



Genetic evaluation of Frieswal cattle for first lactation milk yield from smallholder dairy production systems in Kerala, India

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ABSTRACT

The present investigation was undertaken to determine the genetic worth of Frieswal (62.5% HF × 37.5% Sahiwal) young bulls through progeny testing under field conditions in Kerala state, India. A total of 65 Frieswal bulls were evaluated based on 1037 first lactation records of their daughters calved over a period of 15 years from 1995 to 2010 were used for the study. The overall average breeding value for the first lactation 305-days milk yield was estimated as 2229.19±50.91 kg with a range of 2193.74±66.59 to 2280.62±66.59 kg. Out of 65 bulls inducted in 7 different sets, 33 bulls (50.7%) had breeding values higher than the herd average (2229.19 kg). The number of daughters per bull varied from 7 to 51 whereas the average number of daughters per bull was 16. The genetic superiority and percentage genetic superiority of the top 25 bulls (38.46%) over population ranged from 6.26 to 51.43 and 0.28 to 2.30, respectively. The least squares analysis of variance revealed that the year of calving had a significant effect on the first lactation milk yield of daughters. The increasing trend of first lactation milk yield over year / bull set observed in the present study indicates the successful implementation of large-scale progeny testing programme under field conditions.

Keywords: Frieswal, First lactation milk yield, Field progeny testing, Genetic evaluation

The Kerala state is located at 10.52°N 76.21°E and has an average altitude of 2.83 metres in the southern region of India covering 1.2% of the country's total geographical area. The state is covered by the coastal area along the Arabian Sea on the western side and the mountainous belt of the Western Ghats on the other side. Being a state with hilly terrain, the majority of the cattle population were low milk producing small-sized non-descript animals. In order to increase the milk production potential of cattle, the State has successfully implemented the crossbreeding program by using exotic breeds, viz. Jersey and Holstein Friesian which resulted in an increased crossbred population replacing the majority of the non-descript cattle which in turn led to increased milk production. Presently, more than 90% of cattle in Kerala are crossbreds.

The results of crossbreeding experiments conducted in India revealed that the Holstein Friesian crosses are best suited for higher milk production (Singh *et al.* 2000, Upadhyay *et al.* 2000, Akhter *et al.* 2003) and so the majority of the states have a higher population of HF crosses. Along this line, the Indian Council of

Agricultural Research (ICAR) also implemented a large scale crossbreeding programme called Frieswal (Holstein Friesian × Sahiwal) Project in collaboration with Military Dairy Farms, Ministry of Defence, Government of India to evolve a national milch breed of cattle “Frieswal” by crossing Holstein Friesian with Sahiwal breeds. With the continuous efforts made by the ICAR-Central Institute for Research on Cattle, Meerut, a national milch breed of cattle “Frieswal™” having exotic (HF) inheritance of 62.5±5.0 has been developed.

To sustain and bring further improvement among the crossbred cattle population, there is a need for a large number of genetically superior progeny tested crossbred bulls. In order to produce more proven HF crossbred bulls, ICAR-Central Institute for Research on Cattle (ICAR-CIRC), Meerut executed a Field Progeny Testing Program as a subproject of All India Coordinated Research Project (AICRP) on cattle in collaboration with Agricultural/Veterinary Universities, viz. Kerala Veterinary and Animal Sciences University (KVASU), Thrissur; Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana; G. B. Pant University of Agriculture and Technology (GBPUA&T), Pantnagar and a non-government organization, the Bharatiya Agro Industries Foundation (BAIF) Development Research Foundation, Uruli-Kanchan, Pune (Das *et al.* 2020).

This article focused on KVASU Thrissur. In this unit,

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this project covers about 34,000 test females in the field conditions of Kerala (Das *et al.* 2017). A large number of cows are being inseminated in the program so that records of sufficient daughters are achieved for sire evaluation despite significant data loss (Kumar *et al.* 2015). Selection of sires on the basis of daughter's first lactation milk production trait would be a better choice in crossbred cattle (Singh *et al.* 2017). The first set of bulls at KVASU was executed in January 1992. Subsequently, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, 15th and 16th sets of bulls, were implemented in 1994, 1995, 1998, 2001, 2003, 2005, 2006, 2008, 2009, 2011, 2012, 2014, 2015, 2017 and 2019 respectively. The details of different bull sets and their performance is given in Table 1.

