

Genetic Evaluation and Selection Response of Birth Weight and Weaning Weight in Indigenous Sabi Sheep

N. Assan*, S. Makuza¹, F. Mhlanga¹ and O. Mabuku²

Matopos Research Station, Private Bag K 5137, Bulawayo, Zimbabwe

ABSTRACT : Genetic parameters were estimated for birth weight and weaning weight from three year (1991-1993) data totalling 1100 records of 25 rams to 205 ewes of Indigenous Sabi flock maintained at Grasslands Research Station in Zimbabwe. AIREML procedures were used fitting an Animal Model. The statistical model included the fixed effects of year of lambing, sex of lamb, birth type and the random effect of ewe. Weight of ewe when first joined with ram was included as a covariate. Direct heritability estimates of 0.27 and 0.38, and maternal heritability estimates of 0.24 and 0.09, were obtained for birth weight and weaning weight, respectively. The total heritability estimates were 0.69 and 0.77 for birth weight and weaning weight, respectively. Direct-maternal genetic correlations were high and positive. The corresponding genetic covariance estimates between direct and maternal effects were positive and low, 0.25 and 0.18 for birth weight and weaning weight, respectively. Responses to selection were 0.8 kg and 0.14 kg for birth weight and weaning weight, respectively. The estimated expected correlated response to selection for birth weight by directly selecting for weaning weight was 0.26. Direct heritabilities were moderate; as a result selection for any of these traits should be successful. Maternal heritabilities were low for weaning weight and should have less effect on selection response. Indirect selection can give lower response than direct selection. (*Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 12 : 1690-1694*)

Key Words : Genetic Parameters, Variance Components, Selection Response, Indigenous Sabi Sheep

INTRODUCTION

The Sabi sheep is the most common indigenous breed in Zimbabwe. The breed is small in size and relatively slow growing, but is hardy and fecund under adverse conditions. Most sheep flocks in Zimbabwe have originated from the indigenous Sabi ewe but since the turn of the century there has been a continual infusion of Blackhead Persian (Donkin, 1973). The indigenous breed is a fat tailed type (Ward, 1959) characterized by a non-wooled hairy coat of a multiplicity of colours (Donkin, 1973). The coat of short stiff hair is generally fawn, brown and/or red in colour but black and pure white are also common as are the mixed colours. It has similar features to Red Maasai and Tswana sheep of Eastern and Southern Africa (Mason and Maule, 1960). The resistance of their hairy coat to penetration by awned seeds allows the breed to enjoy wide distribution in the country. The Sabi is noted for its hardiness and fecundity under arduous conditions and in addition, for its resistance to certain local diseases and pests. Sabi sheep are relatively slow growing reaching adult mature weights of 35 kg (ewes) to 45 kg (rams) (Devendra and McLeroy, 1982). Females conceive first at ten months with a body

mass of approximately 18 to 20 kg. Arrowsmith and Ward (1983) noted that males reach puberty (as judged by first ejaculation) at 169 days weighing 21 kg. The most notable feature is the fat tail which seems to function as a food reserve for periods of nutritional stress.

Few attempts have been made to improve the genetic potential of this breed through selection. Genetic improvement of indigenous Sabi sheep is imperative considering the improvement in productivity that has been achieved by changes in management. Although there is an increasing national and international interest in indigenous species of animals for genetic conservation and improvement, relatively little attention in the field of quantitative genetics has been given to the indigenous Sabi sheep in Zimbabwe. Unlike for exotic sheep breeds, no estimates of both covariances components and genetic parameters for weight traits in indigenous Sabi sheep have been estimated to allow the development of sensible breeding programmes. The records of indigenous Sabi flock at Grasslands Research Station, Marondera, Zimbabwe although small provided an opportunity to estimate the genetic parameters for birth weight and weaning weight. The objectives of this study were:

- (a) to estimate direct and maternal heritability for birth weight and weaning weight.
- (b) to determine covariances and correlations between direct and maternal effects for birth weight and weaning weight.
- (c) to predict responses to direct selection for birth weight and weaning weight.

