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Comparative estimation of breeding values in Nellore rams for growth traits using sire and animal models

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Abstract
Estimates of breeding values were obtained for birth weight and body weight at 3, 6, 9 and 12 months of age in Nellore sheep maintained at an organized sheep farm at peddakadupuru village in Kurnool district of Andhra pradesh, India. Data on growth traits were recorded for a total of 756 number of lambs belonging to 18 sires and were analyzed by using 3 different sire evaluation methods *viz.*, simple regressed least-squares (SRLS), best linear unbiased prediction (BLUP) and restricted maximum likelihood (REML) methods. Error variance estimated by SRLS, BLUP and REML methods for birth weight, body weight 3, 6, 9 and 12 months of age were found to be 0.052, 0.051 and 0.058; 0.206, 0.205 and 0.236; 0.212, 0.211 and 0.231; 0.202, 0.201 and 0.225 and, 0.207, 0.206 and 0.284 respectively. The coefficient of determination (R^2) value by SRLS, BLUP and REML methods were found to be 21.6, 27.9 and 1.82; 91.8, 92.5 and 46.1; 95.0, 95.9 and 42.7; 94.9, 96.8, 47.9; 95.3, 97.2 and 18.9 for birth weight and body weights at 3, 6, 9 and 12 months of age respectively. Spearman's rank correlation and product moment correlations between SRLS and BLUP method was found to be highly significant (P<0.01). The BLUP method seems to be the most efficient, (lower error variance) accurate (higher coefficient of determination) and stable (lower coefficient of variation) method among all. However, significant and higher magnitude of rank correlations between BLUP and SRLS showed that SRLS could be used as next best method.

Keywords: SRLS**,** BLUP; REML, body weights, breeding value, Nellore sheep

Introduction
The sheep population in India is estimated to be about 65.07 million (BAHS, 2014) ranking third in the world, and is about 6.13% of the total world population. There are 42 indigenous breeds of sheep in India, reared for meat and wool purpose which play an important role in the biodiversity and livelihood of a large proportion of small and landless labourers. Nellore sheep is tallest meat type breed present in Nellore, Prakasam and Rayalaseema districts of Andhra Pradesh and is known for heat tolerance, disease resistance and thrives well in harsh conditions.

Growth traits are important characters for getting maximum economic benefits to sheep farmers which may vary between breeds, flocks as well as individuals. So, there is great need to estimate the breeding value of rams for production traits. Sire evaluation is one of the most important aspects of breed improvement programs which enhance the genetic potential of animals for any trait in a herd as the contribution of sire path is higher than the dam path for the overall genetic improvement of a trait (Banik and Gandhi, 2007) [1]. The present study was planned to evaluate the rams based on birth weight and body weights at 3, 6, 9 and 12 months of age by using different sire evaluation methods *viz.*, simple regressed least-squares (SRLS), best linear unbiased prediction (BLUP) and restricted maximum likelihood (REML) and to compare their efficiency, to identify the most effective method of sire evaluation in Nellore sheep.

Materials and methods
The data for the present study was collected from Nellore sheep maintained at an organized sheep farm under semi intensive production system in Kurnool district of Andhra Pradesh. Rams and ewes were housed separately in a temporary fence made of bamboo sticks with thatched roofing. Newborn lambs were housed with their dams up to one month of age and thereafter reared separately. The lambs were allowed for suckling twice a day, in the morning and evening until weaning age of 90 days. Body Weights were recorded within 24 hours after birth and at 3, 6, 9 and 12 months of age.

Sheep were uniformly fed with concentrate mixture at the rate of 50 to 100 g per day per animal as per their ages from 15 days to weaning age. Sheep were allowed for grazing from 8.00 a.m. to 5.00 p.m. daily with a break of one hour during mid-day. In poor grazing conditions (*i.e.*, during summer), the animals were supplemented with concentrate mixture at the rate of 50 to 400 g per animal per day depending upon sex, age, pregnancy and lactation conditions.

Statistical analysis

The mathematical model used was based on the assumption that different components fitting in the model were linear, independent and additive. While sire was treated as random effect, the other genetic and non-genetic factors (sex, season and year) were taken as fixed effects in the model. The main objective of sire evaluation is to obtain an accurate and unbiased estimate of breeding value of rams and ranking them on the basis of performance of their daughters so as to enable the breeders to choose the best ram for subsequent improvement of the flock. The following three evaluation methods were used to estimate the breeding values of rams.