The insemination work was undertaken through 8 Artificial Insemination Centers out of which 6 centres are at Dairy Co-operative Societies located nearby Thrissur and 2 at Livestock Farms of Kerala Agricultural University. A total of 315 bulls in 16 different sets had so far been inducted into the program. A total 134789 Artificial Inseminations had so far been done, out of which 11418 female progenies (breed able females) had been produced and 2923 female calves reached the age at first calving through the use of semen of the test bulls. The daughters born from the first 12 sets had completed their 1st lactation milk yield. The crossbred bulls used in these sets had 50-75% exotic inheritance and were evaluated for their merit in the present investigation. The present investigation was undertaken to evaluate the genetic worth of Frieswal crossbred bulls and to rank them on the basis of first lactation 305 days milk yield of their daughters so that top-ranked bulls could be identified and used them under nominated mating for production of future male calves and overall genetic improvement of cattle for enhancing milk production in the state.

MATERIALS AND METHODS

To study the characteristics of the smallholder cattle production system of the Kerala state, information on the socio-economic status of the dairy farmers was collected and analysed using well-designed survey questionnaires. The information on family size, land holding, educational status, occupation, herd size etc. was collected from dairy farmers.

Technical programme: This Field Progeny Testing program envisages testing of 30 Frieswal (HF×Sahiwal) bulls in each set having 62.5% exotic inheritance and dam's minimum mature equivalent milk yield of 4,500 kg. The target is to provide 15000 semen doses (500 semen doses of each bull for a total of 30 bulls) at each unit for test mating. This will involve 300 inseminations per bull at each unit and a population of about 9000 cows per unit thus will be needed for test mating with 30 bulls. Recording of a minimum of 40 daughters from each test bull spread over four different units namely GADVASU, Ludhiana; KVASU, Thrissur; GBPUA&T, Pantnagar and BAIF, Urlikanchan was used for evaluation of bulls.

Statistical methods: The first lactation records of 1037 crossbred cows maintained at farmers' herds in Kerala were used in the analysis for the evaluation of bulls. These crossbred cows which were daughters of 65 bulls and calved during 15 years from 1995 to 2010 were used in the present study. The fixed effects considered in the least squares model were season and year of calving, age at first calving and the set in which the bull was inducted. Each year of calving was divided into 4 seasons, i.e. winter (December to February), summer (March to May) rainy (June to August) and post-monsoon (September to November) based on climatic conditions. Data was also divided into

Table 1. Information regarding different sets of bulls

Set No.	Date of start	Total bulls used	Total inseminations	Total A.I.'s followed	Pregnancies confirmed	Conception rate %	Followed for calving	Females calves	
								Born	Reached AFC
I	01/01/1992	12	23351	6722	2420	36	1902	956	319
II	01/04/1994	11	12817	4800	1680	35	1300	603	240
III	01/07/1995	11	9331	3942	1324	33.6	1065	757	89
IV	01/11/1998	15	11750	3753	1501	39.9	1489	676	178
V	01/07/2001	17	3437	3261	1136	34.8	847	401	139
VI	01/07/2003	20	8173	7683	2582	33.6	1689	746	216
VII	01/02/2005	24	5759	5211	2281	43.7	1298	597	180
VIII	01/09/2006	22	5703	5514	2472	44.8	1538	768	160
IX	01/02/2008	16	3393	3131	1181	37.7	801	394	81
X	01/07/2009	24	5781	5612	2124	37.8	1324	664	162
XI	01/04/2011	21	4820	4401	2006	45.6	1280	659	235
XII	01/08/2012	28	6045	5531	2357	42.61	1302	642	262
XIII	01/03/2014	14	5211	4850	2063	41.97	1114	545	257
XIV	01/07/2015	29	9682	9211	4134	44.88	2515	1229	392
XV	02/08/2017	26	10735	10191	4639	45.52	2733	1361	13
XVI	09/08/2019	25	8801	6704	2801	41.78	859	420	0
Total		315	134789	90517	36701	40.00	23056	11418	2923