* Corresponding Author: N. Assan. Tel: +263-838-264, Fax: +263-838-253, E-mail: ziimagadzire@gatorzw.com

¹ Department of Animal Science, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe.

² Grasslands Research Station, Private Bag 3701, Marondera, Zimbabwe.

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MATERIALS AND METHODS

Flock management

All animals were grazed on free range, and protein concentrates were given during the dry season. The ewes plus their progeny were grazed on an extensively managed dryland veld during the day from 08:00 h to 15:00 h and were penned in a kraal at night. General flock health management included monthly dipping during the rainy season and two monthly dippings during the dry season. All animals were vaccinated against Pulpy Kidney and Rift Valley Fever. Animals had access to water in the kraal at all times.

The ram were left to run with the flock both during grazing and the breeding/ mating period. The main breeding season was between May and June. Ewes which failed to conceive were remated after 20 days. Single sire flocks comprised of one ram to 30 ewes. Ewes were introduced to the breeding flock for mating when they attained one and half years of age and rams were not used for service until they were over one and half years old. Most lambs were born between late October and early November which is the start of the rain season. Lambs were weighed and ear tagged soon after birth and left to suckle their dams during grazing until weaning at three months of age. Lambs were separated by sex at weaning into two weaner flocks. The records taken on lambs included birth weights and weaning weights.

Data and statistical analysis

Data on birth weight and weaning weight were obtained from Grasslands Research Station, Marondera, Zimbabwe. The data included a total of 1100 ewe progeny records from 25 rams and 205 ewes of Indigenous Sabi sheep, born between 1991 and 1993. All animals had the same genetic background and were subjected to the same selection and feeding procedure. The means (\pm SE), standard deviations and the coefficients of variation for the traits measured in the Indigenous Sabi sheep are presented in Table 1. The data were edited to remove outliers and incorrect data. Records were deleted if missing sire or dam identification or duplication of pedigree. An analysis was done using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) (1996) to establish the significance of the non-genetic factors. Weight of ewe at first joining with ram for mating was fitted as a covariate. Only significant non-genetic factors were used in the animal

Table 1. Summary statistics of the data set used to estimate variance components for birth weight and weaning weight in Indigenous Sabi sheep in Zimbabwe

Trait	No of records	Mean	Std. dev	CV
Birth weight	1100	3.29 \pm 0.033	0.926	28.13
Weaning weight	1100	13.96 \pm 0.142	4.042	26.75

model as fixed effects. The linear statistical model fitted was:

$$Y_{ijkl} = \mu + Y_i + S_j + T_k + b(P_{ijkl}) + e_{ijkl}$$

where;

Y_{ijkl} =the traits studied (birth weight, weaning weight);
 μ =overall mean (constant);
 Y_i =fixed effect of year of lambing; i^{th} =1991, 1992, 1993;
 S_j =fixed effect of sex of lamb; j^{th} = male, female;
 T_k =fixed effect of birth type; k^{th} = single, twins;
 b =linear regression coefficient of weight of ewe at joining on birth weight and weaning weight;
 e_{ijkl} =is the error term, assumed to be randomly and independently distributed with a mean equal to 0 and variance equal to 0.

Animal model

Genetic parameters were estimated using the Average Information Restricted Maximum Likelihood (AIREML) methodology (Gilmour, 1995) using an Animal Model. In matrix notation the univariate mixed linear model used was of the maternal form.

$$y = Xb + Zu + Wm + Sl + e$$

where;

y =vector of birth weight and weaning weight;
 b =vector of year of lambing, sex and birth type;
 u =vector of animal (direct) effects;
 m =vector of maternal (indirect) genetic effects;
 l =vector of common environmental (litter) effects of ewe;
 e =vector of random residual effects;

X , Z , W and S are incidence matrices relating records to fixed, animal, maternal genetic and litter effects respectively.

