



Influence of number of daughters per sire on genetic evaluation of Mehsana buffalo bulls under field progeny testing

J P GUPTA¹✉, J D CHAUDHARI¹, B M PRAJAPATI¹, A K SRIVASTAVA¹, H D CHAUHAN¹ and P A PATEL²

Kamdhenu University (erstwhile SDAU), Sardarkrushinagar, Gujarat 385 506 India

Received: 12 April 2022; Accepted: 11 May 2022

ABSTRACT

First lactation production records of 7,825 Mehsana buffaloes, sired by 200 sires maintained at Dudhsagar Research and Development Association, Dudhsagar Dairy, Mehsana over a period of 25 years (1989-2013), were utilised for estimation of breeding value of the first lactation milk yield using BLUP - Univariate sire model and animal model using WOMBAT software. The study aimed to find out the optimum number of daughters that may be sufficient for more accurate and unbiased estimate of breeding value of Mehsana buffalo bulls. The effectiveness of different models run with different daughters per sire for sire evaluation was judged on the basis of within-sire variance. The maximum and minimum estimated breeding values were 1924.04 l (BLUP-AM, 5 daughters/sire) and 1855.61 l (BLUP-SM, 30 daughters/sire), respectively. However, error variance estimated was highest when five daughters/sire were evaluated and lowest, when 30 daughters/sire were evaluated. The present study revealed that the sire evaluation with sires having minimum 5, 10 and 15 daughters are equally efficient. However, if we do evaluation with sires having daughters more than 20, 25 or 30, additional accuracy of approximately 2.5%, 3% and 5%, respectively may be obtained.

Keywords: BLUP-Animal model, BLUP-Sire model, Breeding value, Error variance, Field progeny testing

Indigenous livestock breeds of India may have low production but, are locally well adapted for centuries. Dairy industry in Gujarat is well structured and Mehsana buffalo breed has played a significant role in its development since the days of operation flood. Selection of superior sires with maximum accuracy is more desirable and hence selection of sire is key step in any breed improvement programme (Mir *et al.* 2015). One of the pertinent question in progeny testing method of sire evaluation is that how many progenies performance should be evaluated for selection of appropriate sire? It is common understanding that increase in number of daughters per sire, in sire evaluation shall improve the efficiency of breeding value estimation but what should be optimum number, needs to be ascertained. In India, evaluation of animals (Sires) faces severe bottleneck owing to small herd size (Birtal *et al.* 2006) with no proper recording system. However, these difficulties were tried to overcome with the concept of field progeny testing where animals at doorstep of small-holder livestock keepers were associated so as to get enough number of daughter's records for testing. Present study was envisaged to get a cue from the field progeny testing regarding the requirement of optimum number of

daughters per sire. Importance of this can be understood by the fact that it is difficult to get large number of daughters per sire owing to limited herd size under farm condition and also because the measurement and collection of data under field conditions are tedious.

MATERIALS AND METHODS

The present investigation was carried out using data of first lactation production records of 7,825 Mehsana buffaloes sired by 200 bulls, spread over a period of 25 years (1989-2013), collected from the Dudhsagar Research and Development Association (DURDA), Dudhsagar Dairy, Mehsana. Total first lactation milk yield (FLMY) was calculated as per the procedure suggested by International Committee for Animal Recording (ICAR 2014). The data available for the study were grouped into cluster, periods, season and age at first calving. The data spread over 74 villages, were clustered into 3 groups based on geographical location. The duration of 25 years was classified into 5 periods each of 5 years [Period 1 (P₁) 1989 to 1993, Period 2 (P₂) 1994 to 1998, Period 3 (P₃) 1999 to 2003, Period 4 (P₄) 2004 to 2008 and Period 5 (P₅) 2009 to 2013]. Each year of calving was further classified into 2 seasons (least calving season: January to June and most calving season: July to December) considering the seasonality of reproduction in buffaloes. Further, age at first calving of Mehsana buffaloes were classified into three groups using mean and one standard deviation of AFC in

Present address: ¹College of Veterinary Science and Animal Husbandry, Kamdhenu University (erstwhile SDAU), Sardarkrushinagar, Gujarat. ²Dudhsagar Research and Development Association, Dudhsagar Dairy, Mehsana, Gujarat.
✉Corresponding author email: jp.prakash01@gmail.com

the population (Group 1: 677-1100 days, Group 2: 1101-1678 days and Group 3: 1679-2522 days).

