Monitoring Sustainability of International Dairy Breeds

J. Philipsson, F. Forabosco, and J.H. Jakobsen
e-mail: Jan.Philipsson@hgen.slu.se
Interbull Centre, SLU, PO Box 7023, 75007 Uppsala, Sweden

Abstract

Characteristics of a sustainable breeding program are broad breeding objectives, managing inbreeding rates and continuous genetic improvement of the traits included in the breeding goal to keep populations competitive. We have monitored some measures of sustainability of the six dairy breeds Brown Swiss, Guernsey, Holstein, Jersey, Red Dairy Cattle and Simmental currently involved in the Interbull evaluations. Globally, genetic evaluation and selection within dairy breeds has developed in the last decades to include a broad range of traits. Thus, the Interbull service portfolio now counts seven trait groups including 38 sub-traits for international genetic evaluations.

At each Interbull evaluation a joint pedigree file is formed per breed. In the current study, the rate of inbreeding was computed for bulls with a pedigree completeness of at least 80%. For Holstein the mean inbreeding coefficient increased from 0.022 in 1986 to 0.036 for bulls born in 1998, i.e. close to a rate of 1% per generation, but it has then leveled off. High inbreeding rates were noted also for Brown Swiss, Jersey and Guernsey.

Genetic trends were monitored globally for all bulls in the Interbull evaluations on different country scales. In general, large positive genetic trends were noted for protein production of all six dairy breeds, whereas the genetic trends for somatic cell count and longevity have been rather flat. However, a strong negative genetic trend was observed for female fertility in the Holstein breed.

In summary, data and pedigree information received by Interbull at each evaluation can be utilized to monitor sustainability of international dairy breeds at the global level. However, a more complete pedigree data base at Interbull would provide more accurate trends over longer periods of time, at both the global and regional level.

1. Introduction

Sustainable dairy cattle breeding programs are characterized by broad breeding objectives reflecting the long-term market needs of products that are effectively produced from feed resources not directly available for human consumption, and that the genetic improvement for production will be followed by as small costs as possible. In reality, this means that the goal is high production from healthy cows with good reproduction, i.e. "robust" cows that can function well in a range of environments. The problem to consider is the generally accepted fact that there are unfavorable genetic correlations between milk production and several health and reproduction traits. Such unfavorable correlations are generally of the order 0.2-0.5 (e.g. Philipsson and Lindhé, 2003; Wall *et al.*, 2003; VanRaden, 2006; Jorjani *et al.*, 2007), which clearly means that functional traits will decline as a result of selection for production if not selection pressure is also put on these traits. Furthermore, many studies have shown that there is a considerable amount of additive genetic variation in functional traits, despite their low heritabilities, which justifies inclusion of these traits in breeding objectives. Emphasis of dairy cattle breeding objectives has therefore gradually shifted from conformation and production traits to also include functional traits such as health, fertility, longevity and calving traits into Total Merit Indexes for selection of dairy bulls (Mark, 2004; Miglior and Sewalem, 2009).

Another characteristic of a sustainable breeding program is that the rate of increased inbreeding can be managed. Selection inevitably leads to increased inbreeding, and there are several reports giving alarming figures on declining effective population sizes as a result on the intensive use of few bulls across the whole world, especially within the Holstein breed (Weigel, 2001) through the so-called holsteinization of the black-and-white cow populations. At the international conference on Animal Genetic Resources organized by FAO in 2007 a review was given of the globalization of the major dairy breeds and the genetic trends in important traits as well as their importance for the genetic diversity in a food production perspective (Fikse and Philipsson, 2007). Reports on Jersey, Brown Swiss and Holstein indicated high rates of inbreeding at national levels (personal communications by Schneeberger and by Harris).

Through the experiences from the international genetic evaluations of dairy bulls of six major breeds (Brown Swiss, Guernsey, Holstein, Jersey, Red Dairy Cattle and Simmental) run by Interbull for 15 years it has been possible to study the developments of applying broad breeding objectives. For each of the breeds it is also possible to study the global genetic trends for major functional traits along production.

Updates to the global dairy pedigrees housed by Interbull are a continuous process complemented with the newest young bulls as well as corrections in existing information. The information collected at each evaluation is bull ID, birth date of bull, sire of bull, maternal grand sire and maternal grand dam. Monitoring inbreeding on this amount of information can give indications of inbreeding levels but is far from complete. Currently, Interbull is setting up a database for storage of more complete pedigree information also on bull dams. This improvement should alleviate monitoring of inbreeding trends over time.

Mark *et al*. (2002) computed different descriptive population statistics using the global Interbull pedigrees and in the current study we aimed to redo some of the analyses using seven more years of data.

The aims of this paper are to present genetic trends at the global level for protein yield and a number of functional traits for bulls of breeds evaluated by Interbull, and to present the rates of inbreeding for the bull populations of the same breeds at the global levels. The purpose is to give ideas on how the major breeds can be regularly monitored at the global level to support the breeding industry, including world breed societies, with such facts that help to achieve sustainable breeding programs world-wide.