It is assumed that:

$$\text{var} \begin{pmatrix} \mu \\ m \\ l \\ e \end{pmatrix} = \begin{pmatrix} Ag_{11} & Ag_{12} & 0 & 0 \\ Ag_{21} & Ag_{22} & 0 & 0 \\ 0 & 0 & I\sigma^2_l & 0 \\ 0 & 0 & 0 & I\sigma^2_e \end{pmatrix}$$

where :

g_{11} =additive genetic variance for direct effects;
 g_{22} =additive genetic variance for maternal effects;
 g_{12} =additive genetic covariance between direct and maternal effects;
 $I\sigma^2_l$ =variance due to common environmental (litter)

effects of the ewe;
 σ_e^2 =residual error variance.

A is the numerator relationship matrix among animals and I is the identity matrix.

Total heritability (h_T) was calculated as:
 $h_T = (\sigma_a^2 + 3/2\sigma_{am}^2 + 1/2\sigma_m^2) / \sigma_p^2$

Estimation genetic progress

Genetic progress (R) was calculated using the formula:

$$R = [(i_m + i_f) / (L_m + L_f)] \times h^2 \times \sigma_p^2$$

where :

R= annual rate of response to selection;
 $i_m + i_f$ =selection intensity for males and females respectively;
 $L_m + L_f$ =generation interval for males and females respectively;
 h^2 =heritability for trait of importance;
 σ_p^2 = phenotypic standard deviation;

The selection intensity (i) is a function of the proportion of animals selected to be the future parents (p). In order that the effects of selection intensity on genetic progress may be established, selection intensity used for sires were: $i_m = 1.75$ (p=10%), while for ewes was (i)=0.52 (p=75%). Generation intervals were taken to be 3 years for males and 4 years for females.

Correlated response to selection

Correlated response was calculated using the following formula:

$$CR_x = i h_x h_y r_A \sigma_{PY}^2$$

where:

CR_x =correlated response of birth weight resulting from selection applied to weaning weight;

i=intensity for selection;
 h_x =accuracy of selection for birth weight;
 h_y =accuracy for selection for weaning weight;
 r_A =correlation between birth weight and weaning weight ;
 σ_{PY}^2 =phenotypic variance for weaning weight;

RESULTS AND DISCUSSION

Covariance components and genetic parameter estimates for birth weight and weaning weight are presented

in Table 2. Moderate estimates of direct heritability were obtained for birth weight, 0.27 and weaning weight, 0.38. There are comparable estimates of direct heritability estimates for birth weight (Campbell, 1971; Carriedo et al., 1988; Larqard et al., 1998) and for weaning weight (Babar et al., 1998; Maria et al., 1993, 1993). Literature estimates for direct heritability are variable and range from low to high. Lower direct heritability estimates than in present study have been reported in the ranges of 0.02 to 0.16 (Kirman et al., 1988; Singh et al., 1988; Tsenkov et al., 1989) for birth weight and 0.07 to 0.18 (Abboud, 1989; Notter, 1998) for weaning weight. The direct heritability estimates obtained in this study for birth weight were within the range of 0.03 to 0.43 from ten studies and the weaning weight estimates coincide with the range of 0.08 to 0.62 from 12 studies all summarised by Wiener, (1994). The estimates herein fall within the range also of 0.10 to 0.72 for birth weight and 0.08 to 0.59 reported by Bowman, (1968). Although this study was undertaken in a extensive management system the results are well within those reported for exotic breeds under intensive management (Olivier et al., 1994).

The maternal heritability estimates are lower than direct heritability estimates (0.24 vs 0.27) for birth weight and (0.09 vs 0.38) for weaning weight. The maternal heritability estimate for birth weight is moderate and in agreement with

Table 2. Variance components and genetic parameters in Indigenous Sabi sheep

Component	Birth weight	Weaning weight
σ_a^2	14.19	19.99
σ_m^2	12.42	4.599
σ_{am}^2	13.25	1.931
σ_{litter}^2	1.47	9.586
σ_p^2	52.58	53.278
σ_e^2	10.52	15.71
h_a^2	0.27	0.38
s.e.	0.02	0.006
h_m^2	0.24	0.09
s.e.	0.01	0.006
h_T^2	0.77	0.69
Cov_{am}	0.25	0.18
r_{am}	1.00	1.00
R	0.8	0.14
CR_x		0.26

x =birth weight.

