Journal of Veterinary Science & Animal Husbandry
Volume 6 | Issue 4
ISSN: 2348-9790

Research Article Open Access

Relative Efficiency of Different Sire Procedures in Crossbred Cattle

Lodhi G and Singh CV*

Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar-263145, District Udham Singh Nagar, Uttarakhand, India

***Corresponding author:** Singh CV, Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar-263145, District Udham Singh Nagar, Uttarakhand, India, Tel: +91-5944-234528, E-mail: cvsingh2010@gmail.com

Citation: Lodhi G, Singh CV (2018) Relative Efficiency of Different Sire Procedures in Crossbred Cattle. J Vet Sci Ani Husb 6(4): 403

Received Date: July 28, 2018 **Accepted Date**: October 23, 2018 **Published Date:** October 25, 2018

Abstract

The records of 1198 crossbred cattle sired by 68 bulls were analyzed to estimate breeding values of sires using animal model Restricted Maximum Likelihood (REML), best linear unbiased prediction (BLUP), least squares methods (LSM) and simple daughter average ($\overline{D}$) sire evaluation methods.

The error variance of breeding values of sires were estimated and used in computing the relative efficiency of different sire evaluation methods. In the present study the least squares methods (LSM) have the lower error variance for Age at First Calving (AFC), First lactation milk yield (FLMY) and Lifetime lactation length (LTLL), while (BLUP) methods have the lower error variance for First lactation period (FLP), First dry period (FDP), First calving interval (FCI), First service period (FSP) and Lifetime milk yield (TLMY) as compared to other methods and accordingly, it was adjudged the most efficient sire evaluation method. In the present study, the higher value of coefficient of variation showing, there was very large variation in the herd for most of the traits under study. It indicated that the BLUP method is the best over the other three methods because estimated value of relative efficiency by BLUP method had smaller values than that of the other three methods. On the basis of the error variances of breeding values of sires the BLUP method was found most efficient sire evaluation method.

Keywords: Breeding value; First lactation yield; Lifetime milk yield; BLUP; REML

Introduction

There are several methods of sire evaluation with a wide range of complexity starting from very simple (simple daughter average) to highly complicated restricted maximum likelihood (REML) method. Different methodologies like contemporary comparison, contemporary daughter average index, least squares (LS) technique and simple regressed least squares technique (SRLS) could be used to evaluate sires for a single trait i.e. milk yield. Whereas restricted maximum likelihood (REML) estimate can give bias free estimators.

In recent years, there are several methods of sire evaluation are used, like simple daughter average, Restricted Maximum Likelihood method, Least square method, Best Linear Unbiased Prediction, Contemporary Daughter Average Index and Simple Regressed Least Square could be used to evaluate sires for a single trait i.e. milk yield. Henderson (1986) opined that analysis of variance and covariance may give biased components of variance from selected population, whereas Restricted Maximum Likelihood method can give bias free estimate [1]. Simultaneous attention to reproductive traits in addition to milk production is expected to bring about overall improvement in the index value of a sire, so multi trait criteria of sire evaluation using advance statistical technique like Derivative Free Restricted Maximum Likelihood method would be expected to enhance the accuracy of selection of the sire (Meyer 1998) further (Miszal 2004) developed mixed model programme (BLUP 90 Dairy Pack) in animal breeding for genetic evaluation, estimation of breeding value and variance for single and multiple traits [2,3]. The Best Linear Unbiased Prediction has become the most widely accepted method for genetic evaluation of livestock.

Materials and Methods

Data for the present investigation were collected from history sheets of crossbred cattle at instructional dairy farm of G. B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1198 crossbred cattle from 68 sires were distributed over a period of 45 years from 1966 to 2010. Cows with abnormal and incomplete (The lactation records of less than 150 days were considered as abnormal and were not included in the analysis) records were excluded from the study. Only the sires having records on at least 5 daughters were included in the present study. The records of only those animals with known pedigree and

normal lactation were considered. The total duration of the present study was divided into 10 equal periods of five years each. Each year was divided into three seasons namely winter (November-February), summer (March–June), and Rainy (July – October). In order to classify the data for different genetic group (17 genetic groups of cross bred animals in different combinations), periods (9) and seasons (3) of calving were considered for all the traits. The traits considered in the present study were age at first calving, first service period, first lactation period, first dry period, first calving interval, first lactation milk yield, lifetime milk yield and life time lactation yield. Records on various first lactation and lifetime traits of crossbred cattle being in non-orthogonal nature were analyzed by Least Squares Analysis (LSA) technique of fitting constants for the estimation of genetic parameters as well as to examine the simultaneous effects of different genetic and non-genetic factors affecting any traits.