Simple regressed Least-squares (SRLS)

The breeding value of rams were estimated by Simple regressed least-squares method using LSMLMW and MIXMDL (Harvey, 1990) [3] using following mathematical model:

$$Yij = \mu + Fi + eij$$

Best Linear Unbiased Prediction (BLUP)

The breeding values were estimated by BLUP (Henderson, 1973) [4] using LSMLMW and MIXMDL package of Harvey (1990) [3] as per the following general mixed model:

$$Y = Xb + Zu + e$$

Restricted maximum likelihood (REML)

The breeding values (EBVs) were estimated by REML computer programme using a univariate model as described by Meyer (1989) [6]. Following is the general mixed linear model for a trait with vector of N observations for the trait.

The effectiveness of different sire evaluation methods was judged by within sire variance (error variance). The method giving lowest error variance had higher efficiency and was most appropriate. The efficiency was measured by the following equation.

$$\text{Efficiency} = \frac{1}{\text{Error Variance}}$$

Relative efficiency (RE) of different methods is compared with the most efficient method by the following equation.

$$\text{RE \%} = \frac{\text{Error variance of method}}{\text{Error variance of most efficient method}} x100$$

The coefficient of determination (R^2) values of different methods were estimated for judging the accuracy of sire evaluation method. The coefficient of variation (CV%) values for the traits under study from different models of sire evaluation were estimated for judging the stability of sire evaluation methods. The Spearman's rank correlation between breeding values of sires derived by various methods was used to judge the effectiveness of different methods. The rank correlation was estimated by using following formula (Snedcor and Cochran, 1989) [7].

$$r = 1 - 6\frac{\sum d^2}{n(n^2-1)}$$

Where, r = Rank correlation coefficient

n = number of sires under evaluation

d = difference of rank between paired items under two methods

The significance of rank correlation was tested by u: sing following formula.

$$t = \frac{r}{\sqrt{1-r^2}}\sqrt{(n-2)}$$

Results and discussion

The estimated breeding values sires for birth weight, body weights at 3, 6, 9 and 12 months of age indicates genetic merit of sires. The estimated breeding values (EBVs) of rams by various sire evaluation methods for body weights at different ages are presented in Table.1. In general the highest average estimated breeding value for body weight at different ages was obtained by BLUP method. The estimated breeding values by different sire evaluation methods showed large variation between rams for all the traits under study. The breeding value (kg) by SRLS method ranged from 2.40 to 2.78, 12.30 to 12.68; 19.91 to 20.41; 23.78 to 24.40 and 26.66 to 27.24 kg for birth weight and body weight at 3, 6, 9 and 12 months of age respectively, whereas by BLUP and REML methods, values ranged from 2.56 to 2.87; 12.48 to 12.63; 20.04 to 20.27; 24.16 to 24.31; 26.84 to 27.19 and 1.85 to 2.68; 11.41 to 12.64; 19.54 to 19.71; 22.93 to 24.27 and 25.57 to 27.32 kg respectively.

Rank and Product – moment correlations

Product-Moment and Spearman's rank correlation analysis among different methods of sire evaluation were performed as per standard procedures and are presented in Table 2. It was observed that Spearman rank correlation coefficients The spearman's rank correlation coefficients and product moment correlations for body weights at different ages were found to be more by SRLS x BLUP methods (0.747 to 0.990 and 0.801 to 0.991). Higher correlations close to unity amongst the breeding values of rams from different sire evaluation methods reveal higher degree of similarity in ranking.

Comparison of different sire evaluation methods

Effectiveness of different sire evaluation methods was judged by using various criteria like within sire variance or error variance, coefficient of determination (R^2-value), coefficient of variation (%) and are presented in Table 3. The sire evaluation method with lowest error variance was considered the most efficient and appropriate method. Higher coefficient of determination (R^2) of a fitted model indicates higher accuracy. Lesser the coefficient of variation more will be the stability of the method.

Error Variance

The within sire variance or error variance estimated for birth weight and body weight at 3, 6, 9 and 12 months of age by BLUP & SRLS methods were found to be lowest and similar indicating them as the most efficient methods followed by REML method. Relative efficiency (%) of different methods were estimated in comparison to most efficient method *i.e.* BLUP and are presented in Table 3.

