



Effects of inbreeding on performance traits in Karan Fries crossbred cattle

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ABSTRACT

Present study includes the effect of inbreeding on expected genetic gain and estimation of regression with respect to first lactation production, reproduction and lifetime traits in Karan Fries crossbred cattle maintained at ICAR-NDRI, Karnal. Out of total, only 36.97% were found to be inbred with an average inbreeding coefficient 3.68%. Overall least squares mean for reproduction traits (days) AFC, SP, DP and CI were 1020.41 ± 5.49 , 141.42 ± 3.86 , 74.54 ± 2.04 and 421.20 ± 3.81 respectively. For production traits (kg) were 305MY, LL, LTMY, FY and SNFY were 3169.15 ± 37.87 , 353.25 ± 4.18 , 3686.10 ± 55.10 , 266.19 ± 4.66 and 127.81 ± 2.26 respectively and lifetime traits like LTMY and stayability were 14588.47 ± 486.09 (kg) and 2444.69 ± 41.26 (days) respectively. Among reproduction traits (days), AFC increased by +3.70, DP +3.66 and CI +68.44 however SP decreased by -0.85 d and production traits (kg), 305MY decreased by -10.2 TMY -16.09, LL -1.23 d, 305FY -1.75, 305SNFY -0.26, LTMY 202.02 and stayability -17.37 days per unit increase in the inbreeding coefficient. Although there was no inbreeding depression in any of the traits except AFC. The expected genetic gain of AFC increased two folds in IBL2 ($F_x > 5\%$) as compared to IBL1 ($F_x < 5\%$) group that is not desirable, so in future, to maintain the optimum genetic gain we should keep inbreeding at optimum level and so more precise pedigree recording and planned mating strategies should be adopted to avoid inbreeding depression in next generation.

Keywords: Breeding programme, Genetic gain, Inbreeding, Karan Fries crossbred cattle, Performance traits

The Karan Fries crossbred dairy cattle was developed as a result of crossbreeding by Holstein Friesian (HF), Brown Swiss (BS) and Jersey (J) bulls with Tharparkar cows, project started in 1971, at ICAR-NDRI, Karnal, where it was finally declared as a specific strain in 1982 with the aim of increasing milk yield and also retaining heat tolerance and disease resistance characters of indigenous cattle. Crossbred cattle population contribute more than 50 per cent (50..42%) of the total milk produced by cattle with only 20.81% population which play an important role in white revolution in India (20th Livestock Census 2019). Inbreeding is a common practise in herd to increase the frequency of desirable alleles but to a definite edge and has been accepted until it did not affect the economics of traits (Gowane *et al.* 2014). The demand for genetically superior sire has increased significantly and as a consequence, the intensive use of certain sires (Santana *et al.* 2014) and introduction of small number of animals may lead to productive and reproductive economic loss. Lifetime performance and longevity of breeding stock are highly desirable characteristics that immensely influence the overall profitability of a dairy animal. To make dairying a successful and profitable business,

the animals should not only be high producing, but also healthy with long productive life (Novakovici *et al.* 2014).

Inbreeding does not always lead to decrease in the performance but to maintain the sustainable production, it should be kept at an optimum level, so we need to monitor the inbreeding status periodically (Pekkala *et al.* 2014). Inbreeding mainly has detrimental affects on low heritable traits such as AFC, SP, CI, etc and makes the animals more similar and thus reduces the genetic variation in the population such that the population has a reduced potential for genetic gain in herd (Musingi *et al.* 2018). There is no literature available regarding effect of inbreeding on expected genetic gain of reproductive traits in either of breed and species considered in the present investigation. Therefore the objective of this study was that inbreeding should also be given due emphasis in breeding programmes to maintain the sustained production performance for overall improvement in productivity of dairy cattle in future.