15 groups on the basis of the year of calving. Bulls were divided into 7 groups based on their set numbers to account for selection over years (Gaur *et al.* 2008). Data was also divided into 10 groups on the basis of age at first calving (AFC). Bulls with less than 7 daughter's records were excluded from the study. The bulls were evaluated based on first lactation 305 days milk yield of their daughters in field conditions at the farmer's herd. The milk yield of cows was estimated during test day records. Bulls' breeding values were estimated through the best linear unbiased prediction (BLUP) procedure using a suitable option in least squares and maximum likelihood computer package (Harvey 1990). The heritability estimate of 305 days milk yield used in BLUP analysis was taken as 0.25. The following model was used for the analysis of data sets.

$$Y_{ijklmn} = \mu + B_i + J_j + S_k + P_l + A_m + e_{ijklmn}$$

wherein, Y_{ijklmn} , Observation of 305 days first lactation milk yield on the n^{th} daughter of i^{th} sire within j^{th} sire set; μ , Overall mean; B_i , Random effect of sire; J_j , Fixed effect of sire set; S_k , Fixed effect of k^{th} season of calving; P_l , Fixed effect of l^{th} year of calving; A_m , Fixed effect of age at first calving and e_{ijklmn} , Random residual error.

RESULTS AND DISCUSSION

Socio-economic status of the farmers: Information on the socio-economic status of dairy farmers of Kerala state was collected and analysed, and found that socio-economic factors of the owners of the animals influenced the first lactation milk yield of cattle. More than 80% of the farmers were classified as Agricultural farmers. This is a clear indication that livestock is only a subsidiary enterprise for these farmers. Agricultural labours accounted for 11.21% and the other occupational groups of owners were negligible. About 41% of farmers were having education up to Matric level. Around 11% of the farmers had a college education where as 14% had higher secondary education (Fig. 1).

The land holding pattern showed that 30% of farmers had a holding of 5-10 acres, and 10% had 1-2 acres of land. There were 28% of farmers with 2-5 acres of land and more than 27% of the farmers had landholding more than 10 acres (Fig. 2). The average herd size of farmers was close

to 4. The farmers with 3 or less than 3 animals accounted for 46.29%. The farmers with more than 10 animals in their herd were very low (3.8%). This clearly indicates that the production system followed by farmers in Kerala is a smallholder type.

The herd structure of the project areas showed that milking cows accounted for 45.9% of total cattle and 36.2% of the animals were calves. Dry cows are only 5.8% indicating the sale of dry animals is a practice in the area. Another indication from the low presence of heifers in the herd (12.1%) indicates that farmers are not keeping all their female calves as replacement stock rather they sell it for a higher price because daughters born under the FPT project produce more than 500 kg milk as compared to their contemporaries. A similar finding was also observed in earlier studies (Das *et al.* 2017). In the survey study, it was also found that milk production of animals maintained by educated farmers is comparatively higher (2765.4 kg) as compared to illiterate farmers (2455.8 kg). Similarly, milk production of animals kept by farmers with higher land availability produces more milk as compared to landless farmers. This may be because of the availability of green fodder with the land-holding farmers.

Estimation of breeding values: The BLUP analysis considered the first lactation 305 days milk yield records of 1037 daughters from 65 bulls inducted in 7 different sets from July 1995 to September 2010. The overall first lactation 305 days milk yield in crossbred cows was 2229.19 ± 50.91 kg under field conditions. This was lower than that reported by earlier workers in Friesian $\times$ Sahiwal crosses (Bhat *et al.* 1978, Sain *et al.* 1988, Gaur *et al.* 2006, Singh *et al.* 1990, Rao *et al.* 2000). Similar finding was reported by Iype *et al.* (1993), Garcha and Dev (1994) and Kiran *et al.* (1995). The number of daughters per bull varied from 14 to 51 whereas the average number of daughters per bull was 16. The genetic superiority and percentage genetic superiority of the top 25 bulls (38.46%) over that of the population varied from 6.26 to 51.43 and 0.28 to 2.30, respectively. The details of the top 20 bulls out of a total of 65 evaluated are given in Table 2.