2. Material and Methods

Genetic trends were computed globally of four traits of all bulls by their breed and birth year in the Interbull evaluations. Thus, the trends describe the genetic change by breed in the populations of tested bulls independent on how they were used. All bulls fulfilling the official criteria for inclusion in international genetic evaluations will get their proofs expressed on each participating country's base and scale. For this study we chose to express the global trends on the Nordic Scale (DFS-scale; joint genetic evaluation for Denmark, Finland and Sweden). Breeding values for all traits are on the DFS-scale expressed as RBV's with a mean of 100 and a standard deviation of 10. Data used were official international breeding values from the Interbull April evaluation 2009. Global trends are given for protein yield, female fertility (lactating cows' interval measures such as days open or calving interval), somatic cell score and longevity.

At each Interbull evaluation a joint sire and maternal grandsire pedigree file is formed per breed. In the current study, the rate of inbreeding was computed for bulls with a pedigree completeness (PEC-value) of at least 80%. PEC-values were computed according to MacCluer *et al.,* 1983. Less complete pedigrees give clearly underestimated inbreeding coefficients, and as reported pedigrees of the databases usually become more complete by time the rate of inbreeding may be overestimated.

3. Results and Discussion

Currently, 29 countries from all over the world participate with data for six breeds and seven trait groups. Number of bull populations per breed and trait group is listed in Table 1.

Interbull started international genetic evaluations for production (milk, fat and protein) in 1994 and data from four countries and two breed groups were considered (Figure 1). After fifteen years the total number of sub traits evaluated is 38. Since January 2009, international evaluations for workability have been computed, in addition to production, conformation, udder health, longevity, calving and female fertility.

Figures 2, 3, and 4 show the global genetic trends for Holstein, Red Dairy Cattle and Jersey bulls for protein production, milk somatic cell score, direct longevity and female fertility.

The genetic level for production (protein yield) has increased noticeably during the past two decades for the Holstein, Red Dairy Cattle and Jersey breed groups. The genetic trends were slightly positive (favorable) for direct longevity for all three breed groups. Thus, a similar favorable genetic trend was noticed for milk somatic cells for Holstein and Red Dairy Cattle breed groups. On the other hand, the genetic trend for female fertility for Holstein was strongly negative whereas it was rather unchanged for Red Dairy Cattle and in later years also for Jersey.

Table 1. Total number of populations in the most recent (April 2009) routine Interbull genetic evaluation.

	Production	Conformation	Udder Health	Longevity	Calving	Female Fertility	Workability
Year of first evaluation	1994	1999	2001	2004	2005	2007	2009
Breed Group							
Brown Swiss	9	7	8	8	5	6	5
Guernsey	6	4	5	5	-	4	-
Holstein	26	21	23	20	9	16	5
Jersey	10	9	8	7	-	6	3
Red Dairy Cattle	11	8	10	9	3	7	4
Simmental	11	-	8	2	-	2	-
Total	73	49	62	51	17	41	17

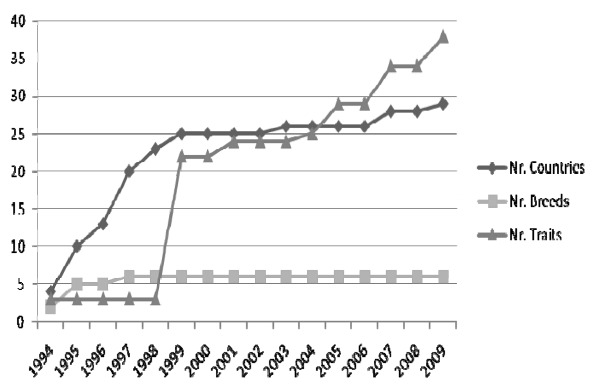

Figure 1. Number of countries, breeds and traits per year of evaluation.

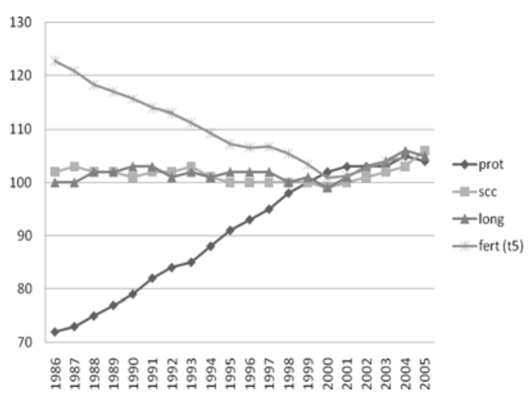

Figure 2. Global genetic trends for protein, scc, longevity, and female fertility for Holstein.