MATERIALS AND METHODS

Genealogical data: A total of 7,348 pedigree records and 5,278 performance records spread over period of 1970-2018 and 1986-2018 for milk constituent traits were collected from stock register and history-cum-pedigree sheets of Karan Fries maintained at Animal Genetics and Breeding (AG&B) division and milk constituents traits from Livestock Research Centre (LRC), ICAR-National Dairy

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Research Institute, Karnal. The records with known pedigree were taken for estimation of inbreeding coefficient. The traits included in the study were age at first calving (AFC), and only first lactation service period (SP), dry period (DP), calving interval (CI), 305 days or less milk yield (305DMY), total milk yield (TMY), lactation length (LL), 305 day fat yield (305FY) and 305 solid not fat yield (305SNFY) and lifetime traits viz. life time milk yield (LTMY) and stayability. The animals with abnormal records like abortion, still birth, delayed calving and other reproductive problems were not considered for association studies. Data on production and fertility performance, as well as lifetime traits were classified according to season of birth/calving, period of birth/calving and genetic group. The coefficient of inbreeding was estimated in Endog v4.8 software. The adjusted data was classified into 5 groups based on the inbreeding level as group 1 (non-inbred), group 2 (>0 to 1.25%), group 3 (>1.25 to 5%), group 4 (>5 to 10%) and group 5 (>10) to see the effect of inbreeding on performance traits. To quantify the change on various performance traits with unit change in inbreeding value simple regression analysis was carried out excluding non inbred groups.

Note: Lifetime milk yield (LTMY) = Total milk yield of all lactations first parity should be normal and minimum two lactation, Stayability = date of disposal – date of birth.

Statistical analysis

Model for adjusting the non-genetic factors: The data was adjusted using least-squares analysis for non-orthogonal data as suggested by Harvey (1990). Duncan's multiple range test as modified by Kramer (1957) was used for testing differences among least squares means.

$$Y_{ijkl} = \bar{y} + P_i + S_j + G_k + e_{ijkl}$$

where, Y_{ijkl} , Observation of i^{th} animal belong to k^{th} genetic group born/calved in j^{th} season and i^{th} period of birth/calving; $\bar{y}$, Overall population mean; P_i , Effect of i^{th} period of birth/calving; S_j , Effect of j^{th} season of birth/calving; G_k , Effect of k^{th} genetic group; and e_{ijkl} , Random error, NID (0, σ_e^2).

*Season and period of birth only for AFC and lifetime traits Genetic group 1– (HF × Tharparkar); 2-Interbred (KF × KF) and 3-Higher cross (HF × KF).

Effect of inbreeding on various traits

$$Y_{jk} = \mu + IB_j + e_{jk}$$

where, Y_{jk} , Observation of j^{th} animal under i^{th} inbred group; μ , Overall mean; T_i , Fixed effect of i^{th} inbred group; e_{ij} , Random error – NID (0, σ^2).

Simple regression analysis

$$Y_{ij} = a + bX_i + e_{ij}$$

where, Y_i , Reproduction/Production trait of j^{th} cow; a , Intercept; b , Regression coefficient; x_i , i^{th} inbreeding value;

e_{ij} , Random error – NID (0, σ^2).

Expected genetic gain: Expected genetic gain was estimated by Rendel and Robertson (1950)

$$\Delta G/\text{year} = h^2 \times S$$

where, ΔG , genetic gain per year; S , selection differential; h^2 , heritability of the trait.

$$\Delta G/\text{generation} = h^2 \times S/GI$$

where GI, generation interval.

RESULTS AND DISCUSSION

The average inbreeding coefficient (F_x) for whole pedigree and inbred population were 1.36 and 3.65% respectively out of which females are more inbred (3.69% F_x) as compared to male. Similarly Singh and Gurnani (2004) reported 1.40% for the same population of KF from 1980-1992 and 5.94% for Karan swiss (Saha *et al.* 2011). Fig. 1 indicated that inbreeding increased considerably until 1998, reaching a value of 2.50 in 1993 and then started decreasing slowly thereafter. This could be due to frequent use of imported pure HF frozen semen or crossbred bull's from different military dairy farm. The increase substantially lowered in recent years (2002 to 2018) as compared with the decade from 1981 to 1993 indicating that the F_x was constant in the entire KF herds. As the generation progressed the common ancestors became remote to the descendents and thus resulted in the decreased inbreeding.

