Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 20(3), September-December, 2022]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

G.B. Pant University of Agriculture & Technology, Pantnagar

PANTNAGAR JOURNAL OF RESEARCH

Vol. 20(3) September-December, 2022

CONTENTS

Evaluation of efficiency of sire model and animal model in crossbred cattle using first lactation and lifetime production traits

MANITA DANGI, C.V. SINGH*, R.S. BARWAL and B.N. SHAHI

Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences,G.B. Pant University of Agriculture and Technology, Pantnagar- 263 145, (U.S. Nagar, Uttarakhand)
**Corresponding author's email id:cvsingh2010@gmail.com*

ABSTRACT: Data for the present investigation were collected from the history sheet of crossbred cattle maintained at the Instructional Dairy Farm of G. B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1029 crossbred cattle from 107 sires were distributed over a period of 49 years from 1966 to 2014. The average breeding values of 91 sires by the Animal Model and 107 sires by the Sire Model were evaluated for all the traits. The average breeding values for AFC, FLMY, FLP, FDP, FCI, LTMY, and LTLL were estimated as 1199.02 days, 2799.08 kg, 332.08 days, 129.30 days, 459.04 days, 10002.88 kg, and 1087.66 days, respectively, by Animal Model. The average breeding values for AFC, FLMY, FLP, FDP, FCI, LTMY, and LTLL were estimated as 1199.85 days, 2799.56 kg, 332.10 days, 129.12 days, 458.57 days, 10005.00 kg, and 1091.55 days, respectively, by Sire Model. Sires were ranked according to their breeding values for both the models, which indicated that all sires would not rank the same for first lactation and lifetime traits. The top-ranking sires between the SM and AM were inconsistent for some traits. There were changes in the rank of first top 10 sires of sire evaluation by the Animal and Sire Model. Comparison between the Animal and Sire Model was done by estimating Information criteria of Akaike (AIC) and Bayesian (BIC) information criteria and found that Animal Model was having highest negative value for (AIC) and (BIC), indicating its superiority over than Sire Model for estimating genetic parameters. which suggested that the Animal Model would be the most adequate model.

Key words: Animal model, crossbred cattle, first lactation milk yield, heritability, life time traits, sire model

The primary importance for the animal breeders is enhancing the productive potential of the dairy cattle. The sire contributes greatly in comparison to the path in the overall genetic improvement of a trait due to the higher intensity of selection (Banik and Gandhi, 2010). With artificial insemination, the use of high genetic merit bulls would bring higher genetic progress when bulls are evaluated by an effective method of selection. The selection of dairy animals is carried out using linear and nonlinear models of genetic evaluation and on the basis of the production performance of its daughters, the sires have ranked accordingly.

Under Indian conditions, the selection of dairy bulls using conventional methods (such as the contemporary comparison of sire evaluation) has long been carried out. The relationships between the individuals of the population are not taken into account in these methods of sire evaluation on which observations have been made, Sun *et al.* (2010). Therefore, for accurate estimation of breeding values (BVs), different advanced linear models are needed to be which lay more emphasis on the relationship between the individuals of the population. Both sire and animal models consider the relationship and inbreeding coefficient of the individuals of the population, as well as the model, including the numerator relationship matrix (NRM). In most countries, the sire model is currently used for genetic evaluation of fertility traits, Interbull(2009). In the sire model, it is assumed that the mates are of equal merit which could result in biased estimates of BVs by Mrode (2005) and, in terms of stability and accuracy of the EBV, the animal model had a superior ability to predict breeding value Sun *et al.* (2009). The sire model has the advantage of less computational demand and might have good predictive properties under the conditions no genetic relationship exists between the sire and dam, that is there are no genetic relationships exist between dams, and thus mating is random. However, the assumed conditions necessary for accurate and unbiased EBV using a sire model are frequently violated in current dairy populations. If mates are non-randomly chosen in some manner, and if the model does not account for mating schemes, sire evaluation may be affected adversely and could be biased (Schaeffer, 1983).

MATERIALS AND METHODS

The data for the present study were collected from history sheets of crossbred cattle maintained at Instructional dairy farm, Nagla, G.B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1029 crossbred cattle from 107 sires were distributed over a period of 49 years from 1966-2014. Cows with abnormal and incomplete records were excluded from the study. Cows with abnormal and incomplete 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 lactation records of less than 150 days were considered abnormal and were not included in the analysis. The total duration of the present study was divided into 10 periods out of which 9 periods are of five years each and period 10 is of 4 years. 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 groups, periods and seasons of calving were considered for all the traits. The traits considered in the present study were age at first calving, first lactation period, first dry period, first calving interval, first lactation milk yield, lifetime milk yield, and lifetime lactation yield.