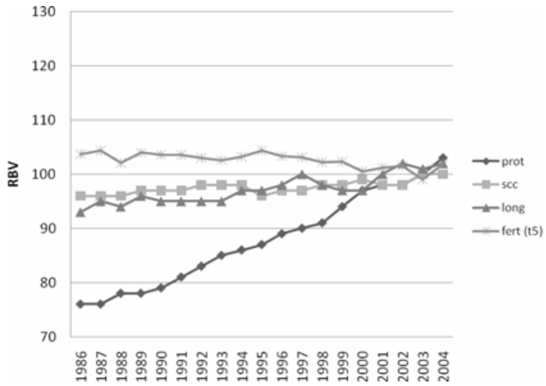

Figure 3. Global genetic trends for protein, scc, longevity, and female fertility for Red Dairy Cattle.

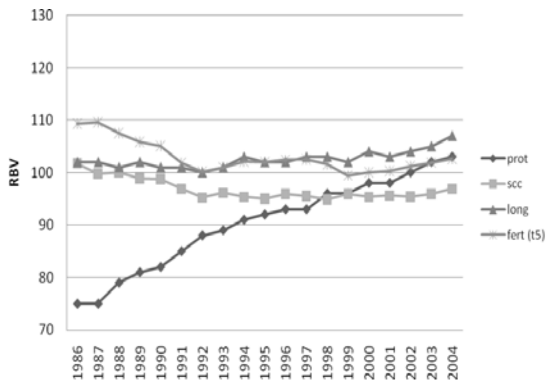

Figure 4. Genetic trend for protein, scc, longevity, and female fertility for Jersey.

The result for female fertility in the Red Dairy Cattle was likely due to the fact that the majority (~75%) of the bulls is tested in the Nordic countries where recording and evaluation for female fertility traits has been practiced for a long time (Philipsson and Lindhé, 2003). The situation for the Holstein breed group relates to the fact that the majority of bull sires (> 90%) came from populations where selection emphasis was not put until recently on female fertility traits in sire selection (Fikse and Philipsson, 2007).

Table 2. Total number of bulls with international production proofs and the number of these bulls born later than 1985 with pedigree completeness (PC) > 80% per breed.

Breed	Total no. bulls	No. bulls born 1986 onwards with PC>0.8	% bulls with PC>0.8
BSW	8073	2956	36.6 %
HOL	107369	71341	66.4%
GUE	951	135	14.2 %
JER	8776	2675	30.5%
RDC	11807	1296	11.0%
SIM	22765	5341	23.5%

In the last two decades several studies have reported inbreeding and inbreeding depression in dairy breeds. As an example Sørensen *et al.* (2005) estimated approximately 1% increase in inbreeding per generation in Danish Holsteins over the last decade.

Number of bulls with international production proofs in the Interbull evaluation April 2009 is shown in Table 2 for Brown Swiss, Holstein, Guernsey, Jersey, Red Dairy Cattle and Simmental, respectively.

Inbreeding is increasing for all dairy breeds (Figure 4). In the Holstein population, the inbreeding coefficient ranged from 0.022 in year 1986 to 0.036 in year 2000. Since year 2000 the inbreeding is slowly decreasing with a slightly negative trend (0.031 in the last year). Similar trends were observed for the Jersey breed group. Brown Swiss and Guernsey show rather strongly increased inbreeding levels, and at the same absolute levels as Holstein and Jersey. The Guernsey trend is rather erratic due to its small number of bulls. RDC and Simmental show low levels due to their broad bases through some crossbreeding.

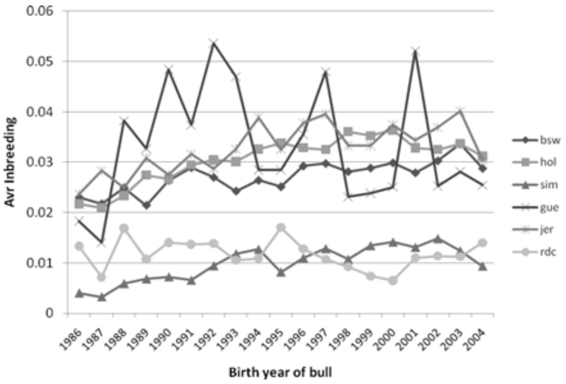

Figure 4. Average inbreeding per birth year of tested bulls (at least 80% pedigree completeness).

More detailed analyses of the trends indicate that the European Holstein population is less inbred than the North-American due the crossing of the previous European Friesian cows with North-American Holstein bulls. For Jersey in the Oceanian region Harris (personal communication) has reported rather strongly increased inbreeding rates,

The results clearly show the seriousness of managing inbreeding in the smaller populations as well as the positive effects of using the global pool of genetic resources within a breed group. However, there is a need to improve the completeness of the Interbull pedigree data base. Then more reliable trends can be provided at both regional and global level for the internationally most important dairy breeds. This type of information should be carefully analysed by the world breed societies for their actions to improve the breeds in a sustainable way.

Conclusion

In summary, data and pedigree information received by Interbull at each evaluation can be utilized to monitor sustainability of international dairy breeds at the global level.

In order to get good estimates of inbreeding trends it is of great importance to collect global pedigree information on both male and female sides of the pedigrees for the Interbull data base.

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