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SELECTION IN YANKASA SHEEP. II. REALIZED RESPONSE IN BIRTH AND WEANING WEIGHTS

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Target Audience: Researchers, educators, sheep breeders , animal scientists

ABSTRACT

The Yankasa sheep flock at the National Animal Production Research Institute, (NAPRI) Shika, Zaria was studied to ascertain response realized in birth weight and weaning weight from selection for weaning weight. Also, paternal half sib analysis was used to obtain estimates of heritability and genetic correlation for the traits. Data on 597 birth and weaning weight records collected from 1984 to 1989 were analysed for selection response. For heritability estimates, 1,262 birth weight records and 699 weaning weight records were used. Results indicate genetic changes per year of 0.048 ± 0.21 and 0.222 ± 1.23 kg for birth weight and weaning weight, respectively. Genetic correlation between the two traits was 0.721 ± 0.123. It was concluded that selection for weaning weight was fairly effective in improving both weaning weight and birth weight of lambs, due to the high heritability of the traits and the high genetic correlation between the two traits.

Key words: Selection response, Yankasa sheep.

DESCRIPTION OF PROBLEM

Selection for traits of moderate to high heritabilities results in genetic progress. Knowledge of the actual responses obtained in economically important traits is essential for any improvement of sheep by selection. It enables comparisons to be made between the realized response and expected response. A number of previous investigations have shown that quite often genetic response falls short of expectations (1, 2).

Selection experiments aimed at genetic improvement of economically important traits of sheep have been carried out extensively on the Merino sheep in

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of 9.7 g and 6.0 g in weight per-day-of age in Rambouillet and Romnelet sheep, respectively. Turner *et al.* (4) reported a response of 2.28% annual clean wool weight in Merino sheep.

The purpose of this paper was to obtain estimates of heritability and genetic correlation for birth weight and weaning weight as well as estimates of the actual response realized in both traits from selection for weaning weight.

MATERIALS AND METHODS

The data for this study were the same as those used to study selection intensity and generation interval in a flock of Yankasa sheep at the National Animal Production Research institute, (NAPRI) Shika, Zaria (6). The location, management of the flock and selection procedures have also been described in the paper. The performance characteristics studied were birth weight and weaning weight. The data were adjusted for environmental effects also as previously described.

Genetic parameters

Estimates of heritability of birth weight and weaning weight and the genetic correlation between them were obtained from least squares analyses of variance and covariance of paternal half-sibs (8). A total of 1,262 and 699 records collected between 1984 and 1989 inclusive were used to estimate the heritabilities of birth weight and weaning weight, respectively. A linear mixed model was used in which factors of year (1-6), parity of dam (1- $\geq$ 6), sex of lamb (male, female), type of birth (single, multiple), season of birth (1-4) and sire (97 for birth weight, 85 for weaning weight) were considered. The model was:

$$Y_{ijklmno} = \mu + R_i + P_j + X_k + T_l + Z_m + s_{n:i} + \Sigma_{jklmno}$$

where:

μ	=	overall mean
R_i	=	fixed effect of the i^{th} year of birth (i = 1,..., 6)
P_j	=	fixed effect of the j^{th} parity of dam (j = 1,..., ≥6)
X_k	=	fixed effect of the k^{th} sex of lamb (k = 1, 2)
T_l	=	fixed effect of the l^{th} type of birth (l =1, 2)
Z_m	=	fixed effect of the m^{th} season of birth (m = 1,..., 4)
$s_{n:i}$	=	the random effect of n^{th} sire nested within the ith year
Σ_{jklmno}	=	random residual error.

No interactions were included since earlier study (9) involving these factors did not indicate the presence of interaction. The term $s_{n:i}$ and Σ_{jklmno} were assumed to be independent random variables with zero means and unit variances (σ^2_s and σ^2_e respectively).

Estimates of sire (σ^2_s) and within sire (σ^2_w) variance components and sire covariance component (σ_{sisj}) between the traits were made. The heritability estimates were computed as 4 times the intraclass correlation coefficients, i.e.

$$h^2_{PHS} = \frac{4\ \sigma^{2s}}{\sigma^{2s} + \sigma^{2w}}$$

and estimate of genetic correlation was obtained as:

$$r_{gigj} = \frac{\sigma^2_{sisj}}{\sqrt{\sigma^2_{si}\ \sigma^2_{sj}}}$$

In addition, realized heritabilities of birth weight and weaning weight were determined by the ratio of the total response to the total selection differentials (5, 10) for the period of six years for which response was estimated.

Genetic progress

A total of 597 records of adjusted birth weight and adjusted 90-day weaning weight collected between 1984 and 1989 inclusive, were used to estimate the genetic response to selection. Genetic change was estimated by the method of within-sire regression of progeny performance on year (11), given as:

$$\Delta G = 2\ (b_{PT} - b_{ST})$$

where:

ΔG = genetic change

b_{PT} = linear regression of population performance on time.

b_{ST} = pooled within-sire regression of progeny performance on time.