Genetic evaluation of Mehsana buffalo bulls was carried out by two methods, Best Linear Unbiased Prediction – Sire Model (BLUP-SM) and Best Linear Unbiased Prediction – Animal Model (BLUP-AM); in which sires were treated as random effect and the other non-genetic factors (cluster, season, period and age at first calving group) were taken as fixed effects. The study aimed to find out the optimum number of daughters that may be sufficient for more accurate and unbiased estimate of breeding value of Mehsana buffalo bulls.

The breeding value of sire was estimated by BLUP method as given by Henderson (1975). In BLUP sire model (BLUP-SM), (co)variance components were estimated by BLUP using WOMBAT software genetic analysis tool (Meyer 2007). The model used in the analysis was,

$$y_{ijk} = Xb_i + Zs_j + e_{ijk}$$

From the above equation, the mixed model equation was developed as follows:

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\alpha \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{a} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

Where, $\alpha = \frac{\sigma_e^2}{\sigma_s^2} = \frac{(4-h^2)}{h^2}$, and A is the numerator relationship matrix (NRM) of all the animals, which has non-zero off-diagonals only for the animal's parents, progeny, and mates. The elements of A can contain additive genetic effects, non-additive genetic effects, maternal effects, and permanent environmental effects. In BLUP-AM, the single trait animal model was considered for estimation of breeding values using WOMBAT software (Meyer, 2007) as:

$$Y_{ijk} = Xb_i + Za_j + e_{ijk}$$

From the above equation, the Mixed Model Equation (MME) obtained was;

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\alpha \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{a} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

Where, $\alpha = \sigma_e^2/\sigma_a^2$, similar to sire model but $\sigma_a^2 = \sigma_s^2/0.25$. Where, all the notations have their own meanings.

The above model was run for both sire and animal model (BLUP-SM and BLUP-AM) each time using different number of progenies viz. 5, 10, 15, 20, 25 and 30. The effectiveness of different models run with different number of daughters for sire evaluation was judged on the basis of within sire variance or error variance. The method with the lowest error variance was considered as most efficient method.

RESULTS AND DISCUSSION

Breeding value estimates for first lactation milk yield:

The average expected breeding value of Mehsana buffalo bulls for first lactation milk yield with different number of daughters per sire was estimated using BLUP-SM and

Table 1. Average expected breeding value (EBV) of Mehsana buffalo bulls with varying number of daughters per sire under BLUP-SM and BLUP-AM

Number of daughters per sire	Average EBV (BLUP-SM) (in L)	Average EBV (BLUP-AM) (in L)
5	1915.43	1924.04
10	1864.24	1882.51
15	1863.13	1878.55
20	1862.12	1876.72
25	1859.44	1870.81
30	1855.61	1863.58