σ_a^2 =direct additive genetic.

σ_m^2 =maternal additive genetic variance.

σ_{am}^2 =direct and additive variance.

σ_{litter}^2 =common environmental (litter) variance.

σ_p^2 =phenotypic variance = sum of variance and covariance components.

σ_e^2 =error variance.

h_a^2 =direct heritability.

h_m^2 =maternal heritability.

h_T^2 =total heritability (total genetic effect).

cov_{am} =direct and maternal genetic covariance.

r_{am} =direct and maternal genetic correlation.

earlier observations in lambs (Maria et al., 1993; Larsgard et al., 1998; Nesar et al., 2001) but higher than those reported by other researchers (Snyman, 1996; Maria et al., 1993; Tosh and Kemp, 1999; Gray et al., 1999). South African breeds maternal heritability estimates vary from 0.07-0.20 (Nesar et al., 2001). The maternal heritabilities reported for weaning weight in the present study are low, 0.09 and are within the range reported in literature of 0.6 to 0.14 (Larsgard et al., 1998; Khaldi et al., 1989; Snyman, 1996).

Total heritability estimates were 0.77 and 0.69 for birth weight and weaning weight, respectively. Direct heritability was higher for weaning weight, but larger maternal component of birth weight gave higher total heritability. The total heritability values are higher than the range of estimates by other researchers (Burfening and Kress, 1993; Van Wyk et al., 1993a; Tosh and Kemp, 1994; Snyman, 1996) which were 0.11 to 0.33 and 0.18 to 0.22 for birth weight and weaning weight, respectively.

Understanding of the relationship between direct and maternal effects will facilitate formulation of optimum breeding programmes and improvement of selection efficiency (Robison, 1981). The results in literature dealing with the genetic correlations between direct and maternal effects for both traits vary (Nesar et al., 2001). The correlations estimates reported are mostly negative in contrast to the positive estimates reported in the present study. Genetic correlations of direct and maternal effects of -0.74 to 0.01 were reported by other authors (Burfening and Kress, 1993; Mousa et al., 1999; Tosh and Kemp, 1994) while the results of Oku et al. (1999) reported estimates ranging from -0.99 to 0.99 which agrees quite well with the value of 1.0 in the present study. Direct and maternal additive genetic correlation of 1.0 was also reported by Snyman et al. (1996) in Merino sheep for weight at 18 month. The high positive direct- maternal additive genetic correlation could probably be the result of a small size of the data set used in this study. However it cannot be ruled out that the high positive direct-maternal additive genetic correlation is an indication of a possibility to improve maternal effect while selecting for both traits. For accurate and unbiased analysis of direct-maternal additive genetic correlation very large data sets are required. With a data set of the size ($n=1100$) used in this study such deviations cannot be expected. Positive estimates of covariances were obtained in this study, 0.25 and 0.18 for birth weight and weaning weight, respectively. Other researchers reported strong negative covariances (Burfening and Kress, 1993; Maria et al., 1993). Negative estimates for direct and maternal correlations have been reported in beef cattle (Tawonezvi, 1982). Yazidi et al. (1997) observed positive direct- maternal correlations for birth weight and weaning weight of approximately, 0.18 and 0.50, respectively which

are lower than those observed in the present study.

Responses to selection were 0.8 kg and 0.14 kg for birth weight and weaning weight, respectively. The estimated expected correlated response to selection for birth weight by directly selecting for weaning weight was 0.26.

Direct heritabilities were moderate and so selection for any of these traits should be successful. Maternal heritabilities were low for weaning weight and should have less effect on selection response.

CONCLUSION

Direct heritabilities were moderate and so conventional selection for both traits should give genetic progress. Maternal heritabilities were low for weaning weight and should have no effect on selection response. Indirect selection gave lower responses than direct selection.

IMPLICATIONS

This study should be repeated with more records from a longer study period on different management regimes.

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