Statistical Analysis

As the data in the present study were non-orthogonal in nature with unequal subclass numbers, they were subjected to least squares analysis of variance without interactions using different models to examine the effect of genetic as well as non-genetic factors on various first lactation traits as per standard procedures of Harvey (1990) [4]. The model 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 (genetic group, season and period) were taken as fixed effects in the model. Breeding value of sires for first lactation traits were estimated by simple daughter average ($\overline{D}$) as proposed by Edward (1932), least square method as described by Harvey (1990), best linear unbiased prediction by Henderson (1975) and Restricted, Maximum Likelihood (REML) by Mayer (1991) [1,4-6]. The effectiveness of different sire evaluation methods was judged by the estimated breeding value of sires as taken twice the sire genetic group solution plus sire solution within sire genetic group for that trait. The method giving lowest error variance had higher efficiency and would be most appropriate. The efficiency of other methods relative to the most efficient method under the present study was calculated as.

$$\text{Relative efficiency of a method } (\%) \frac{\text{Error variance of most efficient method}}{\text{Error variance of any other method}} \times 100$$

Results and Discussion

The error variances of breeding values of sires were calculated and used for calculating the relative efficiency by Simple Daughters Average Method, Least Squares Method, Best Linear Unbiased Prediction and Restricted Maximum Likelihood Method. The sire evaluation method which estimated the breeding values of sires with the least error variance was taken as the best and most efficient method. The estimated breeding value of sires for Age at First Calving (AFC), First lactation milk yield (FLMY) and Lifetime lactation length (LTLL) by Least Squares Method showed small genetic variation in compare to other methods. While for First lactation period (FLP), First dry period (FDP), First calving interval, (FCI), First service period (FSP) and Lifetime milk yield (LTMY), best linear unbiased prediction (BLUP) showed small genetic variation in compare to other methods used in the present study.

Relative efficiency of above mentioned traits was calculated with respect to the most efficient method for the trait. The estimated error variance and relative efficiency of various methods used for estimation of breeding value of 68 sires in the present study are presented in (Table 1). The Least Squares Method (LSM) method for age at first calving (AFC) has relative efficiency 100% and it was placed at first place, while Best Linear Unbiased Prediction (BLUP) at II, Restricted Maximum Likelihood Method (REML) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively. The Best Linear Unbiased Prediction (BLUP) method for first lactation milk yield (FLMY) has relative efficiency 100% and it was placed at first place, while Least Squares Method (LSM) at II, Restricted Maximum Likelihood Method (REML) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively. The Best Linear Unbiased Prediction (BLUP) method for first lactation period(FLP) has relative efficiency 100% and it was placed at first place, while Restricted Maximum Likelihood Method (REML) at II, Least Squares Method (LSM) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively. The Best Linear Unbiased Prediction (BLUP) method for first dry period (FDP) has relative efficiency 100% and it was placed at first place, while Restricted Maximum Likelihood Method (REML) at II, Least Squares Method (LSM) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively. The Best Linear Unbiased Prediction (BLUP) method for first calving interval (FCI) has relative efficiency 100% and it was placed at first place, while Restricted Maximum Likelihood Method (REML) at II, Least Squares Method (LSM) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively.

The Best Linear Unbiased Prediction (BLUP) method for first service period (FSP) has relative efficiency 100% and it was placed at first place, while Restricted Maximum Likelihood Method (REML) at II, Least Squares Method (LSM) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively.