BLUP-AM (Table 1). Whenever number of daughters per sire was fixed, the number of actual sires in the analysis varied and it was 188, 184, 177, 165, 154 and 140, respectively for 5, 10, 15, 20, 25 and 30 daughters per sires. In India, generally the progeny testing programme operational in organised herd have limitation of the number of daughters born per sire. The number of daughters born per sire is low because of having limited space, resources and longer generation interval. Chitra *et al.* (2016) with the records of Murrah buffalo bulls having minimum 3 daughters, estimated the breeding value as 2124.8 kg whereas, Sangwan *et al.* (2016) estimated it as +353.54 kg over average FLMY in Murrah bulls having minimum 5 daughters. Ambhore *et al.* (2018) estimated the breeding value of milk yield in crossbred Phule Triveni cattle maintained at farms of MPKV, Rahuri as 2624 kg (error variance of 3,21,777 kg²) for sires having minimum 3 daughters. Chaudhari *et al.* (2014) estimated the breeding value of FLMY in Murrah graded buffaloes maintained at field progeny testing programme of AMUL as 1704.73 litres from the records of bulls having minimum 10 daughters and the estimate obtained was comparatively lower than present study. Though the trend obtained was not conclusive, however, field progeny testing overcomes the hurdles of space and to some extent resources and it is essential to get an idea about the number of optimum daughters per sire for getting an accurate estimate of breeding value.

In the present investigation, it can be observed that with increase in the number of daughters per sire, there is

Table 2. Relative efficiencies of sire evaluation based on variation in number of daughters per sire under BLUP-SM and BLUP-AM

Number of daughters per sire	BLUP-AM	Relative efficiency (in %)	BLUP-SM	Relative efficiency (in %)
05	465005000	87.81	1348830000	87.84
10	462784000	88.24	1342860000	88.23
15	457531000	89.29	1329240000	89.14
20	444973000	91.78	1291500000	91.74
25	430114000	94.94	1247950000	94.94
30	408341000	100.000	1184820000	100.000

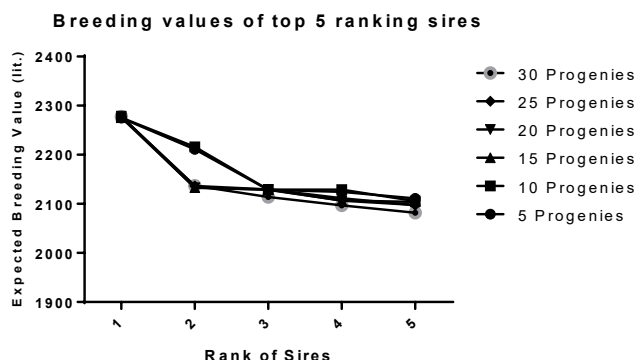


Fig. 1. Breeding values of top 5 ranking sires for FLMY by BLUP-SM with sires having varying number of daughters per sire.

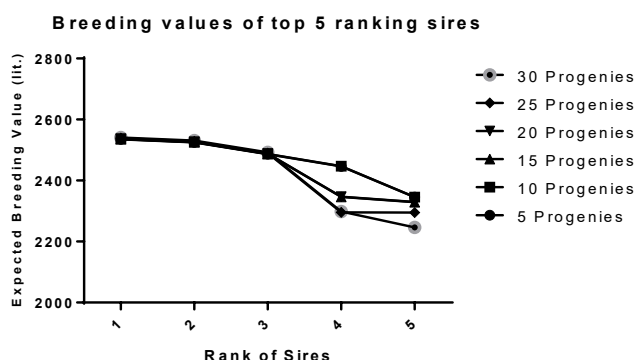


Fig. 2. Breeding values of top 5 ranking sires for FLMY by BLUP-AM with sires having varying number of daughters per sire.

corresponding decrease in the estimate of breeding values as well as error variance. Ratwan *et al.* (2020) in Sahiwal cattle, reported increase in genetic gain upon increasing the number of progenies/sire from 6 to 18, but, a further increase in the number of progenies/sire, gain increased only gradually and the magnitude was low. However, in the present study decrease was less pronounced, as number of daughters per sire increased to 15 and above (Table 1). Searle (1964) demonstrated that if heritability ranges from 0.2 to 0.4, the reduction of number of daughters per sire (25) will lead to only marginal (0.07) decrease in correlation between true and estimated merit of bulls. Moreover, heritability estimate for 305 day FLMY was reported to be 0.18 from the same population which is used for the present study.