However, inbred animals have been increasing over years and generation due to few sires were extensively used and bulls which have played important role to build up inbreeding in the herds. Introduction of new sires with the lowest possible relatedness and the use of appropriate mating strategies are recommended to keep inbreeding at acceptable levels and increase the genetic variability in KF, which has relatively low numbers compared to other commercial cattle breeds.

Effect of inbreeding on reproduction traits: Least square means for various traits for different inbred classes are shown in Tables 1–3 and the inbreeding depression in various performance traits is given in Table 4.

For all cow traits in the present study, there were no significant effects of inbreeding except AFC ($P \leq 0.01$) and this corroborates the result of Martikainen *et al.* (2017). Maximum AFC, SP, DP and CI value (days) observed were 1042.30, 177.25, 83.53 and 428.40 respectively for cows

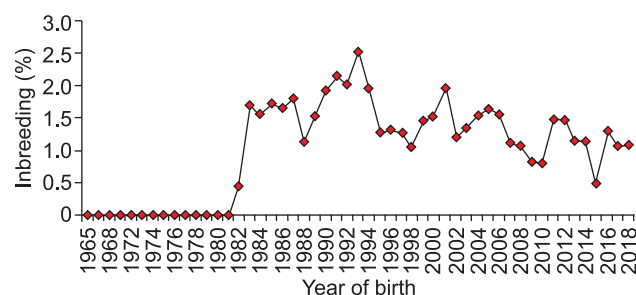


Fig. 1. Average Inbreeding coefficient by year of birth for whole pedigree in Karan Fries cattle.

Table 1. Least squares means $\pm$ standard error for influence of inbreeding on first lactation reproduction traits

Effect	AFC	N	SP	DP	CI
Overall mean (μ)	1020.41 $\pm$ 5.49 (1898)	1384	141.42 $\pm$ 3.86	74.54 $\pm$ 2.04	421.20 $\pm$ 3.81
Level of inbreeding (%)					
0	994.31 ^a $\pm$ 3.66 (1324)	1024	137.96 $\pm$ 2.31	74.09 $\pm$ 1.21	413.44 $\pm$ 2.28
>0 <1.25	1042.30 ^b $\pm$ 10.11 (174)	93	145.15 $\pm$ 7.68	83.53 $\pm$ 3.89	428.40 $\pm$ 7.56
>1.25 <5	1038.21 ^b $\pm$ 8.20 (264)	180	139.07 $\pm$ 5.52	73.38 $\pm$ 2.83	418.38 $\pm$ 5.44
>5 <10	1019.81 ^{ab} $\pm$ 14.21 (88)	57	141.24 $\pm$ 9.81	72.23 $\pm$ 5.15	422.89 $\pm$ 9.66
>10	1007.39 ^{ab} $\pm$ 19.25 (48)	30	143.70 $\pm$ 13.52	69.50 $\pm$ 7.28	422.90 $\pm$ 13.32

Figures in parenthesis indicates number of observation; mean with different superscripts differ significantly from each other.

Table 2. Least squares means $\pm$ standard error for influence of inbreeding on first lactation production and milk constituents traits

Effect	N	305MY (kg)	LL (days)	LTMY (kg)	N	FY (kg)	SNFY (kg)
Overall mean (μ)	1719	3169.15 $\pm$ 37.87	353.25 $\pm$ 4.18	3686.10 $\pm$ 55.10	931	266.19 $\pm$ 4.66	127.81 $\pm$ 2.26
Level of inbreeding (%)							
0	1269	3155.88 $\pm$ 22.65	347.29 $\pm$ 2.50	3661.52 $\pm$ 32.96	574	271.48 $\pm$ 3.04	129.96 $\pm$ 1.48
>0 <1.25	130	3117.60 $\pm$ 70.78	357.51 $\pm$ 7.82	3632.66 $\pm$ 102.97	126	267.19 $\pm$ 6.50	127.54 $\pm$ 3.16
>1.25 <5	216	3233.48 $\pm$ 54.91	353.56 $\pm$ 6.07	3790.67 $\pm$ 79.88	173	281.51 $\pm$ 5.55	134.53 $\pm$ 2.69
>5 <10	67	3123.50 $\pm$ 98.60	347.17 $\pm$ 10.90	3570.17 $\pm$ 143.44	42	271.47 $\pm$ 11.27	130.73 $\pm$ 5.47
>10	37	3215.27 $\pm$ 132.68	360.72 $\pm$ 14.67	3775.48 $\pm$ 193.02	16	239.31 $\pm$ 18.26	116.31 $\pm$ 8.87

