Indian Journal of Animal Sciences **81** (1): 73–76, January 2011

Incidence and consequences of inbreeding in Karan Swiss cattle*

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Received: 6 January 2010; Accepted: 20 October 2010

Key words: Growth traits, Herd-life, Inbreeding coefficient, Karan Swiss cattle, Production traits

Inbreeding declines milk yield, hampers fertility, health and survival, a phenomenon called inbreeding depression. Inbreeding depression reduced the milk yield by 9–26 kg/ lactation (Thompson *et al.* 2000 a,b) and life time production up to 117 kg per 1% increase in inbreeding (Smith *et al*. 1998). Most of the studies on inbreeding were conducted on *Bos taurus* cattle in temperate countries and some on *Bos indicus* in organized herds. However, information is scanty on new breeds or strains of dairy breeds evolved by crossbreeding and subsequent selection. Keeping this in mind, the present study was designed to study the incidence of inbreeding and its impact on various growth, production and reproduction traits in Karan Swiss cattle.

The study was carried out on 3 168 Karan Swiss cows maintained at National Dairy Research Institute, Karnal during 1963–2000. The pedigree of each animal was traced back to the foundation stock, i.e., the pure breeds, zebu cows and exotic bulls, which were present at the time of commencement of crossbreeding programme to prepare the inheritance chart. All the animals in the first filial generation (F_1) were having coefficient of inbreeding as zero.

The coefficient of inbreeding of every animal was estimated by the formula given by Wright (1922). The data collected on various traits, viz. birth weight (BWT), body weight at one year (WOY), weight at first fertile service (WFS), weight at first calving (WFC), age at first fertile service (AFS), age at first calving (AFC), first lactation 305 days or less milk yield (FL305DMY), first lactation total milk yield (FLTMY), first lactation length (FLL), first dry period (FDP), first calving interval (FCI), milk yield per day of lactation length (MY/LL), milk yield per day of calving interval (MY/CI) and herd-life (HL) were corrected for significant effect of various factor like genetic group, paternal generation, maternal generation, season of birth, season of calving, period of birth, period of calving by least squares analysis technique (Harvey 1975). The corrected data were used to study the effect of inbreeding on various growth, production and reproduction traits with the help of least squares analysis technique, including the level of inbreeding as an effect in the model.

Animals were classified into different groups based on the level of inbreeding coefficient as group 1 (below 1%), group 2 (1–6%), group 3 (6 –12%), group 4 (>12%) and group 5 (non-inbred).

The effect of inbreeding on various traits were studied by least squares analysis by including the level of inbreeding as an effect in the model.

$$Y_{ij} = \mu + I_i + e_{ij}$$

where, Y_{ij}, performance of jth individual for ith inbreeding level; μ, population mean;$I_{i,}$ effect of ith inbreeding level; e_{ij}, random error for each observation assumed to be normally and independently distributed with mean 0 and constant variance σ^2_e. Beside least squares analysis, the effect of inbreeding was estimated by regression analysis.

Out of total 3 168 Karan Swiss animals used for this study, 16% animals (507) were found to be inbred with average inbreeding coefficient of 5.94%. Around 65% of the total inbreds were found to have inbreeding coefficient less or equal to 6%. Of the total inbred animals, 11 and 24% were found to be in moderate (inbreeding coefficient 6 to 12%) and highly inbred (> 12%) category. The literature available on incidence of inbreeding varies from 9.24% (Saha *et al*. 2009) in Karan Fries cattle to 82.38% (Reddy and Nagarcenkar 1989) in Sahiwal cattle. The incidence of inbreeding was lower than the findings of Su (1988) and Singh (1995) in Karan Swiss cattle.

The overall percentage of inbred animals was less with high average inbreeding coefficient in early generations but as the generations progressed the incidence of inbreeding showed an increasing trend with corresponding decrease in the level of inbreeding. This could be due to a fewer number of bulls used in the earlier generations. As the generations progressed the common ancestor became remote to the

*Part of the Ph.D thesis submitted by the First author to NDRI Deemed University, Karnal, Haryana, 132 001.

