Inbreeding accumulation and pedigree completeness in the Icelandic dairy cattle population

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SUMMARY

This study emphasizes the necessity to account for the completeness of pedigrees when giving estimates for level and trend in inbreeding. Average inbreeding coefficient for the Icelandic dairy cattle population considering animals born 1980 or later and with at least both parents and one grandparent known was 1.82%. Corresponding figure for animals with at least four ancestral generations known was 2.70%. No significant trend in inbreeding was detected in the period after 1980 when considering animals with at least four ancestral generations known. The A.I. bulls were inbred on average by 2.39% and a significant increase in inbreeding of +0.08 percentage units per year was detected. The effects of inbreeding level upon milk, fat and protein yields in the three first lactations separately were estimated by including inbreeding level in the multitrait animal model currently used for breeding value estimation of the breed. A large proportion of the cows with production records were inbred or 58.6%. Negative effects were detected corresponding to a reduction of 0.22-0.39% of mean production per 1% increase in inbreeding.

INTRODUCTION

The long genetical isolation of the Icelandic dairy cattle, a population of about 70 thousand animals, brings up some questions on the inter se relationship and the inbreeding level of the breed. The recent implementation of an animal model for breeding value estimation of the breed (Sigurdsson & Arnason, 1994b) makes these questions more crucial as the increased weight on pedigree information in animal models compared to previous methods is expected to accelerate the rate of inbreeding to some extent. The purpose of the present study was to estimate the inbreeding level, the rate of inbreeding accumulation and the pedigree completeness for the Icelandic dairy cattle and to assess the inbreeding depression in dairy production shown in the first three lactations separately, for this particular breed.

MATERIAL AND METHODS

Inbreeding coefficients (F) were calculated including all available pedigree information of the Icelandic dairy cattle population. The data included in total 129,115 animals where the oldest animal in the material was born in 1902 and the youngest in 1991. The inbreeding coefficients (Wright, 1922) were computed with a simple method described by (Sigurdsson & Arnason, 1994a). As the amount of available pedigree information is of great importance when it comes to detecting inbreeding and trends in inbreeding, a special coefficient for pedigree completeness (PEC) was established for each animal. This coefficient was calculated in line with MacCluer *et al.* (1983) as follows:

$$PEC_{animal} = (4C_{sire}C_{dam})/(C_{sire}+C_{dam})$$

where C_{sire} and C_{dam} are contributions from the paternal and maternal lines respectively. Those are computed as:

$$C = 1/d\sum a_i;\ i=1,d$$

where a_i is the proportion of ancestors present in generation **i** and **d** is the total number of generations that are taken into account. In this case five ancestor generations were used. To be able to detect any inbreeding at all for a particular animal one has to have a minimum pedigree information of both parents and one grandparent which corresponds to a PEC value of 0.24 or more. Overall and within years mean inbreeding coefficients were calculated for several classes of PEC values to see to what extent the completeness of the pedigree affected the results.

The effect of inbreeding level on milk production in the first three lactations was estimated by including a special effect for inbreeding level in the model currently being used for national evaluation of Icelandic dairy cattle. The data used was exactly the same as described by Sigurdsson and Arnason (1994b). In total there were 38,014 cows with records. The model that was fitted to the data was a multiple trait animal model with the first three lactations being correlated traits i.e separate models for milk yield in the first three lactations, fat yield in the first three lactations and protein yield in the first three lactations. Herd, calving year, calving month, calving age, calving interval and inbreeding level were included as fixed effects. Further description of the model and the solving procedure can be found in Sigurdsson and Arnason (1994a and 1994b). The cows were classified into seven inbreeding classes: Unknown inbreeding due to lack of pedigree information; F=0; 0%<F≤5%; 5%<F≤10%; 10%<F≤15%; 15%<F≤25% and F>25%. All cows that had PEC less than 0.24 were assigned to the class of unknown inbreeding.