Table 3. Least squares means $\pm$ standard error for influence of inbreeding on lifetime traits

Effect	LTMY (kg)	Stayability (days)
Overall mean (μ)	14588.47 $\pm$	2444.69 $\pm$
Level of inbreeding (%)		
0	14172.65 $\pm$	2467.33 $\pm$
	289.28(998)	25.24 (1259)
>0 to <1.25	13925.36 $\pm$	2425.64 $\pm$
	923.13(98)	78.86 (129)
>1.25 to <5	14024.45 $\pm$	2442.12 $\pm$
	696.81(172)	60.12 (222)
>5 to <10	15809.29 $\pm$	2450.14 $\pm$
	1267.29(52)	104.84 (73)
>10	15010.62 $\pm$	2438.26 $\pm$
	1696.99(29)	145.31 (38)

Figures in parenthesis indicates number of observation.

Table 4. Linear regression of various traits with level of inbreeding

Trait	b $\pm$ S.E
AFC (days)	3.70 $\pm$ 5.87*
SP (days)	-0.85 $\pm$ 4.65
DP (days)	3.66 $\pm$ 2.40
CI (days)	68.14 $\pm$ 1.13
305MY (kg)	-10.02 $\pm$ 42.23
TMV (kg)	-16.09 $\pm$ 64.95
LL (days)	-1.23 $\pm$ 4.96
305FY (kg)	-1.75 $\pm$ 4.35
305SNFY (kg)	-0.26 $\pm$ 2.12
LTMY (kg)	-202.02 $\pm$ 62.18
Stayability (days)	-17.37 $\pm$ 4.26

The animals with inbreeding coefficient zero have not been included. **, Significant (P<0.05).

having mild inbreeding 1.25% which was statistically not significant as compared to non-inbred except AFC. Similar findings were reported by Thompson *et al.* (2000) that low to moderate levels of inbreeding (F_x <0.07) appeared to be associated with the lowest age at calving of about 3 to 5 days less than non-inbred animals in Holsteins. However, Saha *et al.* (2009) reported non-significant effect of inbreeding on AFC in KF cattle.

An inbreeding depression of 0.85 was observed in NS (P<0.44) for 1% increase in F_x in SP were as an extension of DP. This might be due to disproportionate distribution of inbred animals in each subclass of the population. Similarly, Saha *et al.* (2009) in KF and Rokouei *et al.* (2010) in Holstein cattle and Mankanjuola *et al.* (2020) in Canadian

Holsteins also reported the non-significant effect of inbreeding on reproduction traits

The regression analysis indicated positive and significant effect of inbreeding on AFC increased by 3.70 days with unit increase in the inbreeding value. However Rokouei *et al.* (2010) reported reduction of AFC by 0.45 days per 1% increase in inbreeding in Holsteins of Iran. DP and CI also increased by 3.66 days and 68.44 days respectively as compared to non-inbred however SP decreased by -0.85 per unit increase in the inbreeding coefficient whereas Saha *et al.* (2009) in KF cattle reported SP and DP were increased by 0.61 and 1.30 days respectively.

Effect of inbreeding on production traits: Despite the stastically non-significant effects, 1% increase in F_x

corresponding reduction of 10.2 and 16.09 (kg) respectively of traits; similarly Maiwashe *et al.* (2008) and Makanjuola *et al.* (2020) reported there was decrease in milk yield by 44.71 kg in Canadian Holstein and 15.42 in Jersey cattle of Africa respectively. In the present study, it was found that reduction was considerably higher for the cows having F_x (5 to 10%) than that of the other class. Similarly, Croquet *et al.* (2006) reported that with 1% increased inbreeding there was decrease of 19.68 kg milk yield in Holstein cattle of Belgium.

