of West African Dwarf (WAD) and Red Sokoto (RS) goats for bodyweight and leather traits.

MATERIALS AND METHODS

Experimental Animals and Breeding Plan

A total of forty-eight matured goats (WAD: 20 does, 4 bucks; SR: 20 does, 4 bucks) of 12 to 18 months were used to form four mating groups (pure and reciprocal crossing). Each sire (buck) was mated to four dams (does). The goats were semi-intensively managed. This involved exposure of the goats to cultivated pastures in addition to provision of housing where preserved hays, salts licks and water were provided. A total of 192 kids were produced, out of which 96 males (24 kids per group) were selected to evaluate cross breeding potentials of the two breeds for bodyweight and leather traits.

Skin Collection and Tanning Process:

Selected goats (males) were slaughtered at yearling to obtain skins which were processed to leather using *Acacia nilotica* (vegetable tanning approach) at Nigerian Institute of Leather and Science Technology (NILEST), Samaru, Zaria, Kaduna state.

Data Collection

Bodyweight

Bodyweight record of the kids were taken at birth and subsequently at weaning (3 months) and yearling (1 year). All weight measurements were recorded in kilogrammes with the use of analogue platform weighing scale of 150kg capacity with back and front cage openings.

Leather assessment

Assessment of the leather properties (physical) was done in the Quality Control Laboratory of Nigerian Institute of Leather and Science Technology (NILEST). Leather samples for the test were collected from butt region which is official sampling position (ISO, 2002) for physical analysis. The physical properties measured werepercentage elongation, thickness and grain properties (i.e. load at crack, distention at crack, load at tear and distention at tear).

Thickness

Thickness of all the leathers was measured using standard type thickness gauge (Model: REF S 4/9) at three different locations on the cut leather samples.

Percentage elongation

This was obtained using tensometer (Model: 9019 GAF 2620) which operates on the principle of two directional pull of the leather samples in two opposite directions. The tensometer has two jaws which move in two opposite directions at equal speed until the leather samples break. The distances between the jaws at initial stage and break of the leather sample were then used to calculate percentage elongation as indicated below.

Percentage Elongation = (Distance at Break – Initial Distance) x 100 / Initial Distance

Grain properties (Load and distension at crack and burst)

Circular leather samples were cuts for the ball burst process. Thesesamples were clamped on electronic lastometer (Model: 5077-ET- MUVER) which performs the test procedure on the grain surface of the leather. The extent of leather sample distension (mm) and the corresponding load (kg) before the notice of crack and that of burst (tear) were recorded by the lastometer.

Data Analysis

Data collected were subjected to simple descriptive statistics to obtain means values of the measured parameters for each of the mating groups using MINITAB statistical package version 13. Mean values obtained were used to estimate reciprocal effect and heterosis as outlined by Keambou *et al.* (2010).

Estimation of heterosis and reciprocal effect

Percent heterosis: H_{AB} (%) = $\{[P_{F1} - (P_A + P_B)/ 2] \times 100\} / (P_A + P_B)/2$

H_{AB} (%) = Heterosis; P_{F1}= Mean performance of F_1 reciprocal crossbreds

P_A= Mean performance of RS pure-line; P_B= Mean performance of WAD pure breed

Note: Specific heterosis was estimated using the mean of individual cross and pure breed average.

Percent reciprocal effect

RE (%) = (R/ Mean of crossbred) x 100

R = Reciprocal difference = $PF_{1\ (AB)} - PF1_{\ (BA)}$

PF_1 (AB) = Mean performance of F_1 progenies from crossing of breed A buck and breed B doe; PF_1 (BA) = Mean performance of F_1 progenies from crossing of breed B buck and breed A doe.

RESULTS

Heterosis and reciprocal effect for bodyweight at different ages is presented in Table 1. The mean bodyweight of pure breed (WAD and RS combined) at birth and weaning were higher than that of reciprocal crosses by 0.17 and 0.06kg respectively. The reciprocal crosses however had a comparatively higher yearling weight than the pure breed.

Negative general heterosis was obtained for bodyweight at birth (-8.99%) and weaning (-11.15%) while the heterosis for yearling weight was positive (6.69%). Specific heterosis for birth and yearling weights were also negative in the reciprocal crossings. Highest reciprocal effect (9.88%) was obtained on birth weight while that of weaning weight was slightly higher than the yearling weight with 0.66%.