RESULTS AND DISCUSSION

The mean inbreeding coefficient for all animals included was 0.80% . Of the total number of animals 36.5% were inbred with the mean inbreeding coefficient being 2.36%. Figure 1. gives the mean inbreeding coefficients within year for all animals and for animals with different levels of PEC. This figure indicates clearly the necessity of taking the pedigree completeness into account when giving estimations of inbreeding. Inspection of figure 1 shows that if taking all animals into account without any respect to the completeness of pedigree there is a significant rise in inbreeding with years. This is also true if taking only animals which meet the minimum requirements of both parents and one grandparent known (PEC≥0.24). If, on the other hand, more pedigree completeness is required (PEC>0.6) the trend in inbreeding becomes negative when taking the whole period from 1960 and when looking at the last ten years the inbreeding level seems to be quite constant. In table 1. the average inbreeding and inbreeding trend is given considering the years 1960-1991 and the years 1980-1991 separately. Figures are listed for all animals, with different pedigree completeness, and A.I. bulls. The A.I. bulls had much more complete pedigree tables with in most cases at least five ancestral generations completely known. The average inbreeding level for the A.I. bulls was consistent for both periods, 2.39%, and a significant rise in average inbreeding coefficient of 0.08% per year was detected. A significant rise in inbreeding of 0.02%/year is found if the data is restricted to animals with possible inbreeding but becomes insignificantly different from zero if more pedigree completeness is required.

Table 1. Mean inbreeding and inbreeding trend considering two time periods for all animals and A.I. bulls

	All animals				A.I. Bulls
	No restriction	PEC≥0.24	0.6<PEC≤0.8	0.8<PEC≤1.0	PEC≥0.24
Born 1960-91 #	122,993	68,898	21,173	24,473	455
F %	0.89	1.59	1.89	2.80	2.39
ΔF%/yr	+0.0471	+0.0582	-0.0382	-0.0987	+0.0840
Born 1980-91 #	59,276	37,876	10,583	19,259	243
F %	1.17	1.82	1.67	2.70	2.39
ΔF%/yr	+0.0295	+0.0218	+0.0011	+0.0052	+0.0781

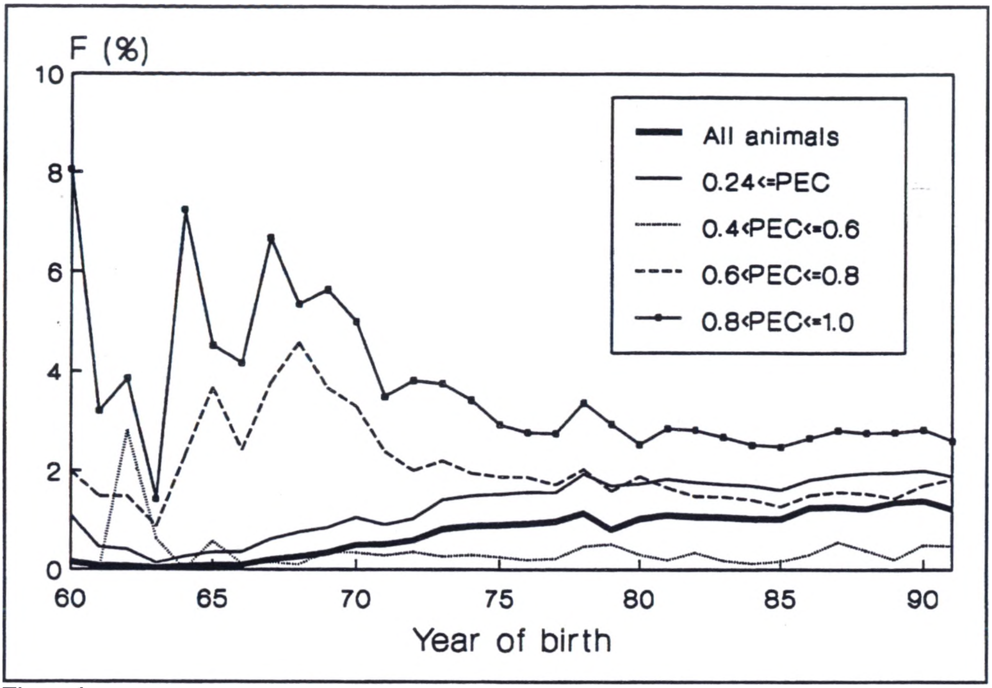

Figure 1. Average inbreeding within year of birth for different pedigree completeness groups.