Maximum FLTMY (3775.48 ± 193.02 kg) was produced in cows having 1.25 to 5% F_x as compared to other inbred cows. This might be due to higher exotic inheritance in inbred cattle in addition to disproportionate distribution in each subclass of the population. However, minimum average was reported among the animals with F_x more than 5-10%. Tohidi *et al.* (2002) and Rokouei *et al.* (2010) reported that inbreeding significantly reduced 0.39 and 0.44 kg of FY for each 1% increase in inbreeding in Holstein cattle in Iran.

Effect of inbreeding on lifetime traits: There was no significant difference among inbred and non-inbred in LTMY and stayability traits. The decreasing trend in stayability with inbreeding from 0.01 to >10% maximum stayability observed (2467.33 ± 25.24 days) in non-inbred as compared to inbred cow. LTMY and stayability was decreased by 202.02 kg and 17.37 days respectively per unit increase in the inbreeding coefficient. Thompson *et al.* (2000), Mc Parland *et al.* (2007) and Saha *et al.* (2009) reported consistent decreasing trend in herd life with increased inbreeding (statistically significant). Hudson and VanVleck (1984) also observed that 1% increase in inbreeding resulted in small reduction in productive stayability at 48 months of age in Ayrshire cattle.

Expected genetic change: To see the influence of F_x on the expected genetic change, the populations were divided into 2 groups based on inbreeding level (IBL). First group of animal having inbreeding (0.1 to 5) % and second group of animal having inbreeding (>5)% and the expected genetic gain were estimated for each class. The AFC increased two folds in IBL2 as compared to IBL1 (Fig. 2). It can be concluded that in the population, sufficient genetic diversity can be maintained for higher response and optimum genetic gain can be attained by maintaining the inbreeding level up to 5% for sustainable production in the breeds under study.

Out of total 4,632 inbred individuals, 13% were found to be moderately inbred (inbreeding coefficient 5 to 10%) and only 9% were highly inbred (inbreeding coefficient > 10%). Incidence of inbreeding followed an increasing trend over the generations, whereas level of inbreeding reduced over the generations. The effect of inbreeding on production and lifetime traits was not significant except on Age at first calving with slightly increased trend. The foremost cause of low inbreeding level in herd was carrying out of optimal breeding programme resulting into introduction of new allele variants and culling of related animals to avoid mating them and lastly lack of complete pedigree in exotic Holstein

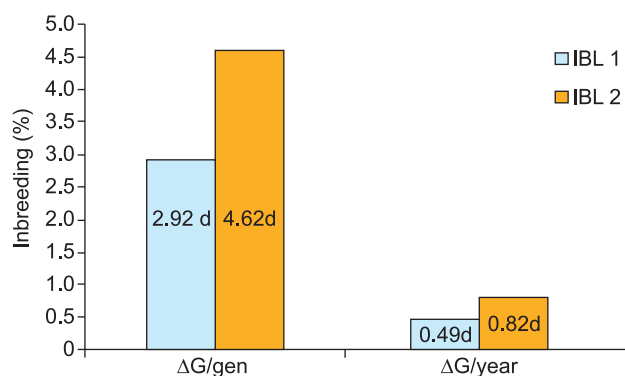


Fig.2. Expected genetic gain/generation and per year in AFC at different inbreeding level in Karan Fries cattle.

Friesian frozen semen used in earlier generation in herd since inception mainly founders. The genetic gain of Age at first calving increased two folds in inbreeding level 2 as compared to first level which is not desirable and indicated that the inbreeding should be kept below 5% level in the herd for sustained production. On the basis of our results it can be concluded that there is a little deleterious consequence of inbreeding on most of the traits and low inbreeding level indicating herd had adequate diversity and adopted successful breeding programme to achieve the desired genetic gain but in future to maintain sustained production we should give due weightage to the optimum inbreeding level in breeding programme for selection or culling the animal..

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