Statistical Analysis

Multiple traits analyses using animal and sire models will be fit to estimate breeding values using the multiple traits animal model program (MTDFREML) proposed by Boldman *et al.* (1995). The following linear animal model will be used for the studied traits.

$Y = X\beta + Za + e$ (Model 1)

Where:

Y = is a vector of observations for the studied traits,
X= is the incidence matrix for the fixed effects,
β = is the vector including the overall mean and the fixed effects,
Z = is the incidence matrix for random effects,
a = is the vector of the direct genetic effect of the animal where Var (a) = $A\sigma 2a$ where A is the numerator of the relationship matrix of animals, and
e = is a vector of random residuals normally and independently distributed with zero mean and variance I $\sigma 2e$.

The following linear sire model will be used for the studied traits.

$Y = X\beta + Zs + e$ (Model 2)

Where,

s = is the vector of direct genetic effect of sire, and other terms in the model are defined as in model 2.

Comparison criteria; Information criteria of Akaike (AIC) and Bayesian (BIC) information criteria tests will be used in the comparison of the models. In both tests, the most accurate model will be the one that has the highest negative AIC and BIC values. According to these two tests, we will select the model which fits better to data structures. The values of the Akaike information criteria and Bayesian information criteria will be obtained as follows:

AIC = - 2 log (MLk) +2pk

BIC = - 2 log (MLk) + pk log (n) (LUKAČ *et al.,* 2017)

where,

MLk= Maximum Log Likelihood for model k;
pk = number parameter for model k;
n = number of observations in model k;

RESULTS AND DISCUSSION

Estimation of breeding value for first lactation and lifetime production traits by Sire Model and Animal Model is presented in Table 1

The average breeding value for age at first calving in crossbred sires was found to be 1199.02 and 1199.85 days by the Animal and Sire Model, respectively. In Animal Model, there were 44 sires out of 91 sires whose breeding values were above the average breeding value, while in the Sire Model 57 sires out of 107 sires were having a breeding value above the average breeding value. The highest and lowest breeding values were observed as 1292.15 and 1053.11 days for sire numbers 1095 and 1079, respectively, in Animal Model. Whereas highest and lowest breeding values observed for age at first calving were 1242.169 and 1161.8 days, for sire numbers 1014 and 1079, respectively. The difference between the highest and lowest breeding value was 239.04 and 80.369 days, respectively.

The average breeding value for first lactation milk yield in crossbred sires was estimated as2799.08 and 2799.56 kg by the Animal and Sire Model, respectively. The lowest breeding value observed for first lactation milk yield was 2145.91 and 2271.073 kg for sire numbers 1064 and 1067and the highest values were 3542.62 and 3538.41 kg for sire numbers 1014 and 1014 in the Animal and Sire Model, respectively. In Animal Model, out of 91 sires, there were 43 sires whose breeding values were found to be above the average and 48 sires with breeding values below the average breeding value while in Sire Model out of 107 sires 53 sires were having a breeding value above the average breeding value and 54 sires having breeding values below the average breeding value. The difference between the highest and lowest breeding value was 1396.71 and 1267.33kg in the Animal Model and Sire Model, respectively.

The average breeding value for the first lactation period in crossbred sires was found to be 332.08 and 332.10 days by the Animal and Sire Model, respectively. In Animal Model, the highest breeding value observed for the first lactation period was 361.72 days for sire number 1105 and the lowest breeding value was 306.50 days for sire number 1010. There were 44 sires whose breeding values were above the average breeding value and 47 sires out of 91 sires had breeding values below the average breeding value. In Sire Model, the highest breeding value observed for the first lactation period was 357.28 days for sire number 1095 and the lowest breeding value was 305.02 days for sire number 1077. The difference between the highest and lowest breeding values was 55.22 and 52.26 days for the Animal Model and Sire Model, respectively.

The average breeding value for the first dry period was estimated as129.30 and 129.12 days by the Animal and Sire Model, respectively. In Animal Model, the highest breeding value observed for the first dry period was 171.22 days for sire number 1031 and the lowest breeding value was 81.56 days for sire number 1027. In Sire Model, the highest breeding value observed for the first dry period was 150.30 days for sire number 1075 and the lowest breeding value was 106.30 days for sire number 1027. There were 27 sires out of 68 sires whose breeding values were observed above the average and 41 sires with breeding values below the average breeding value. There were 39 sires (out of 91) and 50 sires (out of 107) whose breeding values were above the average breeding value in the Animal and Sire Model, respectively. The difference between the highest and lowest breeding value was 89.66 and 44 days in the Animal and Sire Model, respectively.

