Analysis of Inbreeding in the Israeli Holstein Dairy Cattle Population

J. I. Weller[1] and E. Ezra[2]
[1]Institute of Animal Sciences
ARO, the Volcani Center
[2]Israel Cattle Breeders' Association

Introduction

Quaas (1976) was the first to propose an algorithm suitable to compute inbreeding for a large commercial population. Since then various other algorithms have been proposed, and since 1995 inbreeding has been analyzed for several large commercial cattle populations. The estimate of inbreeding for registered Holstein females in the US population born during 1990 was 5.1±0.4% for a random sample of 600 two-line pedigrees (Young and Seykora 1996), while Wiggans *et al.* (1995) estimated mean inbreeding of females as 2.6% for cows born in 1990. Since 1992, inbreeding in the UK has increased at a rate of 0.17%/yr. In 2002, the average inbreeding was 2.64% for females and 3.06% for males (Kearney *et al.* 2004). Average inbreeding in Denmark for calves born in 2003, was 3.9, 3.4, and 1.4% for Holstein, Jersey, and Danish Red, respectively (Sørensen *et al.,* 2005). Now more than 93% of the Danish Holstein genes are of North American origin.

The Israeli Herdbook has nearly complete parentage recording for all cows calving since 1985, and for all bulls born since 1960. Bulls were imported to Israeli through the 1950's and 1960's. During the 1970's and 1980's only a small quantity of semen, chiefly from the US, was imported to sire bulls. In the last few years about 5% of the cows were inseminated with foreign semen. Currently more than 99% of all milk cows in Israeli belong to the Israeli Holstein strait.

Beginning in the late 1980's Dr. H. Sturman instituted the following protocol to manage inbreeding in Israel: Each inseminator first types in the proposed mating on a computer terminal. The terminal issues a warning if the proposed mating results in >=3.25% inbreeding. However, the current software only checks back three generations, and assumes that all ancestors have zero inbreeding. Inbreeding level for the entire population has not been previously computed.

Our objective was to estimate inbreeding for the entire Israeli Holstein population, and develop an algorithm for exact computation of inbreeding coefficients, including all known relationships, suitable for on-farm mating planning.

Material and Methods

The analysis included all cows with valid protein records, calves that were inseminated during 2002-2004, bulls in service during 2002-2004, all parents, grandparents, and great-grandparents of these animals, and all known ancestors of bulls born since 1960.

The number of bulls and cows included in the analysis by birth year are given in Figure 1. A total 643,287 cows and 2,707 bulls were included in the data file. Cows were born between 1923 and 2003, and bulls were born between 1919 and 2003. The analysis included 452 North American bulls with US inbreeding coefficient values (http//:aipl.arsusda.gov/). We used the algorithm of Meuwissen and Luo, which we found to be much faster than the algorithm of Quaas (1976).

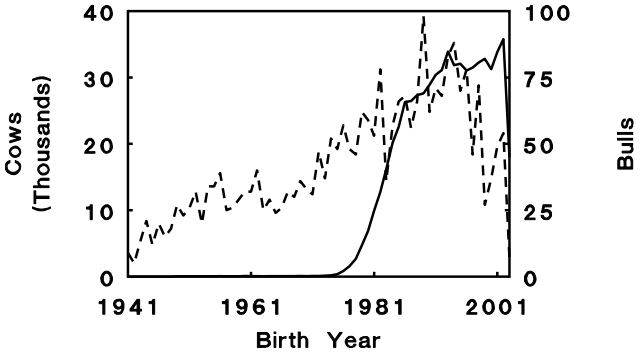

Figure 1. Number of bulls and cows by birth year. - -, bulls; ——, cows.

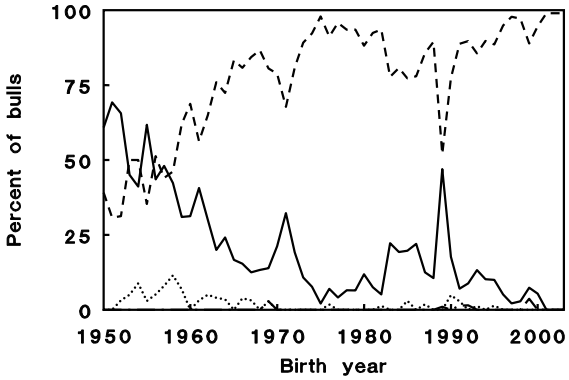

Figure 3. Percent of bulls with known parents by birth year. - -, both parents known; ⋯, sire known, — · —, dam known ——, neither parent known.

Results and Discussion

The percentages of cows and bulls with known parents by birth year are given in Figures 2 and 3. Both parents were recorded for 549,424 cows (85%) and 2,086 bulls (77%). There was nearly complete parentage recording of bulls born since 1964 and cows born since 1984. From 1976 through 1983 nearly all the sires of cows are listed, but not dams. Since 1958 the sires of most bulls were recorded. The "dip" in Figure 2 at 1989 is due to 44 bulls of breeds other than Holstein born in 1989 without parentage recording. None of these bulls were widely used within the population. There were very few animals with only dam recorded. In the algorithm applied, only animals with both parents recorded can have positive inbreeding values.

