A METHOD THAT PREDICTS THE GENETIC COMPOSITION AND INBREEDING OF THE FUTURE AUSTRALIAN DAIRY HERD

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SUMMARY
A method that predicts future inbreeding (F), using information on the current cow population, semen use (mating decisions) and progeny test (PT) bulls, is described. The genetic composition of the future cow herd of Australian Holstein-Friesian (HF) (upto 9 years into the future) is predicted. There are about 650,000 cows with both parents known and about 450,000 cows with four grandparents known. The F of cows born in 2000 is 0.014 (known parents) or 0.017 (known grandparents). The average F of HF cattle born in 2003 was estimated to be about 0.02 and is predicted to reach 0.03 in animals that are expected to be born in 2008. The average F of the prospective progeny of the top 10 bulls (on estimated breeding value) randomly mated to active cows of 2004 was 0.024 and was reduced to 0.012 when bulls are mated selectively to minimise F. The information on the genetic composition of the current and future cow herd can be used to identify potential bull sires and/or young bulls that can be used to minimise future F. This can be combined with the information on genetic merit when breeding companies decide to cull bulls after PT or when selecting bull sires.

Keywords: Inbreeding, genetic composition, future herd, minimising future F.

INTRODUCTION
The use of an animal model to calculate estimated breeding values (EBVs) has increased the accuracy of EBVs but leads to increased probability of selecting related animals. Concurrently advances in reproductive technology have increased the reproductive capacity of individuals leading to increased use of a few influential animals. Both circumstances increase the rate of inbreeding (F) which among other things result in reduced performance of inbred animals (Smith et al. 1998; Thompson et al. 2000). Although reduction in performance in individual traits may be small, the overall effect of F on all economic traits over the lifetime of the animals can be high. For example, over the lifetime of a registered Holstein-Friesian (HF) cow the losses in milk, fat and protein yield were estimated to be 1.7% of the average yields per 1% F. The net economic loss over the lifetime of a cow per 1% of F was estimated at US$22 (Smith et al. 1998). A 1% F in Australian HF cattle resulted in about 0.4% and 1% reduction in milk yield traits and survival, respectively (Man 2004).

The dairy industry is concerned that F is becoming too high. However, when formulating policy, it would be more useful to have a good prediction of future F than past and current F, because it is only future F that can be modified by changes in policy. The first aim of this paper is to predict the F that will occur upto 9 years into the future by predicting the pedigree of the cows in the national herd. We do this by combining pedigree data on the current cow herd with data on semen use (mating decisions) in the past 3 years and the pedigrees of progeny test (PT) bulls that are expected to graduate in the coming 4 years.
Currently desirable genetic material is acquired globally mainly via semen. In this situation F can be managed by identifying and using bulls that are less related to the national cow population. Therefore, when selecting sires, we need to know the F of calves that will be born if the bulls are mated to the cow herd. However, if we are selecting sires of young bulls, it will be 7 years before these young bulls are widely used for mating and, hence, it is the cow herd in 7 years time that is relevant. The second aim of this paper is to illustrate how the predicted future cow herd can be used to minimise F by selective mating of bulls. Ultimately the objective is to use information on the genetic composition of the current and future cow population to identify potential bull sires and/or young bulls that can be used to minimise F while ensuring the utilisation of the best bulls.

MATERIALS AND METHODS

A computer program was written that predicts the pedigree of the cows born each year. There are four populations that are updated each year – cows 2-12 years old, heifers 0-1 year old, proven bulls and young bulls 1-5 years old.

Starting populations. Calving, mating and pedigree data of HF cattle that were available at the Australian Dairy Herd Improvement Scheme (ADHIS) on December 31, 2003 were used. The data consisted of the active breeding cow herd of 2001 to 2003 including heifer calves, bulls whose semen was used in 2001 to 2003, and young bulls in the PT program (born between 1998 and 2002). Only cows whose parents are known were used. Each year some cattle were culled and the rest moved to the next age class. Culling rate of 5% (young cows) to 70% (cows over 10 years of age) were applied. About 90% of newly born female calves were recruited for replacement in 2002 and 2003 and to maintain a uniform cow population this was decreased to 70% among calves born in 2006 and later.

Information on the current cow population consisted of birth, calving, mating and culling dates. Young replacement heifers that were born after January 2000 were also added to the cow population. Some culling decisions, births and calvings do not reach ADHIS on time. To account for this, only female animals born before 1999 that calved after December 2000 or had mating data in 2001 to 2003 were included in the current cow herd. Cows that did not calve between 2001 and 2003 were assumed culled if they were not found in the mating data. For young cows or heifers born after 1999 such restriction was not applied because we assumed that the flow of information from farms to ADHIS on status of two-year old cows could be slow compared to cows that are already in the database.