The Best Linear Unbiased Prediction (BLUP) method for Lifetime milk yield (LTMY) has relative efficiency 100% and it was placed at first place, while Restricted Maximum Likelihood Method (REML) at II, Least Squares Method (LSM) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively. The Least Squares Method (LSM) method for Lifetime Lactation length (LTLL) has relative efficiency 100% and it was placed at I place, while Restricted Maximum Likelihood Method (REML) at II, Best Linear Unbiased Prediction (BLUP) at III and Simple Daughters Average ($\overline{D}$) at IV place respectively.

Methods	Traits	Error variance	Relative efficiency (%)	Rank
$\overline{D}$	AFC	1548714.88	2.35	IV
LSM	AFC	36443.069	100	I
BLUP	AFC	36667.35	99.3	II
REML	AFC	36848.25	98.9	III
$\overline{D}$	FLMY	8113186.4	6.0	IV
LSM	FLMY	489908.45	99.62	II
BLUP	FLMY	491740.03	100.0	I
REML	FLMY	503313.60	97.33	III
$\overline{D}$	FLP	113234.77	2.0	IV
LSM	FLP	3304.97	9.5	III
BLUP	FLP	3150.47	100.0	I
REML	FLP	3278.63	96.09	II
$\overline{D}$	FDP	19917.56	20.0	IV
LSM	FDP	4106.10	97.7	III
BLUP	FDP	4011.69	100.0	I
REML	FDP	4092.41	98.02	II
$\overline{D}$	FCI	221224.9	1.92	IV
LSM	FCI	4409.70	96.54	III
BLUP	FCI	4257.32	100	I
REML	FCI	4327.82	98.37	II
$\overline{D}$	FSP	47001.72	8.6	IV
LSM	FSP	4210.85	96.13	III
BLUP	FSP	4048.063	100.0	I
REML	FSP	4119.51	98.26	II
$\overline{D}$	LTMY	215572508.3	1.0	IV
LSM	LTMY	22269518.83	10.0	III
BLUP	LTMY	2289718.53	100.0	I
REML	LTMY	13424678.32	17.05	II
$\overline{D}$	LTLL	6278074.84	2.0	IV
LSM	LTLL	129184.85	100.0	I
BLUP	LTLL	133278.13	96.92	III
REML	LTLL	133150.98	97.02	II

AFC: Age at First Calving; FLM: First Lactation Milk Yield; FLP: First Lactation Period; FDP: First Dry Period; FCI: First Calving Interval; FSP: First Service Period; LTMY: Lifetime Milk Yield; LTLL: Lifetime Lactation Length; $\overline{D}$: Simple Daughters Average; LSM: Least Squares Method; BLUP: Best Linear Unbiased Prediction; REML: Restricted Maximum Likelihood Method

Table 1: Comparison of various Sire Evaluation Methods in Term of Error Variance and their Relative Efficiency

In the present study, Simple Daughters Average Method, Least Squares Method, and Restricted Maximum Likelihood Method were having highest error variance among all methods of sire evaluation, this could be because of non-genetic variations were present and not removed from data prior to the estimation of breeding value of sires, which might have resulted in to the highest error variance and lowest relative efficiency of this method .This findings was in agreement with the reports of Sahana and Gurnani (2000) and Aswathanarayana *et al.* (2003) [7,8]. Dahiya *et al.* (2003), and Moges *et al.* (2009) also reported BLUP method as most efficient than the other methods [9,10]. However, Sahana and Gurnani (1996), Mukharjee (2005), Singh and Singh (2011), Singh *et al.* (2014), Abbas *et al.* (2016) [11-15]. Reported that the least squares methods of sire evaluation was the most efficient method for estimating the breeding value of sires.

Conclusion

The error variances of breeding values of sires were calculated and used for calculating the relative efficiency of Simple Daughters Average Method, Least Squares Method, Best Linear Unbiased Prediction and Restricted Maximum Likelihood Method. The higher value of coefficient of variation showing, there was very large variation in the herd for most of the traits under study. It indicated that the BLUP method is the best over the other three methods because estimated value of relative efficiency by BLUP method had smaller values than that of the other three methods. On the basis of the error variances of breeding values of sires the BLUP method was found most efficient sire evaluation method.

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