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Comparison of sire evaluation methods for first lactation reproduction traits in Tharparkar cattle

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Abstract

First lactation data of 91 Tharparkar dairy cows from 10 sires were analyzed to estimate the breeding values of the sires by observing the first lactation reproduction traits (AFC, FSP and FCI) using simple daughter's average method (D), Contemporary comparison method (CC), least-squares method (LSM) and best linear unbiased prediction (BLUP). Using, CC, LSM and BLUP methods of sire evaluation the average breeding value of sires for age at first calving was 1509.60, 1512.70, 1580.43 and 1575.58 days respectively, the mean breeding value of sires for first service period were 148.06, 149.75, 151.51 and 151.49 days respectively, average breeding value of sires for first calving interval was 421, 422.27, 432.89 and 432.63 days respectively. The LSM method is found best method of sire evaluation in this study due to its lowest error variance and highest coefficient of determination whereas BLUP method follows. Higher rank correlation between LSM and BLUP methods of sire evaluation indicated that there was higher degree of similarity of ranking of the sires by both the methods of sire evaluation.

Keywords: BLUP, cattle, LSM, Tharparkar

Introduction

Domestic cattle are particularly adapted to the climate and environment of their breeding areas. They are heat tolerant, disease resistant and can thrive in extreme weather conditions. The Thapakar cow has adapted to harsh climates such as extreme weather conditions, storms, famine and dry vegetation. In arid and semi-arid regions, Tharparkar cattle play an important role in milk production and are reared in arid regions in northwestern India. Sire selection should be made according to the breeding value of the bull. A number of methods are devised by different scientists from time to time for sire evaluation and the important one's are simple daughter's average method (D), Contemporary comparison method (CC), least-squares method (LSM) and best linear unbiased prediction (BLUP). In this study, an investigation is done on records of the first lactation reproduction traits of Tharparkar cattle to compare the effectiveness of these methods of sire evaluation. The variance components and breeding values of sires of Tharparkar cows for first lactation reproduction traits (AFC, FSP and FCI) are calculated using simple daughter's average method (D), Contemporary comparison method (CC), least-squares method (LSM) and best linear unbiased prediction (BLUP).

Materials and Methods

In this study, the primary lactation reproduction traits data of ninety-one Tharparkar dairy cattle, daughters of ten bulls distributed over 11 years i.e. 2006 to 2016 maintained at Livestock research station, Beechwal, Bikaner, Rajasthan are used to observe the breeding values of sires. Four methods of sire evaluation are used namely simple daughter's average method (D), Contemporary comparison method (CC), least-squares method (LSM) and best linear unbiased prediction (BLUP). For finding out the best method among these methods error variance, coefficient of determination (R^2) and rank correlations are used to compare these methods. Most accurate and efficient method will have lowest error variance. Following are the formulas and methods used in current study:

Simple Daughter's average (D): The method proposed by Edward (1932) ^[2] is used for calculating D . $S = D$, Where D is the average milk yield of all daughters of sire.

Contemporary Comparison (CC) method: Sire index by CC was calculated by following formula:

$$S = A + (\bar{D} - \bar{C}_i) = 2nh^2/4 + (n-1)h^2$$

Where, A = Herd average, \bar{C}_i = Contemporary daughter's average, n = No. of daughters of the sire, h^2 = Heritability of the trait, and \bar{D} = Daughter's average.

Least-Squares Method (LSM): Least-square breeding values (LSBV) are calculated with following model.

$$Y_{ijk} = \mu + S_i + A_j + e_{ijk}$$

Where S_i is the fixed effect of i th sire and A_j represents all other fixed effects included in the previous models.

$$LSBV = \mu + S_i$$

Where μ is the overall least-squares mean S_i is the least squares constant of i^{th} sire.

Best linear unbiased prediction (BLUP): Henderson (1973) [3] devised BLUP procedure for sire evaluation is used in this study. For judging the effectiveness of various sire evaluation

methods following methods are used.

Relative efficiency as percent error variances of a method relative to the variance of most efficient method having least error variance.

Relative efficiency (%) = Error variance of most efficient method/100 Error variance of other method

Coefficient of determination (R2-Value): For evaluating the accuracy of sire evaluation method The R2 value of different methods is calculated. The accuracy is related directly to R2 value.