The average breeding value for the first calving interval was estimated as459.04 and 458.57 days by the Animal and Sire Model, respectively. In Animal Model, the highest breeding value observed for the first calving interval was 533.29 days for sire number 1031 and the lowest breeding value was 396.41 days for sire number 1010. In Sire Model, the highest breeding value observed for the first calving interval was 495.58 days for sire number 1031 and the lowest breeding value was 401.00 days for sire number 1075. There were 42 sires (out of 91) and 56 sires (out of 107) whose breeding values were above the average breeding value in the Animal and Sire Model, respectively. The differences between the highest and lowest breeding values were 136.88 and 94.58 days in the Animal and Sire Model, respectively.

The average breeding value for lifetime milk yield in crossbred sires was found to be 10002.88 and 10005.00 kg by Animal and Sire models, respectively. In Animal Model, the highest breeding value observed for lifetime milk yield was 10436.97 kg for sire number 1088 and the lowest breeding value was 9333.99 kg for sire number 1079. There were 47 sires out of 71 sires whose breeding values were above the average breeding value. In Sire Model highest breeding value was 10387.50 kg for sire number 1014 and the lowest breeding value observed for lifetime milk yield was 9586.31 kg for sire number 1079 and there were 52 sires out of 107 sires whose breeding values were above the average breeding value. The difference between the highest

Table 1: Average breeding value estimates of sires for first lactation and lifetime production traits by different methods

Traits	Sire evaluation method	Average breeding value	Minimum breedingValue (below average)	Maximum breeding value (above average)	Number of sires over average breeding value % of sire)	Number of sires below average breeding value % of sire)
AFC	ANIMAL MODEL	1199.02	1053.11	1292.15	44(48.36)	47(51.64)
	SIRE MODEL	1199.85	1161.80	1242.17	57(53.27)	50(46.73)
FLMY	ANIMAL MODEL	2799.08	2145.91	3542.62	43(47.25)	48(52.75)
	SIRE MODEL	2799.56	2271.07	3538.41	53(49.53)	54(50.47)
FLP	ANIMAL MODEL	332.08	306.50	361.72	44(48.36)	47(51.64)
	SIRE MODEL	332.10	305.02	357.28	57(53.27)	50(46.73)
FDP	ANIMAL MODEL	129.30	81.56	171.22	39(42.86)	52(57.14)
	SIRE MODEL	129.12	106.30	150.30	50(46.73)	57(53.27)
FCI	ANIMAL MODEL	459.04	396.41	533.29	42(46.16)	49(53.84)
	SIRE MODEL	458.57	401.00	495.58	56(52.34)	51(47.66)
LTMY	ANIMAL MODEL	10002.88	9333.99	10436.97	47(51.65)	44(48.35)
	SIRE MODEL	10005.00	9586.31	10387.50	52(48.60)	55(51.40)
LTLL	ANIMAL MODEL	1087.66	466.73	1511.56	51(56.05)	40(43.95)
	SIRE MODEL	1091.55	616.01	1432.96	53(49.54)	54(50.46)

AFC=Age at first calving, FLMY=First lactation milk yield, FLP=First lactation period, FDP= First dry period, FCI= First calving interval,LTMY=Lifetime milk yield and LTLL =Lifetime lactation length

Table 2: Sires of top 10 ranks on the basis of estimated breeding values of sires for first lactation traits by different methods

	AFC		FLMY		FLP		FDP		FCI	
RANK	ANIMAL MODEL	SIRE MODEL	ANIMAL MODEL	SIRE MODEL	ANIMAL MODEL	SIRE MODEL	ANIMAL MODEL	SIRE MODEL	ANIMAL MODEL	SIRE MODEL
1	1079	1079	1014	1014	1105	1095	1027	1027	010	1075
2	1074	1059	1108	1108	1031	1014	1016	1048	016	1106
3	1026	1067	1008	1081	1021	1082	1010	1077	027	1010
4	1080	1080	1022	1008	1012	1018	1077	1016	106	1027
5	1078	1026	1038	1022	1079	1089	1048	1071	077	1034
6	1039	1025	1031	1075	1018	1108	1029	1037	048	1050
7	1007	1074	1073	1019	1033	1058	1058	1050	001	1016
8	1077	1064	1078	1090	1013	1101	1037	1010	002	1048
9	1059	1077	1040	1031	1074	1099	1002	1020	034	1029
10	1032	1103	1079	1040	1059	1042	1034	1025	029	1007

