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Construction of new selection criteria for Malpura sheep

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ABSTRACT

Malpura sheep is one of the heavy mutton type sheep breeds found in semi-arid region of Rajasthan. Objective of the study was to revise the earlier selection criteria and set up a new one for Malpura sheep. The data on 2,995 Malpura sheep descended from 188 sires and 1,021 dams for 11 years (2004–2014) was used to construct the indices using various combination of traits. Genetic parameters were estimated for the traits to be included in the analysis for the data. Estimate of additive genetic variance for 6 month live weight (6WT) was low ($h^2 = 0.19 \pm 0.04$). It was recommended to incorporate external germplasm for enhancing the additive genetic variability of the flock. The selection indices were constructed and highest accuracy (51.9%) was observed for the index that involves weaning weight (WWT) and first greasy fleece weight (GFW). Estimated genetic gain after 1 generation post selection was measured to be 221 g in WWT and 81.753 g in GFW. Possibility of direct selection for single trait (6WT) was explored. Results revealed higher response for 6WT (897 g) and high correlated response for other traits such as WWT (0.566 kg), ADG1 (5.601 g), ADG2 (3.132g) and GFW (26.52 g) as compared to index selection. As milk yield of dam has strong influence on pre-weaning gain, preliminary selection at weaning followed by direct selection at 6 month age based on single trait selection (6WT) was recommended as selection criteria.

Key words: Genetic improvement, Heritability, Malpura sheep, Selection criteria

The Malpura sheep, one amongst the heaviest sheep breeds of India, is widely distributed in the semi-arid region of Rajasthan, mostly Tonk, Jaipur and Sawai Madhopur districts. The total economic value of an animal always depends upon several traits. Several traits in selection necessitate lower selection intensity for each individual trait. In spite of the fact that multi-trait selection is the only possible way to increase the total economic value of the animal, it decreases the progress in individual trait. Out of the 3 methods (tandem selection, independent culling level and selection index) of multi-trait selection (Hazel and Lush 1943), selection index is considered as the best method due to relative weightage assigned to each trait.

Malpura sheep were selected in the past using selection index that involved live weight at 6 months and first greasy fleece yield, however due to decreasing importance of wool in the market, it was removed from the index and subsequently, average daily gain that reflects the maternal influence due to milk yield was incorporated. As the selection index is robust only for 4 to 5 years, it was envisaged to revise the index and also consider the option of single trait selection along with correlated response *vis-a-vis* selection index for expected response per generation.

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MATERIALS AND METHODS

The present study was conducted on the data of 2,995 Malpura animals descended from 188 sires and 1,021 dams for 11 years (2004–2014) to revise and construct the selection index/criteria for Malpura sheep flock. The sheep flock was maintained at the institute. Details of the management of the flock are as given in Gowane *et al*. (2010a). Birth weight (BWT) is taken within 24 h of birth of lamb, and weaning weight (WWT) and 6 month weight (6WT) were taken on exact dates. Average daily gain (ADG) was calculated as ADG1 = [(WWT-BWT)/90] × 1,000 and ADG2 = [(6WT-WWT)/90] × 1,000.

Estimation of genetic parameters: Genetic parameter estimates for all the traits under study were calculated by animal model with animal as the only random effect. The linear model for data analyses was:

$$y = X\beta + Z_a a + \varepsilon$$

where, y, vector of records; β, a and ε vectors of fixed, additive animal genetic and residual effects, respectively; with association matrices X and Z_a. Fixed effects in the model included year of birth and sex of the lamb. Ewe weight at the time of birth and dam age at the time of birth were included as the covariates for growth traits. The significance of fixed effects on the production traits were analysed by SPSS (2005). Estimates of genetic parameters (G, additive genetic variance covariance matrix; P, phenotypic variance covariance matrix; h^2,direct heritability; r_g, genetic correlation; and r_e, residual correlation) for different traits were obtained by restricted maximum likelihood (REML) WOMBAT (Meyer 2007) using an average information (AI) algorithm. Convergence was assumed when change of value of the natural logarithm of the restricted likelihood function in 2 consecutive iterations was lower than 5×10^{-4}. Bivariate animal model were run to know the genetic correlation between the traits being used for construction of index.

Construction of selection indices: Four production traits, viz. birth weight (BWT), weaning weight at 3 months (WWT), 6 month weight (6WT), average daily gain from birth to 3 months (ADG1), average daily gain from 3 to 6 months (ADG2), and first greasy fleece yield (GFW) at 6 month age were taken to construct different selection indices having combination of 2 traits each. Selection objective included enhancing the growth properties of the Malpura sheep. Selection indices were constructed as follows (Falconer and Mackay 1998):

$$b = P^{-1}Ga$$

where, b, vector of regression coefficient for respective traits; and a, vector of relative economic values for traits under study.