The breeding values of the bulls in the present investigation were lower than that reported by Gaur (2003)

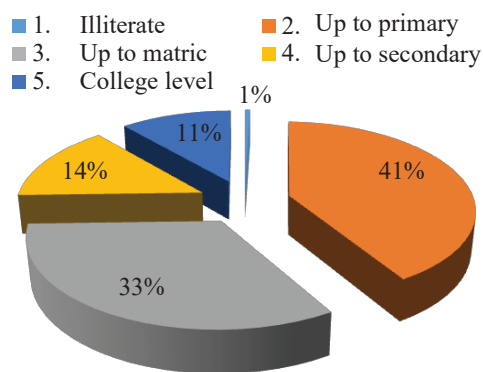


Fig. 1. Education status of farmers.

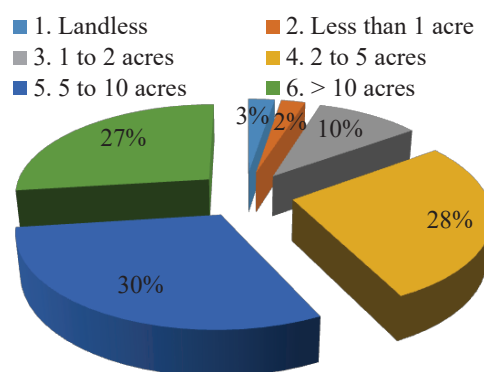


Fig. 2. Land holding pattern of farmers.

Table 2. Breeding value of top 20 bulls based on first lactation milk yield of daughters

Bull name	Bull origin	Set No	Progeny size	Breeding value	Genetic superiority over population	% of Genetic superiority over population	Ranking
Overall mean			1037	2229.19±50.91			
GOPAL	CIRC	1	28	2280.62	51.43	2.30	1
GLORY	BAIF	6	19	2259.27	30.08	1.34	2
DILWAR	CIRC	1	23	2257.89	28.7	1.28	3
DHANAJI	BAIF	7	16	2256.80	27.61	1.23	4
HEERA	CIRC	2	30	2250.37	21.18	0.95	5
DAVID	BAIF	2	14	2249.59	20.4	0.91	6
FC1201	GADVASU	7	17	2249.39	20.2	0.90	7
IDEAL	CIRC	1	21	2248.87	19.68	0.88	8
GULAB	BAIF	5	18	2248.51	19.32	0.86	9
RANCHO	CIRC	5	19	2248.30	19.11	0.85	10
HASMUK	BAIF	2	37	2242.73	13.54	0.60	11
YAHOO	BAIF	6	14	2242.36	13.17	0.59	12
GIRISH	BAIF	6	15	2241.79	12.6	0.56	13
HARNAM	BAIF	6	16	2241.19	12	0.53	14
DIWANA	CIRC	3	18	2239.56	10.37	0.46	15
DINAR	BAIF	5	17	2239.22	10.03	0.44	16
KALA	CIRC	3	19	2239.18	9.99	0.44	17
HEMANT	CIRC	1	15	2238.45	9.26	0.41	18
DEBU	BAIF	4	16	2238.20	9.01	0.40	19
GAMA	BAIF	5	19	2238.12	8.93	0.40	20