This technique of within-sire regression measures the genetic change as changes in array of sires and assumes that the same rate of change is occurring in both sexes (11). The technique is based on the assumption that the change in performance of a population over a period of time is due to both environmental causes (t) and genetic causes (g).

The variance of the estimate was obtained by the formula:

$$4\sigma^2 / \bar{n}\ \Sigma_s\ T_Y$$

where:

$\bar{n}$ = the average number of records for each sire in any year

$T_Y = Y(Y^2 - 1)/12$, where Y = number of years in which the s[th] sire was present.

From this variance, the reliability (standard error) of the estimate of genetic change was obtained as:

$$\sqrt{4\sigma^2 / \bar{n}\ \Sigma_s\ T_Y}$$

RESULTS AND DISCUSSION

Realized response to selection

Phenotypic and genetic time trends

The phenotypic means and pooled within-sire means by year and their regressions on years for birth weight and weaning weight are presented in

Table 1. Estimates of total phenotypic and genetic changes for each of the traits are also shown. The regression of the phenotypic mean of birth weight on years was 0.041 kg/year or a total change of 0.246 kg. The genetic change was 0.048 kg per year or 0.12 kg/generation, equivalent to a total change of 0.288 kg over the period of six years. This result suggests that the annual rate of genetic progress was about 2% of the phenotypic mean in the base year (1984). These changes in birth weight are as a result of the phenotypic and genetic correlations between it and weaning weight since no direct selection was practised for birth weight. The phenotypic and genetic changes of 0.041 and 0.048 kg/year, respectively, in birth weight were almost equal. This would imply that the environment was fairly stable so that virtually all the phenotypic improvement was genetic. The result obtained for weaning weight would make this seem unlikely. On the other hand it could be argued that the environments that affect birth weight may be entirely different from those of weaning weight. If management sticks consistently to the same practices e.g. flushing and adequate nutrition during pregnancy, enabling environment for birth weight can be kept fairly stable.

Table 1. Phenotypic means and pooled within-sire means by year, and regression on years for birth weight and weaning weight

	Birth weight (kg)		Weaning weight (kg)	
Year	Phenotypic mean	Pooled within-sire mean	Phenotypic mean	Pooled within-sire mean
1984	2.58	2.58	11.45	11.82
1985	2.57	2.66	11.04	11.14
1986	2.66	2.71	10.80	10.64
1987	2.54	2.60	10.28	10.51
1988	2.59	2.69	11.08	10.89
1989	2.88	2.70	12.40	12.09
Mean	2.64	2.66	11.18	11.18
Regr. on years	0.041 ± 0.03[NS]	0.017 ± 0.01[NS]	0.124 ± 0.02[NS]	0.031 ± 0.17[NS]
Δ P[1]	0.246	0.102	0.744	0.078
Δ G[2]		0.048 ± 0.21		0.222 ± 1.23
Δ G[3]		0.120		0.553
Δ G[4]		0.288		1.332

[1] Total phenotypic change over 6-year period.
[2] Genetic change per year (kg).
[3] Genetic change per generation (kg).
[4] Total genetic change over 6-year period.
[NS] Not significant (P >0.05).

The regression of phenotypic means of weaning weight on years was 0.124 kg per year or a total change of 0.744 kg over the 6-year period, suggesting an upward trend in weaning weight. The genetic change was 0.222 kg per year or 0.553 kg/generation, equivalent to a total change of 1.332 kg over the period. This annual genetic change represents about 2% of the phenotypic mean in the base year, similar to the result obtained for birth weight. The genetic change per year in weaning weight was greater than the annual phenotypic change, suggesting that the environmental trend was negative. Nwakalor *et al.* (1) also noted a similar observation in their study. This negative environmental trend was probably due to deterioration in range conditions caused by changes in climate and especially increased stocking rates. It can be recalled that the flock size was drastically increased in 1987.

However, the regression coefficients obtained for birth weight and weaning weight were not significant ($P > 0.05$). It must be pointed out that even though heavy lambs at birth grow faster and are therefore desirable, large increases in birth weight are not desirable because of problems of difficult lambing.

The large standard errors of estimates of genetic changes obtained here place less confidence in the reliability of the estimates. Since only few sires were used for more than a year in the flock, there might not have been enough overlap in the progenies of different sires. Smith (11) had noted that without such overlap in time of progenies of different sires, the within-sire change, and so the genetic change cannot be accurately estimated. By implication, the within-sire regression which appeared to be the most appropriate method for analysing the data did not prove to be an efficient estimator of genetic change for this flock. These results reflect some of the difficulties involved in estimating genetic change in selection lines which have not been originally designed for estimating selection response.

In other selection studies Vesley and Peters (5) using the within-sire regression method estimated annual response of 1.0 kg and 1.2 kg in weaning weight of Rambouillet and Romnelet sheep, respectively when selection was for weight-per-day-of-age. Pattie (3) estimated a response of 15% per annum in weaning weight of Australian Merino Sheep. Differences in the methods of estimation, breeding and mating structures of the various flocks and the amount of additive genetic variance present in the various breeds could be responsible for the differences in results obtained in this and previous studies.