Relative economic values for traits were given as per the method of income from respective traits. Mutton has market value of ₹ 300/kg, with respect to expected 50% dressing percentage, it becomes ₹ 150/kg of live weight. Market value of the wool is ₹ 140/kg. Now considering the total weight harvested at particular age and fleece yield at 6 month based on the average values of the traits (Table 1), the economic weights were assigned to each trait with respect to 6WT, as given in Table 1. Indices were constructed including WWT, 6WT, ADG1, ADG2 and GFW. BWT was not included for construction of index, as its inclusion masks individuals true potential due to maternal effect. Accuracy of selection and expected genetic gain was calculated. The intensity of selection in males was 20% that yielded the value of i as 1.3.

Correlated response: Alternative approach of estimating the expected genetic gain by selection through correlated response was also used. Assuming, 6WT as the most important trait in selection, the correlated response in other traits was calculated and comparison with expected response from the index was made.

RESULTS AND DISCUSSION

The present study aimed at studying the production characteristics of the Malpura sheep and looking in to the importance of traits in to consideration, set up a suitable selection criteria. Least squares means along with the standard deviation (SD) and percent coefficient of variation for lamb growth traits and GFW under study are given in Table 1.

Genetic and phenotypic variance-covariance matrices for combination of 2 traits at a time were estimated. Additive genetic variance for 6WT was observed to be moderate in Malpura sheep (h^2= 0.19±0.04). Present estimate is based on recent data that spans over 11 years (2004–2014). Earlier estimates of h^2 for 6WT were little higher in Malpura sheep (Gowane *et al*. 2010a, Prakash *et al*. 2012), however those estimates were based on large data set (23–25 years). Since last many years, there has been no addition of germplasm from outside in the nucleus flock. Continuous selection for 6WT has resulted in decline in the genetic variance of the sheep for this trait. Additive genetic variance for BWT was high (h^2= 0.43±0.03), for WWT, ADG1 and GFW the estimates were moderate and for ADG2, it was low. Heritability estimates along with the genetic, phenotypic and residual correlations for the current data are presented in Table 2. Estimate of genetic correlation of BWT with other traits was positive and moderate to high except for ADG2, where negative association was observed. High and positive estimate of genetic correlation was observed for WWT-6WT and WWT-ADG1. Genetic correlation of 6WT with all the growth traits and GFW was high and positive, indicating better scope for correlated response, if the single trait selection based on 6WT is practiced. Similar results were obtained by Prakash *et al*. (2012) in Malpura sheep.

Table 1. Characteristics of the data structure for traits of economic importance in Malpura sheep

	BWT	WWT	6WT	ADG1	ADG2	GFW
Data structure						
No. of records	2995	2651	2192	2625	2159	2109
No. of sires	188	184	166	184	166	163
No. of dams	1021	990	924	982	921	908
Summary statistics						
Mean	3.07	14.64	22.19	128.47	80.71	666.19
SD	0.59	3.43	4.48	35.74	32.41	236.47
CV(%)	19.21	23.43	20.19	27.82	40.16	35.50
Economic weightage (a)	0.13	0.65	1	0.73	0.35	0.025

In total 10 selection indices were constructed using combination of 2 traits each. The estimates of regression coefficients (b) values obtained for each selection index along with the accuracy of the index and expected genetic gain for individual trait after one generation of selection using the prescribed selection index is given in Table 3. Index involving 6WT and GFW gives regression coefficients of 0.137 and 0.008 for the respective traits, indicating very low weightage for GFW as compared to 6WT. Ganai (1996) reported b value of 0.20 and 2.15 for 6WT and GFW in index constructed for Marwari sheep. For Bharat Merino sheep, b value of 0.06 and 0.61 for 6WT and GFW was reported earlier (Gowane *et al*. 2010b). For current study, index involving 6WT and ADG1 has regression coefficients of 0.622 and 0.050, respectively. For 6WT and ADG2 estimates for b were 0.398 and 0.004, respectively.