Table 3: Sires of top 10 ranks on the basis of estimated breeding values of sires for lifetime production traits by different methods

	LTMY		LTLL	
RANK	ANIMAL MODEL	SIRE MODEL	ANIMAL MODEL	SIRE MODEL
1	1088	1014	1095	1088
2	1095	1081	1043	1096
3	1043	1088	1088	1081
4	1014	1108	1096	1095
5	1019	1096	1092	1036
6	1092	1036	1100	1014
7	1096	1043	1099	1043
8	1100	1092	1019	1092
9	1107	1089	1041	1089
10	1108	1008	1036	1093

and lowest breeding values was 1102.98 and 801.19 kg in the Animal and Sire Model, respectively.

The average breeding value for lifetime lactation length in crossbred sires was found to be 1087.66 and 1091.55 days by the Animal and Sire Model, respectively. In the Animal Model, the highest breeding value was 1511.56 days for sire number 1095 and the lowest breeding value observed for lifetime lactation the length was 466.73 days for sire number 1079. There were 51 sires out of 71 sires whose breeding values were above the average breeding value while 40 sires had breeding values below the average breeding value. In Sire Model, the highest breeding value was 1432.96 days for sire number 1088 and the lowest breeding value observed for lifetime milk yield was 616.01 days for sire number 1079 and there were 53 sires out of 107 sires whose breeding values were above the average breeding value. The differences between the highest and lowest breeding values were 1044.83 and 816.95 days in the Animal and Sire models, respectively.

Ranking of sires on the basis of estimated breeding values of sires for first and lifetime production traits

The breeding values of the top 10 sires on the basis of age at first calving, first lactation milk yield, first lactation period, first dry period, first calving interval, first service period, lifetime milk yield, and lifetime lactation length estimated by the Animal model and Sire Model are presented in Table 2 and 3 respectively.

The top 10 sires ranked on the basis of age at first calving revealed that sire number 1079 ranked first in Animal Model and Sire Model. Sire numbers 1032 and 1103 ranked 10th in Animal Model and Sire Model, respectively.

Table 4: Comparison and evaluation AM and SM based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)

Model	AIC	BIC
Animal model	-39918.663	-40111.128
Sire model	-39948.198	-40140.663

The top 10 sires ranked on the basis of first lactation milk yield revealed that sire no. 1014 ranked 1st in both Animal Model and Sire Model. Sire numbers 1079 and 1140 ranked 10th in Animal Model and Sire Model, respectively by having a minimum average breeding value for FLMY.

On the basis of estimated breeding values of the first lactation period. Sire numbers 1105 and 1095 ranked 1st in Animal Model and Sire Model, respectively. Sire numbers 1059 and 1042 ranked 10th in Animal Model and Sire Model, respectively.

The top 10 sires ranked on the basis of the first dry period revealed that sire no 1027 ranked 1st for both the models. Sire numbers 1034 and 1025 ranked 10th in Animal Model and Sire Model, respectively for having maximum value for the first dry period.

On the basis of estimated breeding values for the first calving interval sire, numbers 1010 and 1075ranked 1st according to Animal Model and Sire Model, respectively (Table 4). Sire numbers 1029 and 1007 ranked 10th by Animal Model and Sire Model, respectively. Sire numbers 1010 and 1029 ranked 3rd and 9thaccording to the Sire model and Animal Model. The top-ranking sires between the SM and AM were inconsistent.

The top 10 sires ranked on the basis of lifetime milk yield (LTMY) revealed that sire number 1088 and 1014 ranked 1st, according to Animal Model and Sire Model, respectively (Table 5). However, sire number 1088 ranked 3rd by Sire Model, and sire number 1014 ranked 4th by Animal Model. Sire numbers 1108 and 1008 ranked 10th according to the Animal Model and Sire Model.

On the basis of lifetime lactation length (LTLL) breeding values, sire numbers 1095 and 1088ranked 1st in Animal Model and Sire Model, respectively, (Table 5). Sire number 1088 ranked 3rd by Animal Model. Sire numbers 1036 and 1093 ranked 10th by Animal and Sire models, respectively. Whereas, sire number 1036 ranked 4th by Sire Model. These results indicated that all sires would not rank the same for first lactation and lifetime traits according to both models. However, the rank of sires for different traits revealed that some of the sires almost had a similar rank for first lactation and lifetime traits. However, the ranks of sires for different traits revealed that 4-5 % of top sires had a similar rank for all the traits. These results suggested that to improve the productivity of the herd, major culling of bulls should be done on the basis of their daughter's first lactation milk yield. Similar results were also reported by Dubey and Singh (2014),Bajetha*et al.* (2015) and Lodhi *et al*. (2016)

Comparison of the efficiency of Sire and Animal Models

Information criteria of Akaike (AIC) and Bayesian (BIC) information criteria tests were used for the comparison of the models. The most accurate model is the one that has the highest negative AIC and BIC values. According to these two tests, the model which fits better with the data present can be selected. The values of the Akaike information criteria and Bayesian information criteria are obtained as shown in Table 4.