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Table 1. Average performance of various growth and reproduction traits in different inbred groups in Karan Swiss cows

Group	BWT	WOY	WFS	WFC	AFS	AFC	FSP	FDP	FCI
Up to 1%	26.50±0.41[b] (121)	145.72±4.17 (50)	286.08±6.91 (47)	348.23±7.69 (42)	741±20 (73)	1026±19 (82)	107±11 (42)	77±5 (37)	421±13 (43)
1–6%	26.36±0.35[b] (185)	145.98±3.66 (65)	286.43±6.98 (46)	347.99±8.04 (30)	747±21 (68)	1011±19 (85)	110±11 (36)	77±5 (37)	454±12 (45)
6–12%	26.16±0.40[b] (53)	144.59±7.62 (15)	285.11±15.80 (9)	347.72±14.94 (11)	733±39 (19)	1033±39 (20)	124±18 (13)	79±8 (13)	424±22 (14)
>12%	24.75±0.67[c] (124)	143.85±3.94 (56)	285.09±10.60 (20)	345.62±9.20 (29)	797±22 (60)	1072±22 (62)	134±10 (33)	82±5 (32)	467±15 (35)
Non-inbred	27.36±0.09[a] (2323)	147.57±1.04 (801)	289.74±1.96 (583)	356.23±2.06 (574)	763±4 (1446)	1044±41 (1594)	124±2 (926)	72.50±1.01 (935)	422±3 (994)

Figures in the parenthesis indicate number of observation; BWT, figures with different superscript varies significantly (P<0.05).

Table 2. Average performance of various production traits and herd life in different inbred groups in Karan Swiss cows

Group	FL305D MY	FLTMY	FLL	MY/FLL	MY/FCI	HL
Up to 1%	2509.50±121.32 (67)	2756.02±161.49 (66)	331.70±14.39 (66)	8.75±0.29 (65)	7.49±0.31 (43)	1178.67±124.38 (102)
1–6%	2518.14±122.23 (66)	2619.57±162.72 (65)	326.45±13.61 (57)	8.70±0.31 (57)	7.38±0.31 (41)	1101.67±105.04 (143)
6–12%	2352.01±234.07 (18)	2601.39±309.32 (18)	325.24±25.69 (16)	8.72±0.59 (16)	7.30±0.57 (13)	1070.32±198.82 (40)
>12%	2296.14±129.28 (59)	2591.65±170.80 (59)	325.45±14.39 (51)	8.67±0.33 (51)	7.26±0.57 (34)	907.67±108.92 (133)
Non-inbred	2646.17±25.82 (1479)	3407.24±34.09 (1479)	357.93±2.82 (1322)	8.86±0.06 (1317)	7.55±0.06 (973)	1511.12±25.29 (2466)

Figures in the parenthesis indicate number of observation.

descendents and thus resulted in the reduction of level of inbreeding in later generations.

The present study revealed nonsignificant effect of inbreeding on WOY, WFS, WFC, whereas, the effect was significant (P≤0.05) for BWT (Table 1). However, Su (1988) in Karan Swiss and Saha *et al.* (2009) in Karan Fries observed nonsignificant effect of inbreeding on BWT. As expected, the minimum birth weight averages were among highly inbred animals (>12%) compared to other inbred categories for all the growth traits. Carolino and Gama (2008) also found minor detrimental effect of inbreeding on growth and carcass traits.

The regression coefficient of BWT, WOY, WFS, WFC on inbreeding coefficient was –0.114±0.035 kg, –0.046±0.471 kg, –2.842±0.852 kg and -1.148±1.008 kg (Table 3). This indicated deterioration with respect to growth traits with the increase in the magnitude of inbreeding coefficient.

The least squares means of FL305DMY, FLTMY and FLL for different inbred groups and non-inbred animals are presented in the Table 2. No significant differences with respect to FL305DMY, FLTMY and FLL were observed between non-inbreds and inbreds. However, for FL305DMY and FLTMY, the minimum average was found among the animals with inbreeding coefficient more than 12%. Robertson (1954) reported significantly adverse effect of inbreeding on FL305DMY in Friesian cattle beyond 10.0 to 12.5% level of inbreeding. A consistently declining trend in FLTMY with the increase in level of inbreeding was found in this study. Thompson *et al*. (2000b) showed that milk production losses caused by inbreeding for US Holsteins were generally 35 kg per 1% increase in inbreeding but increased to 55 kg per 1% increase in inbreeding from inbreeding coefficients of between 7 and 10%. Regression of FL305DMY, FLTMY and FLL on inbreeding coefficient was statistically nonsignificant (Table 3).