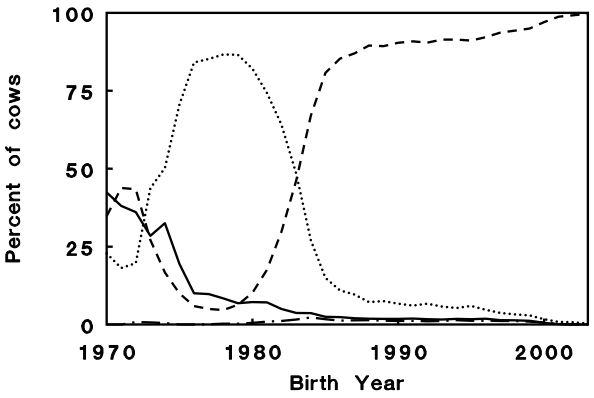

Figure 2. Percent of cows with known parents by birth year. - -, both parents known; ⋯, sire known, — · —, dam known ——, neither parent known.

The mean inbreeding levels of bulls and cows by birth year are given in Figure 4. The curve for bulls is less stable, due to the relative small number of bulls born each year. Mean inbreeding in 2000 was 1.7% for both sexes. Since 1976 the regression of inbreeding on birth year was 0.05%/yr for bulls, and 0.079% for cows. Despite application of the protocol to reduce inbreeding there were 288 cows with inbreeding > 25%. In all cases the sire of the cow was also the sire of her dam. There were 446 bulls with inbreeding coefficients > 1%, and 22 bulls with inbreeding coefficients > 10%. Of these, 21 were foreign bulls. For 16 of these bulls the same bull was the paternal and maternal grandsire. There were three bulls with inbreeding coefficients > 25%. Only one was an Israeli bull. For these three bulls the sire was also the maternal grandsire. There were only six Israeli bulls with inbreeding coefficients > 6%. Only one of these was returned to general service after his progeny test.

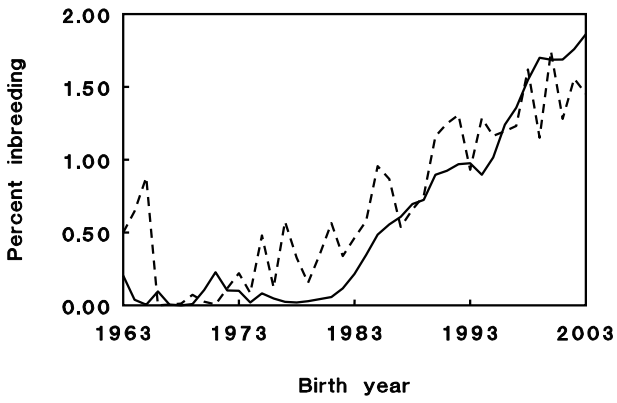

Figure 4. Mean inbreeding levels by birth year. - -, bulls; ——, cows.

There were 213 North American bulls with inbreeding coefficients in Israel, and positive values in either the US or Israel. The comparison of AIPL and Israeli inbreeding coefficients for 213 North American bulls used in Israel are given in Figure 5. The correlation between the Israel and US analyses for these bulls was 0.92. The regression of the US values on the Israeli values was 0.94 with a Y intercept of 0.07. Discrepancies were due to differences in the data sets.

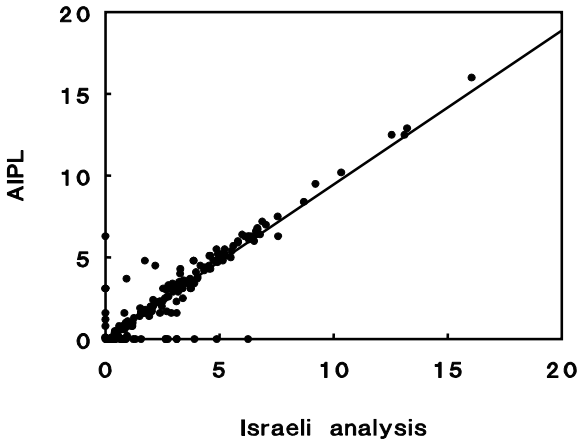

Figure 5. Comparison of AIPL and Israeli inbreeding coefficients for 213 North American bulls used in Israel.

Conclusions

The mean inbreeding level in the Israeli Holstein population is lower than in the other Holstein populations analyzed (US, UK, Denmark). For calves born in 2003 mean inbreeding levels were 1.9% in Israel, 3.9% in Denmark, and 3.1% in the UK. The correlation between the Israel and US analyses for 213 bulls with positive inbreeding values in at least one analysis was 0.92.

Acknowledgements

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References

Kearney, J.F., Wall, E., Villanueva, B. & Coffey, M.P. 2004. Inbreeding trends and application of optimized selection in the UK Holstein population. *J. Dairy Sci. 87,* 3503-3509.

Meuwissen, T.H.E. & Luo, Z. 1992. Computing inbreeding coefficients in large populations. *Genet. Sel. Evol. 24,* 305-313.

Quaas, R.L. 1976. Computing the diagonal elements and inverse of a large numerator relationship matrix. *Biometrics 32,* 949-953.

Sørensen, A.C., Sørensen, M.K. & Berg, P. 2005. Inbreeding in Danish dairy cattle breeds. *J. Dairy Sci. 88,* 1865-1872

Wiggans, G.R., VanRaden, P.M. & Zuurbier, J. 1995. Calculation and use of inbreeding coefficients for genetic evaluation of United States dairy cattle. *J. Dairy. Sci. 78,* 1584-1590.

Young, C.W. & Seykora, A.J. 1996. Estimates of inbreeding and relationship among registered Holstein females in the United States. *J. Dairy Sci. 79,* 502-505.