Table 2. Estimated differences of milk, fat and protein yields (kg) in the first three lactations between the classes of inbred and non-inbred animals and corresponding regression coefficients.

Inbreeding class	Milk (kg)			Fat (kg)			Protein (kg)		
	First	Second	Third	First	Second	Third	First	Second	Third
0%<F≤ 5%	-22.9	+4.2	+41.6	-1.3	-0.1	+1.2	-0.7	+0.1	+1.4
	(10.6)[1]	(13.5)	(17.9)	(0.5)	(0.6)	(0.8)	(0.4)	(0.5)	(0.6)
5%<F≤10%	-109.6	-45.1	-65.6	-5.4	-1.7	-3.5	-3.7	-1.3	-2.4
	(23.0)	(28.4)	(37.1)	(1.0)	(1.3)	(1.7)	(0.8)	(1.0)	(1.3)
10%<F≤ 15%	-124.3	-114.7	-96.1	-5.7	-6.9	-6.1	-4.3	-4.2	-3.4
	(43.8)	(53.3)	(70.4)	(1.9)	(2.4)	(3.2)	(1.5)	(1.8)	(2.4)
15%<F≤25%	-175.8	-272.1	-196.4	-6.1	-16.5	-14.2	-5.9	-7.9	-7.2
	(99.0)	(130.7)	(178.6)	(4.4)	(5.9)	(8.2)	(3.3)	(4.5)	(6.1)
25%<F	-301.2	-211.7	-474.1	-13.3	-8.9	-16.2	-8.0	-6.8	-14.0
	(126.4)	(162.3)	(212.1)	(5.6)	(7.4)	(9.7)	(4.3)	(5.6)	(7.3)
Regression	-10.75	-10.17	-17.62	-0.49	-0.50	-0.69	-0.30	-0.32	-0.54

[1] SE are calculated from a model ignoring the random animal effect and are therefore approximations.

A large proportion of the cows with records were inbred or 58.6% but for 28.7% of the cows inbreeding could not be determined because of lack of pedigree information (PEC<0.24). The cows that were inbred had on average more than 4 ancestral generations (PEC>0.8) known in their pedigree tables. Table 2. shows the differences, in milk, fat and protein yields (kg), between the inbred classes and the non-inbred class. The overall trend is the same for all traits and lactations that as inbreeding increases production decreases. There are signs of inbreeding depression already at low level of inbreeding ($0\% < F \leq 5\%$) for the production in first lactation but for the second and third lactations the negative effects are first shown when inbreeding is higher than 5%. Allaire and Henderson (1965) compared intrasire regression lines of first lactation and mean production records and got the result that the rate of inbreeding depression was greater among mean yield records than first lactation. Several other researchers have obtained the opposite trend (e.g. Brum *et al.* 1963). The last line of table 2. gives the regression coefficients corresponding to the mean inbreeding and inbreeding depression within classes listed above. The regression coefficients indicate that effect of inbreeding is similar on first and second lactation but greater on the third but the estimates for the last two inbreeding classes are subject to large standard errors and increasingly so for the second and third lactation. The regression coefficients expressed as reduction of the population means are 0.31, 0.24 and 0.39 % for the first, second and third lactation milk yields respectively. Comparable figures from recent studies are 0.27% for milk yield in the first lactation for Canadian Jersey (Miglior *et al.*, 1992) and 0.53% for mean milk yield in 1st-4th lactation for Swiss Braunvieh (Casanova *et al.*, 1992).

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