Relative effectiveness of sire evaluation based on variation in number of progeny: The relative efficiencies for different progeny (daughters) number in both the methods (BLUP-SM and BLUP-AM) were compared. It was observed that the model which considered sire with 30 or more daughters is observed to have least error variance (Table 2) that is why it was considered to be the most efficient, and assigned with 100% relative efficiency in order to calculate the relative efficiency of other methods. However, estimate of breeding values obtained by Kumar and Chakravarty (2016) could not give clear relationship between breeding value and number of daughters per sire. The reason of getting either no or feeble relationship between the number of daughters per sire and breeding

value estimate by Kumar and Chakravarty (2016) might be due to the fact that they estimated the breeding value of different set of bulls, and the daughter's performance were evaluated in different farms at different set of environment.

Sire evaluation is one of the most important aspects of animal genetic improvement programme. Traditionally, it involves the estimation of breeding value of the bulls on the basis of first lactation 305-days milk yield of their daughters with a rationale to minimise generation interval. In country like India the average herd size at farmers herd as well institutional farm is either very small or small. Many a times under such conditions, getting more number of progenies per sire is difficult or rather impossible. Present study revealed that the sire evaluation with sires having 5, 10 and 15 daughters are equally efficient. However, if we further go for sire evaluation with sires having progenies more than 20, 25 or 30 we may get additional accuracy of approximately 2.5%, 3% and 5%, respectively.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to the Principal, College of Veterinary Science and Animal Husbandry and Director of Research, Sardarkrushinagar Dantiwada Agricultural University, for all possible cooperation and facilities for the successful completion of this study. Help rendered by Dudhsagar Research and Development Association, Dudhsagar Dairy, Mehsana for providing the data with useful information for research work is duly acknowledged.

REFERENCES

- Ambhore G S, Singh A, Deokar D K, Singh M, Prakash V and Sahoo S K. 2018. Sire evaluation using REML and conventional methods for first lactation 300 day milk yield in Phule Triveni cattle. *Indian Journal of Animal Sciences* **88**(3): 352–55.
- Birthal P S, Jha A K, Joshi P K and Singh D K. 2006. Agricultural diversification in North eastern region of India: Implications for growth and equity. *Indian Journal of Agricultural Economics* **61**(3): 328–40.
- Chaudhari PN, Upadhyay M R, Patel A C, Patel S B and Rank D N. 2014. A Comparison of Different Methods of Sire Evaluation for Production and Reproduction Traits of Murrah Graded Buffaloes. *International Journal of Research in Humanities & Social Sciences* **8**(2): 16–24.
- Chitra A, Anand J, Manoj K, Poonam R and Gupta A K. 2016. Genetic evaluation of sire for milk production and its composition traits in Murrah buffaloes. *Indian Journal of Dairy Science* **69**(6): 721–24.
- Henderson C R. 1975. Best linear unbiased prediction under a selection model. *Biometrics* **3**: 423–36.
- ICAR. 2014. International Committee for Animal Recording-ICAR. International Agreement of Recording Practices, approved by the General Assembly held in Berlin, Germany, pp. 91–92.
- Kumar V and Chakravarty A K. 2016. Evaluation of breeding values Murrah buffalo bulls under organized farms. *Buffalo Bulletin* **35**(3): 371–77.
- Meyer K. 2007. WOMBAT-A tool for mixed model analyses in quantitative genetics by restricted maximum likelihood (REML). *Journal of Zhejiang University-Science Biomedicine*

- and Biotechnology* **8**(11): 815–21.
- Mir M A, Kumar M and Vohra V. 2015. Factors affecting quality dairy bulls production in India. *Applied Research Journal* **1**(4): 197–200.
- Ratwan P, Chakravarty A K and Kumar M. 2020. Assessment of genetic gain and its simulation for performance traits in Sahiwal cattle. *Turkish Journal of Veterinary and Animal Sciences* **44**(4): 879–85.
- Searle S R. 1964. Progeny-tests of sire and son. *Journal of Dairy Science* **47**(4): 414–20.