Mating and generation of progeny. If the last record on a cow was a mating, then a calf with the appropriate pedigree was generated 282 days later. If the last record was a calving, then a mating was generated 90 days later using semen chosen at random from the bull population with each bull used according to the proportion of his semen in the total for that year. The mating data were used to determine the frequency of use of bulls in the base population. Heifers were first mated in the season after they were 15 months of age. This process generated ‘hypothetical cows’ that gradually replaced the ‘real cows’ in the starting population. Because the data was incomplete for heifer calves, some hypothetical cows were born in 2001-2003 and all calves born after 2004 were ‘hypothetical’.
Computing techniques: Developments and validations

The use of a particular bull on the cow (hypothetical and real) population depended on the frequency of use of that bull in the mating data. Semen use for 2001 to 2003 was based on the frequency of use of a bull in the mating data. In addition young bulls born in 2000 to 2002 were assumed to have been PT when they are yearlings in 2001 to 2003, respectively, for the first time and were assumed to have been mated to at least 100 cows. After 2003 mating data were not available. Thus, bulls with over 100 matings (the ‘most popular’) in 2003 were given the opportunity to mate real and hypothetical cows in 2004 to 2007. The number of cows mated to these bulls was reduced successively every year assuming that they would be gradually replaced with new ‘better’ bulls that graduate from the PT program. A large proportion of the progeny born in 2005 to 2008 were generated by mating real and hypothetical cows to bulls born in 1999 to 2002 assuming that they will graduate 5 years later. Sex of hypothetical progeny was allocated randomly. Mating was at random except that matings between sire and daughter and between full-sibs were not allowed.

Estimation and minimisation of F. F of all the animals was calculated using the software package of Boichard (2002). The effect of pedigree completeness on estimated F was examined by comparing cows whose parents are known to cows with four grand parents known. As an example, the top 10 bulls (based on August 2004 EBV release) were mated to 5% of the active cows of 2004. The mean F for the prospective offspring of each bull was calculated assuming random and selective mating to minimise F.

RESULTS AND DISCUSSION

The total number of breeding females based on lactation, pedigree and mating records was about 1 million. After excluding cows with unknown birth date and parents, and based on the latest calving date, culling decisions, etc. about 650,000 cows were likely to calve yearly. The number of cows was reduced to about 446,000 cows when only those with 4 known grand parents were used. In 2002 about a third of the calves were already recorded and the rest were generated from the hypothetical and real matings. In 2004, about 87% of the calves were born to real cows and 13% were born to hypothetical cows and by 2008, 81% of the calves were born to hypothetical cows. Of the total number of calves born in 2004, 45% were sired by bulls born before 1997 and this dropped to 25% in calves born in 2008. The total number of bulls used over the years was 2,748.

The difference in F of progeny due to completeness of pedigree is small (Figure 1). The trend in F for animals with known paternal grand sire and dam is not plotted because it was similar to that with known parents. During 1979 to 1992 F increased by only 0.0003 per year probably because Australian cows were being mated to distantly related bulls of North American ancestry. From 1992 to 2001, F increased by 0.001 per year and from 2001 to 2008 it is predicted to increase by 0.0017 per year. Man (2004) estimated an F of 0.012 for cows born in 1997 which was the same as our estimate for animals with paternal grand sire and dam known (result not shown in the figure).

The average F of prospective progeny from mating the top 10 bulls randomly to the cow-herd of 2004 was 0.024. This, as expected, is similar to mean of F all progeny born in 2005 because these 10 bulls are also used extensively in 2004. The F of individual progeny varied from 0 to 0.33 and about 1.35%
of them had over 0.1 F. The mean F of the progeny for the bulls varied from 0.01 to 0.034. When the bulls are mated to the same cows and all bulls are used equally but F was minimised, the average F was 0.012 and the maximum F of any progeny was reduced to 0.039, and the mean for each bull varied from 0.009 to 0.014. This shows that it is possible to use high EBV bulls while restricting the F of the progeny at an acceptable level. In the second example, where 23 bulls born in 2003 (selected for PT in 2004) are mated to active cows in 2008 (after graduation), the mean F of progeny of the bulls varied from 0.025 to 0.039 when mated randomly. In this case with selective mating the mean F of the prospective progeny was reduced to 0.021 and the mean F of progeny of each bull varied from 0.009 to 0.026 when each bull produces equal number of progeny.

Estimates of mean F of bull's prospective progeny, combined with information on its genetic merit, can be used by AI studs when deciding which young bulls to PT or breed without markedly increasing the F level in the future herd. The F of prospective progeny from mating a potential bull randomly to the future cow-herd can serve as an 'early warning system' as it indicates the worst case scenario. Estimating the relationship of a bull's sire to cows that will be available 7 or 8 years into the future can be used when deciding which bulls or team of bulls to use as sires of bulls. On the other hand estimating the relationship with the current cow herd can be used when deciding which team of bulls to keep or cull when proofs are available. By also selecting a team of bulls which are less related to each other, an AI stud will have one or more bulls suitable for each current or future cow.

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REFERENCES