Accuracy of the selection index is essential for comparison of the selection indices. Accuracy was calculated and presented in Table 3. Almost all the indices had similar accuracy ranging from 33.9% for WWT-ADG1 to 51.9% for WWT-GFW. Index involving 6WT-GFW had accuracy

Table 2. Estimates of heritability (diagonal), genetic correlations (above diagonal) and phenotypic correlations (below diagonal) of different economically important traits of Malpura sheep

Trait	BWT	WWT	6WT	ADG1	ADG2	GFW
BWT	**0.43±0.03**	0.50±0.10	0.41±0.10	0.22±0.12	–0.009±0.16	0.38±0.09
WWT	0.38±0.02	**0.13±0.03**	0.92±0.04	0.95±0.01	0.41±0.21	0.28±0.13
6WT	0.34±0.02	0.78±0.01	**0.19±0.04**	0.90±0.05	79±0.10	0.39±0.11
ADG1	0.22±0.02	0.99±0.001	0.76±0.01	**0.12±0.03**	0.39±0.22	0.18±0.14
ADG2	0.02±0.02	–0.04±0.02	0.64±0.01	–0.04±0.02	**0.08±0.03**	0.34±0.16
GFW	0.23±0.02	0.31±0.02	0.40±0.02	0.28±0.02	0.24±0.02	**0.29±0.04**

Table 3. The b values, accuracy of the index and expected genetic gain# after 1 generation of selection for Malpura sheep including 2 traits

Indices	Traits	b_1	b_2	r_{HI} (%)	Δg_1	Δg_2
1	WWT-6WT	0.087	0.182	0.408	0.568	0.807
2	WWT-ADG1	0.787	0.016	0.339	0.482	4.665
3	WWT-ADG2	0.226	0.031	0.355	0.470	2.989
4	WWT-GFW	0.014	0.007	0.519	0.221	81.753
5	6WT-ADG1	0.622	0.045	0.387	0.768	5.536
6	6WT-ADG2	0.398	0.004	0.390	0.841	3.201
7	6WT-GFW	0.137	0.008	0.513	0.596	80.115
8	ADG1-ADG2	0.103	0.065	0.385	50299	2.400
9	ADG1-GFW	0.077	0.007	0.369	40263	46.999
10	ADG2–GFW	0.022	0.009	0.464	2.337	77.312

#Genetic gain in kg for all the traits except GFW, ADG1 and ADG2, where it is in gram. b_1, b_2 are regression coefficients and Δg_1, Δg_2 are estimates of expected genetic gains for trait 1 and trait 2, respectively, using the index.

Table 4. The estimate of correlated response in traits (Y) per generation due to direct selection for 6 month weight#

Traits	Genetic correlation with 6WT	Δg as correlated response
BWT	0.41±0.10	0.081 kg
WWT	0.92±0.04	0.566 kg
ADG1	0.90±0.05	5.601 g
ADG2	0.79±0.10	3.132 g
GFW	0.39±0.11	26.517 g

#expected response in 6WT by direct selection shall be 897 g per generation.

of 51.3%. Accuracy of 0.526 was reported for index involving 6WT-GFW in Marwari sheep by Ganai (1996) and 0.257 in Bharat Merino sheep by Gowane *et al*. (2010b). Considering the use of each selection index for one generation, the genetic gain per year can be obtained. It was estimated that after using these 10 indices for at least one generation of selection, there shall be improvement in the traits (Table 3). All the indices had positive expected genetic gains; however the gain varied depending on the weightage given to each trait in different indices. Estimated milk production is correlated with progeny growth traits. This correlation has averaged over 0.70 indicating that half the variability in progeny weaning weight is accounted for by differences among dams in milk production in sheep (Gardener and Hogue 1964). The amount of milk produced by various breeds at various stages of lactation has a strong influence on lamb growth during the preweaning period, with 20 to over 60% of the variation in weaning weight accounting for the volume of milk produced (Peart 1982). Therefore, while setting selection criteria in sheep, the average daily gain till weaning should be given due importance.

Correlated response in traits was estimated for direct selection of 6WT (Table 4). Estimate of direct response in 6WT was observed to be 897 g/generation, which was higher than all the expected genetic gains as obtained using different indices, which involve 6WT as one of the traits for selection. The correlated response in other traits was calculated and it was observed to be 81 g in BWT, 566 g in WWT, 5.601 g in ADG1, 3.132 g in ADG2 and 26.52 g in GFW. All these responses are positive and higher or at par with the expected gains by using selection indices except for GFW. This picture is very encouraging if single trait selection for 6WT is practiced. The importance of wool has declined and therefore giving much emphasis for improvement of GFW will not be much beneficial.

Improvement in the desired traits for growth is essential to harvest the benefits of selection in Malpura sheep. This flock has moderate genetic variability for weight at 6 months for the dataset studied and hence, the additive variance must be increased by incorporating good external germplasm in the nucleus. However, looking at the results of this study, it is envisaged that the single trait selection using 6WT shall be the best selection criteria for this flock. Genetic correlation between WWT and 6WT is 0.92, and hence preliminary selection at weaning followed by final selection at 6WT should be practiced for improvement of this flock. This type of selection criteria is expected to deliver better response not only in 6WT but also for other traits of economic importance in Malpura sheep.

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