in the Holstein-Friesian × Sahiwal cross. He observed the breeding values of young crossbred bulls ranging from 2481 to 2768 kg for first lactation milk yield. This may be due to the source of data, as the referred study was based on the performance of Frieswal (HF × Sahiwal) maintained in different organised Military dairy farms, whereas the present study is based on the performance of Frieswal in farmers' herd. The breeding values of certain bulls were higher than the corresponding daughter's average (phenotypic value) in all sets. This reflected that the genetic potential of the bulls could not be exploited fully in the given environment. Bulls within the set had minimum variation in first lactation milk yield while those between the sets had maximum variation. The breeding values for first lactation milk yield varied from 2049.07 to 2295.88 kg in 1st set, from 2013.47 to 2225.62 kg in 2nd set, from 2025.55 to 2237.60 kg in 3rd set, from 2031.58 to 2200.57 kg in 4th set, from 2174.65 to 2394.87 kg in 5th set, from 2340.70 to 2760.75 kg in 6th set and from 2646.09 to 2651.36 kg in 7th set. Some bulls showed lower breeding value with more number of daughters as compared to those with less number of daughters. The accuracy was however more for the bulls evaluated based on more number of daughters (Das *et al.* 2020). The average first lactation milk yield of daughters of bulls of different sets was 2141.24±98.68 kg in 1st set, 2099.07±136.98 kg in 2nd set, 2141.68±76.78 kg in 3rd set, 2112.98±128.67 kg in 4th set, 2288.29±114.12 kg in 5th set, 2494.67±119.99 in 6th set and 2649.11±147.40 kg in 7th set which clearly indicates that there is a trend of gradual improvement in milk production in progenies

of bulls under test. The improved breeding value of the bulls in subsequent sets and positive trends reflected that the program has moved in the desired direction and further improvement may be expected in the near future when more sets will be introduced in the program.

There is a consistent trend of increase in the average 1st lactation 305 days milk yield of daughters in subsequent sets of bulls. In the 1st set of bulls, it was recorded as 1958.4 kg and in the current set of bulls (14th), it was recorded as 3140.43 kg which indicates a sharp increase of 1182 kg milk (60.35%) in progenies of bulls under test. A trend of decrease in AFC was also observed in subsequent sets of bulls. It was recorded as 1136.4 days in progenies of 1st set of bulls (1992) which has reduced to 990.12 days in the current set of bulls (14th) which indicate a sharp decrease of 146.28 days (12.87%) in AFC (Fig. 3)

Productive and reproductive indicators: The year-wise trends of production and reproduction indicators from the last ten years from 2011-2020 in the performance of daughters of Frieswal bulls under test were analysed and positive trends in all the parameters were observed except AFC which showed a desirable decreasing trend. In the year 2011, the total calving and female calves born were 706 and 345 which had reached to 1468 and 721 in 2020, respectively, indicating an improvement of about 48% in both traits. Simultaneously, the number of female calves that reached AFC and those that completed 1st lactation were 62 and 89 in the year 2011. The corresponding numbers in the year 2020 were 237 and 201, respectively (Fig. 4).

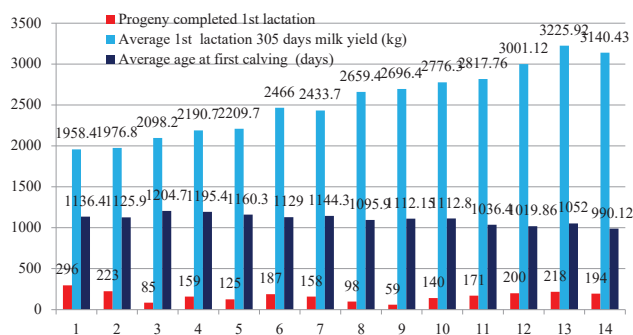


Fig. 3. Set-wise progeny performance at KVASU unit since inception.

The cows calved during the winter season had the highest least square means for first lactation 305 days milk yield (2277.37 ± 58.43 kg). This was followed by those calved during rainy (2235.88 ± 56.79 kg), post-monsoon (2203.85 ± 56.95 kg), and summer season (2199.68 ± 58.09 kg) in field conditions (Table 3). This variation could be due to the type of feed, environmental deviations and management practices adopted by different farmers in field conditions. Farmers do not opt for alternatives as in the case of organized farms. A similar finding was also observed in earlier studies (Kumar *et al.* 2015). There was a trend of increasing first lactation milk yield year-wise, which was lowest (1935.09 ± 130.36 kg) in the year 1997 and highest (2507.41 ± 185.81 kg) in 2010. The year of calving has a significant effect on first lactation milk yield. A significant effect of year of calving on milk yield was reported in previous studies (Gaur *et al.* 2008, Komatwar *et al.* 2010, Kumar *et al.* 2017). On the other hand, the non-significant effects of season and period of calving on the first lactation milk yield were reported by other workers (Nehra 2011, Rajeev *et al.* 2017, Singh *et al.* 2018). The variation in milk yield observed in different years indicated the level of management as well as environmental effects prevailed in those years. The regression of 305 days 1st lactation milk yield was found significant on age at first calving. A similar finding was also observed in earlier studies (Das *et al.* 2020). Cows under the age group of 1094-1254 days showed the lowest breeding value of 2118.08 ± 35.63 , whereas those in the age group of more than 2054 days showed the highest breeding value of 2391.34 ± 352 .