Table 1: Average expected breeding values (EBVs) of Nellore rams for body weights at different ages by using different sire evaluation methods

Sire evaluation method	Average EBV (Kg)	Maximum EBV (Kg)	Minimum EBV (Kg)	No. of rams above average	No. of rams below average
Birth Weight					
SRLS	2.66	2.78	2.40	10 (55.55%)	8 (44.45%)
BLUP	2.72	2.87	2.56	9 (50%)	9 (50%)
REML	2.60	2.68	1.85	7 (38.89%)	11 (61.11%)
Body wt 3 months age					
SRLS	12.49	12.68	12.30	10 (55.55%)	8 (44.45%)
BLUP	12.52	12.63	12.48	10 (55.55%)	8 (44.45%)
REML	12.12	12.64	11.41	9 (50%)	9 (50%)
Body wt 6 months age					
SRLS	20.05	20.41	19.91	11 (61.11%)	7 (38.89%)
BLUP	20.18	20.27	20.04	10 (55.55%)	8 (44.45%)
REML	19.62	19.71	19.54	11 (61.11%)	7 (38.89%)
Body wt 9 months age					
SRLS	24.08	24.40	23.78	12 (66.67%)	6 (33.33%)
BLUP	24.28	24.31	24.16	12 (66.67%)	6 (33.33%)
REML	23.64	24.27	22.93	8 (44.45%)	10 (55.55%)
Body wt 12 months age					
SRLS	26.86	27.24	26.66	10 (55.55%)	8 (44.45%)
BLUP	27.09	27.19	26.84	12 (66.67%)	6 (33.33%)
REML	26.42	27.32	25.57	9 (50%)	9 (50%)

Table 2: Spearman Rank correlations and Product – moment correlations among estimated sire merits for Body weights at different ages in Nellore sheep

Variable	SRLS x BLUP	SRLS x REML	BLUP x REML
	Spearman Rank Correlation		
Birth weight	0.747**	0.307	0.081
3M Bwt	0.936**	0.078	0.128
6M Bwt	0.990**	0.290	0.206
9M Bwt	0.988**	0.024	0.028
12M Bwt	0.984**	0.069	0.041
	Product - Moment Correlation		
Birth weight	0.801**	0.262	0.117
3M Bwt	0.861**	0.081	0.109
6M Bwt	0.988**	0.296	0.257
9M Bwt	0.986**	0.046	0.077
12M Bwt	0.991**	0.158	0.110

(** Significant at 1% level)

Table 3: Comparision of different sire evaluation methods for their effectiveness for Body weights at different ages in Nellore sheep

Methods	Error variance (Kg^2)	Relative efficiency (%)	Coefficient of determination (%)	Coefficient of Variation (%)
Birth weight				
SRLS	0.052	98.07	21.6	8.68
BLUP	0.051	100	27.9	8.50
REML	0.058	87.93	1.82	9.54
Body weight at 3 months age				
SRLS	0.206	99.51	91.8	3.74
BLUP	0.205	100	92.5	3.63
REML	0.236	86.86	46.1	13.6
Body weight at 6 months age				
SRLS	0.212	99.53	95.0	2.35
BLUP	0.211	100	95.9	2.24
REML	0.231	91.34	42.7	11.47
Body weight 9 months age				
SRLS	0.202	99.50	94.9	1.90
BLUP	0.201	100	96.8	1.79
REML	0.225	89.33	47.9	10.59
Body weight 12 months age				
SRLS	0.207	99.52	95.3	1.72
BLUP	0.206	100	97.2	1.62
REML	0.284	72.53	18.9	10.25

Coefficient of determination

The highest coefficient of determination (R^2) for body weights at different ages was observed by BLUP method, indicating that this method is the most accurate followed by SRLS and REML methods.

Coefficient of variation

For all the growth traits under study, lower coefficient of variation (CV) was found by BLUP followed by SRLS and then REML method indicating that BLUP is the most stable method of sire evaluation among all in Nellore sheep.

These results are in contrast with the results reported by Jeichitra *et al.*, 2014 in Mecheri sheep for the growth traits, where DFREML method was found to be the most accurate, efficient and stable method.

Conclusions

Comparison of SRLS, BLUP and REML methods of sire evaluation revealed that BLUP method was the most efficient method due to its lowest error variance, Coefficient of variation and highest coefficient of determination (R^2) values for birth weight and body weight at 3, 6, 9 and 12 months of age in Nellore sheep. The SRLS method was next best method of sire evaluation followed by REML method.

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