The least squares means of reproduction traits, viz. AFS, AFC, FSP, FDP, FCI for different levels of inbreeding (Table 1) confirmed the adverse effect of inbreeding on these traits. However, the effect of inbreeding was statistically nonsignificant. For AFS, AFC, FSP, FDP and FCI maximum value was observed for highly inbred animals (F >12%). Our results were in consonance with the findings reported by Khanna *et al.* (1979) in Hariana, Srinivas and Gurnani (1981) in Sahiwal, Singh (1995) and Saha *et al.* (2009) in Karan Fries cows. Santana *et al.* (2010) also reported negative effect of inbreeding on reproduction and growth traits in Nellore cattle in Brazil. On the other hand, favourable effect of low

Table 3. Regression of different performance traits on inbreeding coefficient in Karan Swiss

Trait	Intercept constant	Regression coefficient±SE
BWT	27.155	–0.114±0.035**
WOY	48.837	–0.046±0.471
WFS	88.472	–2.842±0.852**
WFC	86.386	–1.148±1.008
AFS	320.913	1.191±2.494
AFC	521.173	6.225±3.397*
FL–305DMY	1006.334	–5.853±8.720
FLTMY	1095.927	–3.640±10.040
FLL	120.901	–0.684±1.091
FSP	31.159	0.557±0.373
FDP	18.130	0.150±0.227
FCI	118.044	1.718±1.205
MY/FLL	3.380	–0.037±0.029
MY/FCI	2.002	–0.023±0.022
HL	778.798	–10.656±6.637

**significant deterioration; *significant growth.

to mild inbreeding (F<8%) was also reported by Malik *et al.* (1967) in Hariana cows, however, it was statistically nonsignificant.

Regression of AFS, FSP, FDP, FCI on inbreeding coefficient was statistically nonsignificant, whereas, it was significant for AFC (Table 3).

The least squares means of MY/FLL for different levels of inbreeding varied from 8.67±0.33 kg for highly inbreds (F >12%) to 8.86±0.06 kg for non-inbred animals. A consistent declining trend of MY/FCI was observed with the increase in level of inbreeding. Singh (1992) also reported unfavourable influence of inbreeding on MY/FLL, MY/FCI in Sahiwal cattle beyond 12% of inbreeding coefficient. The regression coefficient of MY/FLL and MY/FCI on inbreeding was –0.037±0.029 kg and –0.023±0.022 kg, respectively, which was statistically nonsignificant (Table 3).

There was statistically nonsignificant effect of inbreeding on herd life in Karan Swiss cattle. The least squares mean for HL ranged from 1070.32±198.82 days (highly inbreds) to 1511.12±25.29 days (non inbreds). A consistent decreasing trend of HL was observed with increase in level of inbreeding. It is further quantified by regression coefficient of HL on levels of inbreeding (–10.65±6.63 kg per 1%), which was statistically nonsignificant (Table 3).

The results indicated detrimental effect of inbreeding on growth, production and reproduction traits. However, for majority of traits, depressing effect of inbreeding was not statistically significant. The most logical explanation for the detrimental effect of homozygous recessive genotype is because deficiencies of important or essential enzyme that would have been produced by dominant alleles. Recessive gene may sometime result in production of abnormal or defective proteins (Stufflebeam 1987).

SUMMARY

The data on 3168 Karan Swiss cows maintained at NDRI, Karnal during 1963–2000 were utilized to study the incidence and consequences of inbreeding. Out of total 3168 Karan Swiss animals, 16% animals (507) were found to be inbred with average inbreeding coefficient of 5.94%. Around 65% of the total inbreds have inbreeding coefficient ≤6%. Out of total inbred animals, 11% were found to be moderately inbred (inbreeding coefficient 6–12%) and 24% were highly inbred (inbreeding coefficient > 12%). Incidence of inbreeding followed an increasing trend over the generations, whereas level of inbreeding reduced over the generations. Detrimental effect of inbreeding on various performance traits was observed at relatively higher level of inbreeding. The animals with inbreeding coefficient > 12% were poorer with respect to various growth, first lactation production, reproduction traits and herd life. However, the effect of inbreeding was significant only for birth weight (BWT) in Karan Swiss, whereas, for other traits the effect was statistically non-significant. Regression of various performance traits on inbreeding indicated the deleterious effect of inbreeding on the respective traits. Regression coefficients were found significant for weight at first fertile service (WFS) and age at first calving (AFC).

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