Table 1. Heterosis (%) and reciprocal (%) effects for bodyweight in the crossing of WAD and RS goats

Traits	P/Mean ±SE	C/Mean ±SE	GH(%)	SH(%)R*W	SH(%)W*R	RE(%)
B/W *(kg)*	1.89 ± 0.03	1.72 ± 0.02	-8.99	-13.23	-4.23	9.88
W/W *(kg)*	8.61 ± 0.15	7.65 ± 0.11	-11.15	-8.36	-13.94	6.28
Y/W (kg)	14.35 ± 0.20	15.30 ± 0.13	6.64	9.62	3.62	5.62

Note: B/W= Birth Weight; W/W = Weaning Weight; Y/W = Yearling Weight; P/mean = Parental mean; C/Mean = Crosses mean; GH(%) = General heterosis; SH(%)R*W = Heterosis using mean performance of F_1 resulting from the cross of RS buck and WAD doe; SH(%)W*R = Heterosis using mean performance of F_1 resulting from the cross of WAD buck and RS doe; RE(%) = Reciprocal effect.

Heterosis and reciprocal effects for skin and leather traits are presented in Table 2. A relatively higher mean values were obtained for the reciprocal crosses than the pure breed in all the parameters except percentage elongation. The highest heterosis for skin property (12.77%) was obtained on skin weight while the lowest (0.78%) was recorded on skin thickness. All the leather parameters studied showed positive heterosis ranging from low to high except percentage elongation which was negative (-2.63). Leather thickness had the lowest positive heterosis (0.78%) while the heterosis for leather weight was higher than that of leather surface area by 7.10%. Specific heterosis for skin and leather traits was higher for WADxRS crossbred except for leather thickness where the difference was negligible.

The heterosis and reciprocal effect for grain properties is presented in Table 3. The reciprocal crosses had higher mean values than the pure breed for all the measured grain properties of the leather samples. Specific heterosis for load at crack and load at tear was higher when RS doe was mated with WAD buck, while distention properties were more favored with the use of RS bucks and WAD does. The general and specific heterosis as well as reciprocal effects for distention at tear were higher than that of distention at crack.

Table 2. Heterosis (%) and reciprocal (%) effects for skin and leather properties in WAD and RS goats

Traits	P/Mean ±SE	C/Mean ± SE	GH(%)	SH(%)R*W	SH(%)W*R	RE(%)
Skin						
TN (mm)	1.39 ± 0.18	1.46 ± 0.17	6.88	3.60	6.48	2.74
SA (dm²)	375.48 ± 2.23	398.86 ± 1.22	6.23	5.74	6.71	0.91
Weight (g)	1021.65 ± 2.78	1152.20 ± 2.87	12.77	12.11	13.44	1.18
Leather						
TN (mm)	1.29 ± 0.03	1.30 ± 0.04	0.78	0.78	0.77	0.77
PE (%)	74.86 ± 1.58	72.89 ± 2.28	-2.63	14.11	19.37	4.38
SA (dm²)	369.17 ± 2.34	389.15 ± 1.03	5.41	4.89	5.94	1.00
Weight (g)	944.60 ± 2.59	1062.95 ± 2.63	12.51	11.91	13.11	1.10

Note: TN = Thickness; PE = Percentage Elongation; SA = Surface Area. P/mean = Parental mean; C/Mean = Crosses mean; GH(%) = General heterosis; SH(%)R*W = Heterosis using mean performance of F_1 resulting from the cross of RS buck and WAD doe; SH(%)W*R = Heterosis using mean performance of F_1 resulting from the cross of WAD buck and RS doe; RE(%) = Reciprocal effect.

Table 3. Heterosis (%) and reciprocal (%) effects for leather grain properties in WAD and RS goats

Traits	P/Mean ±SE	C/Mean ±SE	GH (%)	SH(%)R*W	SH(%)W*R	RE (%)
CL (kg)	20.29 ± 0.38	24.12 ± 1.25	18.88	14.93	22.77	6.59
CD (mm)	4.65 ± 0.22	6.95 ± 0.38	49.46	61.72	37.20	16.40
TL (kg	11.27 ± 1.14	14.95 ± 1.26	32.65	12.33	52.88	30.57
TD (mm)	4.15 ± 0.23	6.71 ± 0.38	61.6	79.76	43.37	22.50

Note: Note: CL = Load at crack; CD = Distention at crack; TL = Load at Tear; TD =Distension at Tear; P/mean = Parental mean; C/Mean = Crosses mean; GH(%) = General heterosis; SH(%)R*W = Heterosis using mean performance of F1 resulting from the cross of RS buck and WAD doe; SH(%)W*R = Heterosis using mean performance of F1 resulting from the cross of WAD buck and RS doe; RE(%) = Reciprocal effect.