The overall average breeding value for the first lactation 305-days milk yield was estimated as 2229.19 ± 50.91 kg

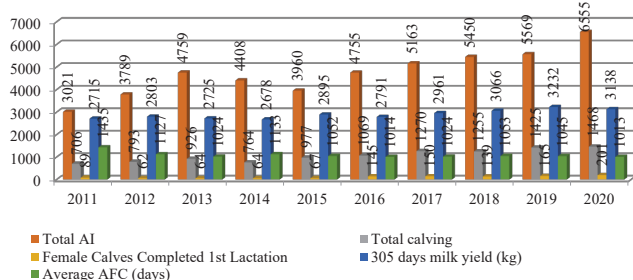


Fig. 4. Trends of various productive and reproductive indicators in the Field Progeny Testing Programme.

Table 3. Least squares mean of first lactation milk yield based on set of bull, year and season of calving and age at first calving

Factor/ Effect	No. of observations	LSM±SE
Overall mean	1037	2190.00±22.28
<i>Set of induction</i>		
Set -1	293	2107.03±104.68
Set-2	224	2170.76±103.87
Set-3	64	2138.51±124.77
Set-4	136	2204.58±105.46
Set-5	94	2232.12±126.69
Set-6	158	2317.92±139.53
Set-7	68	2433.43±176.86
<i>Year of calving*</i>		
1995	74	1989.49±144.07
1997	148	1935.09±130.36
1998	125	2019.17±126.64
1999	88	2079.65±128.24
2000	90	2269.83±127.28
2001	37	2153.04±143.42
2002	30	2325.67±125.60
2003	35	2300.82±136.94
2004	74	2376.43±120.28
2005	25	2088.29±121.38
2006	64	2183.24±119.08
2007	85	2432.65±119.42
2008	82	2361.42±130.55
2009	58	2415.71±149.63
2010	22	2507.41±185.81
<i>Season of calving</i>		
Winter	252	2277.37± 58.43
Summer	284	2199.68± 58.09
Rainy	275	2235.88± 56.79
Post-monsoon	226	2203.85± 56.95
<i>Age at first calving*</i>		
614-774	36	2295.74± 86.55
774-934	154	2260.66± 44.26
934-1094	282	2267.56± 33.10
1094-1254	256	2118.08± 35.63
1254-1414	182	2150.40± 42.76
1414-1574	74	2158.55± 63.34
1574-1734	35	2314.81± 89.02
1734-1894	11	2256.99±153.98
1894-2054	5	2077.82±234.45
>2054	2	2391.34±352.15

**P<0.01.

with a range of 2193.74 ± 66.59 to 2280.62 ± 66.59 kg. Out of 65 bulls inducted in 7 different sets, 33 bulls (50.7%) had breeding values higher than the herd average (2229.19 kg). The increasing trend of first lactation milk yield over year / bull set observed in the present study indicates the successful implementation of large-scale progeny testing programme under field conditions. The results of the program are encouraging and are comparable with the performance of Holstein-Friesian crosses maintained under farm conditions. The semen of top-ranked bulls is

used in nominated mating for the production of male calves for induction in the new sets. The program is not only restricted to producing and testing the superior crossbred male calves in the field but is consistently improving the genetic potential of the cows available in the operational area as well as in nearby areas of the program leading to a consistent increase in milk production.

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