The relative efficiency of different methods for sire evaluation is measured by Spearman's rank correlation with following formula.

$$\text{Spearman's rank correlation: } r_s = 1 - 6\sum d_i^2 / [n(n^2 - 1)]$$

Where, r_s = Spearman's rank correlation

n = Number of sires under observation

d_i = Difference between the ranking of a sire by the two methods

Results and Discussion

Table 1: Average and range of sire's breeding values for AFC, FSP and FCI

Traits	Methods	Average breeding value	No. of sires above average	No. of sires below average	Maximum breeding value	Minimum breeding value	Range of breeding value	Range of % of average breeding value
Age at First Calving	\bar{D}	1509.60	6	4	1746 (15.66)	1112 (26.33)	634	42%
	CC	1512.70	6	4	1723.76 (13.95)	1198.82 (20.75)	524.94	34.70%
	LSM	1580.43	5	5	1626.11 (2.89)	1517.51 (3.98)	108.6	6.87%
	BLUP	1575.58	5	5	1621.98 (2.94)	1497.97 (4.93)	124.01	7.87%
First Service Period	\bar{D}	148.06	4	6	186.00 (25.62)	122.8 (17.06)	63.2	42.69%
	CC	149.75	3	7	173.75 (16.03)	139.16 (7.07)	34.59	23.09%
	LSM	151.51	4	6	154.55 (2.00)	149.56 (1.29)	4.99	3.29%
	BLUP	151.49	5	5	156.99 (3.63)	149.32 (1.43)	7.67	5.06%
First Calving Interval	\bar{D}	421	5	5	445.2 (5.75)	395.6 (6.03)	49.6	11.78%
	CC	422.27	5	5	443.08 (4.92)	402.74 (4.63)	40.34	9.55%
	LSM	432.89	2	8	438.57 (1.31)	429.27 (0.85)	9.3	2.15%
	BLUP	432.63	3	7	440.39 (1.80)	427.42 (1.20)	12.97	2.99%

Figures in the parenthesis represent the percent higher/ lower than the average breeding value.

Table 2: Values of Error variances, relative efficiency and coefficient of determination (%) of sire evaluation methods for First Lactation reproduction Traits (AFC, FSP, FCI).

Method	Error variances	relative efficiency	Coefficient of determination (%)
Age at First Calving			
\bar{D}	30470.93	3.90	9.3
CC	26988.66	4.40	8.1
LSM	1187.13	100.00	53.40
BLUP	1727.47	68.72	47.00
First Service Period			
\bar{D}	333.64	0.46	10.29
CC	94.56	1.62	17.67
LSM	1.53	100.00	42.65
BLUP	4.66	32.83	24.74
First Calving Interval			
\bar{D}	252.01	2.11	5.63
CC	107.90	4.94	15.67
LSM	5.33	100.00	42.00
BLUP	10.61	50.24	31.21

Table 3: Rank correlations among sire breeding value for AFC, FSP and FCI by different methods.

Age at first calving			
Method	CC	LSM	BLUP
\bar{D}	0.95	0.55	0.56
CC		0.65	0.61
LSM			0.92
First service period			
\bar{D}	0.90	0.77	0.78
CC		0.87	0.85
LSM			0.99
First calving interval			
\bar{D}	0.95	0.89	0.89
CC		0.94	0.94
LSM			1

The mean breeding value of sire for first lactation reproduction traits estimated by various models used is presented in Table 1. Simple daughter's average, contemporary comparison, LSM and BLUP method measures average breeding value for age at first calving as 1509.60 days, 1512.70 days, 1580.43 days and 1575.58 days respectively.

The average breeding value for first service period calculated by simple daughter's average method, contemporary comparison, least-square and BLUP method were 148.06 days, 149.75 days, 151.51 days and 151.49 days respectively. Average breeding value for first calving interval is retrieved by simple daughter's average method (421 days), contemporary comparison method (422.27 days), least-square method (432.89 days) and best linear unbiased prediction method (432.63 days).

LSM has the smallest change (1187.13, 1.53 and 5.33 days for AFC, FSP and FCI respectively) and is therefore considered the most effective method, followed by BLUP method (Table 2). Researchers such as, Sahana and Gurnani (1999) [7], Mukherjee (2005) [5], Banik and Gandhi (2006) [11], Singh and Singh (2011) [9], Kishore (2012) [4] and Singh (2015) [8] also support the LSM method as the best method merged with BLUP method of sire evaluation. If we estimate the relative performance of all methods used in terms of error variance, relative efficiency and coefficient of determination (%) it can be said that as far as efficiency is concerned LSM and BLUP methods are more or less equally efficient in portioning of variance as shown in Table 2.

There is a high rank correlation among breeding values of sires as calculated from LSM and BLUP as represented in Table 3. Parekh and Singh (1989) [6] also supported high correlation between these two methods.

Conclusion

It can be concluded from the present study that the least-squares method (LSM) is most accurate and efficient as the error variance is smallest. In addition, a high rank correlation indicates that BLUP method is equally good in terms of efficiency and accuracy for ranking Tharparkar sires for first lactation reproduction traits.

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