DISCUSSION

The positive heterosis for yearling weight is an indication that crossbreeding was favourable in improving the post-weaning bodyweight of WAD goat. This result supports earlier reports by several authors (Silva and Araujo, 2000; Mushi *et al*., 2009; Moyo *et al.,* 2012) indicating crossbreeding as tool for improving meat production traits in goat. The fluctuations with age in the percent F1 heterosis agrees with the earlier report of William *et al.* (2011) who obtained different percent heterosis for bodyweight at birth, pre-weaning and weaning stages in the crosses involving Boer, Kiko and Spanish goat breeds. Negative heterosis obtained for birth weight in this study was similar to the report by Salako (2012) in his work on the crossbreeding between Nigerian WAD goat and French Alpine goat. It may be desirable to have negative heterosis for some traits (Yahaya *et al*., 2009) and implies higher parental (pure lines) average than the observations for the crossbred in the traits of concern (Keambou *et al.,* 2010). Salako (2012) had earlier suggested that potential heterosis may be obscured by stressful environmental conditions and thus making the local parental-type to be comparatively better in performance than the crossbreds. Strong negative heterosis is also an indication of greater genetic distance between the tested breeds (Keambou *et al.,* 2010).

The specific heterosis for birth and weaning weights in the reciprocal crossbreds (i.e. RSxWAD and WADxRS) varied in the magnitude and direction of effects. Such results are common in literatures, for instance Fayeye (2013) obtained varying level and direction of heterosis for litter characteristics at different weeks in rabbit crosses. The higher heterosis for birth weight in RSxWAD may be linked to maternal effects. Earlier report (Yusuff and Fayeye, 2016) showed that Red Sokoto goat is morphologically bigger. It therefore has tendency for longer uterine horn which provides more room for foetal development and thus bigger neonatal bodyweight when RS is used as dam. The RSxWAD genotype however had higher heterotic effect for both weaning and yearling weight compare to WADxRS. Differences observed in percent heterotic effect for bodyweight at weaning and yearling ages in RSxWAD and WADxRS suggest that manifestation of heterosis is not only due dominance or over-dominance effect of genes but also epigenetic factors and epigenetic interactions (Baranwal *et al*., 2012). The positive general and specific heterosis obtained for bodyweight in the yearling goats suggests that some genetic gain in bodyweight could still be achieved after weaning through crossbreeding. The results showed that the gains in bodyweight accruable from reciprocal effects is greater than that of heterosis in the present crossbreeding programme. A similar report was obtained by Fayeye (2013) in a crossbreeding work involving three genotypes of domestic rabbit. The results obtained generally indicated positive heterosis at varying levels for skin quality. This shows superiority of the F_1crosses over the mean parental performance (Ibe, 1998).

The present results showed that crossbreeding was favourable in improving most of the skin and leather traits considered in the study. The results also showed that improvement of skin and leather traits would be faster through heterosis than the gains accruable from reciprocal effects. The comparatively higher reciprocal effect for leather elongation is an indication of larger genetic distance between the parental lines with respect to the locus controlling leather elongation (Hossain *et al.,* 2002).

The positive heterosis for the measured skin and leather parameters aside percentage elongation revealed a comparatively better performance of the crossbred over the average performance of the parental lines (Hossain *et al.,* 2002). Consistently higher heterosis (general and specific) and recicprocal effect for distention at crack than distention at tear suggest higher genetic distance between the WAD and RS with respect to the loci controlling distention at both tear and crack (Hossain *et al.,* 2002). Smaller degree of genetic resemblance between the parental populations (William and Pollack, 1985) usually results into higher heterosis. Thus, suggesting the WAD and RS goats used as parental lines are highly genetically different with respect to the loci controlling the grain properties of the leather. Reciprocal effect for grain properties were generally high (6.59 – 30.57%) compare to skin and other leather traits. Thus, the two parental lines could be summarized to have large genetic distance with respect to the loci controlling grain properties.

CONCLUSIONS

It is therefore concluded that crossbreeding improves bodyweight and leather traits in WAD and RS goats. The use of RS as sire line is recommended for the improvement of bodyweight, and WAD as sire line for the improvement of leather properties in WAD and RS crossbreeding program.

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