According to Table 4 in our model's information criterion of Akaike (AIC) and Bayesian information criterion (BIC) values were the highest negative for the Animal Model, which suggested that the Animal Model would be the most adequate model, while the Sire Model has the largest AIC and BIC, which suggests that this model is not an adequate model for evaluation of genetics parameters and concluded that the Animal Model would be the most adequate model for evaluation of genetics parameters. Using an animal model, particularly with the multiple traits analysis, for estimating BV's showed higher genetic diversity compared with the sire model which would lead to a rapid genetic gain in the future generations. The results were in agreement with the findings of Ramirez-Valverde *et al*. (2001), Sun *et al*. (2009), Dash*et al*. (2014), and Elsaid and El-Gabbas (2018).

REFERENCES

Bajetha, G., Singh, C. V.andBarwal, R. S. (2015). Sire evaluation by different methods in crossbred cattle. *American Advances Journal of Natural Sciences,* 1: 22-26.

Banik, S. and Gandhi, R. S. (2010). Sire evaluation using single and multiple trait animal models in Sahiwal cattle. *Indian Journal of Anima. Science*, 80: 269-270.

Boldman, K. G., Kriese, L. A., Van Vleck, M. D., Van Tassell, C. P. andKachman, S.D.(1995). A manual for use of MTD FREML. A set of programs to obtain estimates of variances and covariances [DRAFT], U.S. Department of Agriculture, Agricultural Research Service, USA

Dash, S.K., Gupta, A.K., Singh, A., Chakravarty, A. K., Madhusoodanan, M., Valsalan. J., Shivahre, P. R.and Hussain, A. (2014). Evaluation of efficiency of sire model and animal model in Holstein Friesian crossbred cattle considering first lactation production and fertility traits.*Veterinary World, 7*(11): 933-937.

Dubey, P. P.and Singh, C.V. (2014). Sire evaluation considering first lactation yield for improvement of life time production in Sahiwal and crossbred Cattle. *Advances in Animal and Veterinary Sciences*, *2*(1): 56-62.

Elsaid, R.and El-Gabbas,H. M. (2018). Estimation of heritability and breeding values for some wool traits in barki sheep, using single and multiple traits animal models in comparison with sire models. *Egyptian Journal of Sheep and Goats Sciences*, 13(2): 1-10.

Lodhi, G., Singh, C. V., Barwal, R. S.and Shahi,B.N. (2016). Genetic and phenotypic parameter s of first lactation and life time traits in crossbred cattle. *International Journal of Agricultural Policy and Research, 4*(8): 143-148.

Lukač, D., Miščević, B., Könyves, T., Puvača, N., Džinić, N.andDuragić, O.(2017). Comparison of models for genetic analysis of traits from performance test of gilts using restricted maximum likelihood. *Romanian Biotechnological Letters, 22*(4): 12802.

Mrode R A. (2005). Linear Models for the Prediction of Animal Breeding Values. 2nd ed. CAB International,Wallingford, UK.

Ramirez-Valverde, R., Misztal, I.and Bertrand,J.K.

(20010. Comparison of threshold vs linear and animal vs sire models for predicting direct and maternal genetic effects on calving difficulty in beef cattle. *Journal of Animal Science, 79*(2): 333-338.

Schaeffer, L.R.(1983). Effectiveness of model for cow evaluation intraherd. *Journal of Dairy Science,* 66:874–880.

Sun, C., Madsen, P., Lund, M. S., Zhang, Y., Nielsen, U. S.andSu, G.(2010). Improvement in genetic evaluation of female fertility in dairy cattle using multiple-trait models including milk production traits. *Journal of Animal Science,* 88: 871-878.

Sun, C., Madsen, P., Nielsen, U. S., Zhang, Y., Lund, M. S.andSu, G. (2009). Comparison between a sire model and an animal model for genetic evaluation of fertility traits in Danish Holstein population. *Journal of Dairy Science,* 92(8): 4063-4071.

Received: December 29, 2022
Accepted: December 31, 2022