Annual rate of genetic improvement in livestock are usually small but they are continuous and cumulative for up to 10 years (12, 13) so that the amount estimated in this study could reach 2.22 kg in 10 years for weaning weight. A genetic change is permanent; it is not used up, but yields its benefits continuously and needs no further input to maintain it. It is therefore a self-sustaining and growing resource (13).

Genetic parameters

Estimates of Heritability for birth weight and weaning weight and the genetic correlation between them are shown in Table 2. Heritability estimates for birth weight and weaning weight obtained by paternal half sib (PHS) correlation via resemblance of relatives were 0.394 ± 0.091 and 0.599 ± 0.142, respectively. Corresponding realized heritability estimates obtained by regression of direct response on selection differential were 0.324 and 0.140. The heritability estimate for birth weight from PHS obtained in this study is similar to numerous other estimates. For instance, Blackwell and Henderson (14) reported a pooled estimate of 0.33 in a population comprising four breeds; MacNaughton (15) in Canadian Corriedale, 0.36; and Tallis (16) in Australian Merino, 0.34. The present estimate of 0.599 for weaning weight is similar to the value of 0.56 reported by Warwick and Cartwright (17) in Rambouillet sheep but is higher than most other reported values (5, 15, 18, 19, 20, 21).

Table 2. Estimates of heritability and genetic correlation for birth weight and weaning weight

Trait(s)	Parameter	No. of obs.	Estimate	SE
Birth weight (BWT)	h^2 (PHS corr.)[1]	1,262	0.394	0.091
	h^2 (Realized)[2]	-	0.324	ND
Weaning weight (WWT)	h^2 (PHS corr.)[1]	699	0.599	0.142
	h^2 (Realized)[2]	-	0.140	ND
BWT and WWT	Genetic correlation	699	0.721	0.123

SE = Standard error
[1] Heritability by paternal half-sib correlation.
[2] Realized heritability.
ND = not determined.

The heritability estimates of 0.394 ± 0.091 and 0.595 ± 0.142 for birth weight and weaning weight are higher than values of 0.270 ± 0.065 and 0.453 ± 0.075, respectively, obtained by Osinowo *et al.* (9) in an earlier study of the same flock. The sampling errors of estimates due to different degrees of freedom among sires as well as different corrections applied to the data could account for the discrepant results. The present estimates are based on larger amount of data and more number of sires. They have also taken better care of environmental effects and should, therefore, be more reliable.

Estimate of realized heritability for birth weight is a little lower than the heritability estimate from paternal half-sib correlation. In weaning weight, however, estimate of realized heritability was much lower than the estimate obtained from paternal half-sibs correlation. Realized heritability represents the actual accomplished change resulting from selection practised (22). The magnitude of realized heritability therefore gives an indication of the effectiveness of selection in changing the performance of the population in a given trait. It is evident that whatever errors that were associated with the estimate of response (as pointed out earlier) are reflected in the magnitude of the estimate of realized heritability since it is a ratio of selection response to selection practised. More confidence should then be placed on the heritability estimate obtained from paternal half-sibs correlation in this study than on the realized heritability for weaning weight. Heritability estimate from this study is moderate for birth weight and high for weaning weight. Therefore, selection would be effective in the improvement of these traits. On the basis of the magnitude of heritability estimates from paternal half-sib correlation, it appears that weaning weight would respond more to direct selection than birth weight.

The genetic correlation between birth weight and weaning weight was estimated at 0.721 ± 0.123. There are no estimates in the literature of genetic correlation between birth weight and weaning weight in the Yankasa sheep for comparison with the present result. However, reports on other breeds include estimates of 0.33 ± 0.30 in Rambouillet sheep (21), 0.53 in Polish Merinos and 0.79 in Polish long wool sheep (23), and 0.59 ± 0.38 in Corriedale sheep for genetic correlation between birth weight and 70-day weaning weight (14). The present result is within the upper and lower limits of estimates by these workers. Given the high genetic correlation between birth weight and weaning weight (0.721), substantial response in birth weight would be expected to result from direct selection for weaning weight. This has been demonstrated in this study, judging that the annual genetic change in each these traits was about 2% of the mean phenotypic performance in the base year, reflecting pleiotropic gene effects in action.

CONCLUSION AND APPLICATIONS

It can be concluded from this study that;

(1) Selection for weaning weight has been fairly effective in improving both weaning weight and birth weight of lambs.

(2) The result is attributed to the moderate to high heritability of the traits and the high genetic relationship between them. Perhaps much better response would have been realized if the selection pressure applied was a lot more intense than that reported in the first paper.

(3) However, it must be borne in mind not to over-emphasize birth weight in any selection programme, to avoid the problems of dystocia and lamb death losses. Nevertheless, optimum birth weights should result in heavier weights at weaning.

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