How sustainable are the breeding programs of the global main stream dairy breeds? - The Latin-American situation

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Abstract

The main stream international dairy breeds, particularly the Holstein, are a basis for dairy production in Latin-America, where they are widely used either as purebreds or in crosses, their genes flowing mainly from North American and European countries, mostly by semen imports. However, the decline in health and fertility in those breeds are a cause of concern worldwide. Literature is reviewed indicating that selection for high milk yield per cow and for type (dairy form) have resulted in cows partitioning a higher proportion of the nutrient intake towards milk production at the expense of body tissues, negatively affecting health and fertility.

Although a genetic antagonism between high yield and health and fertility was well documented more than 30 years ago, the economics of dairy production led to unsound excessive emphasis on breeding for yield and type in detriment of fitness. Genetic antagonisms between high yield and heat tolerance have also been recently documented. The deterioration of health and fertility was carried over to the importing countries. Inbreeding due to intensive use of famous sires aggravates the problems. Crossbreeding, breed substitution and selection on functional traits may all be used to improve health and fertility. In Brazil, the increased popularity of more fertile and adapted breeds indicates that farmers are at least partially aware of the economic set back associated with high yield genetics, although nonetheless more research on the better alternatives, and wide dissemination of the results, are needed to aid farmers to take faster and sounder decisions, properly taking into account unprovoked substantial propaganda. Unfortunately, research and information are too often directed more towards attending vendors' interests than the farmers' needs.

Key words: Dairy cattle, breeding, milk yield, fertility, health, inbreeding

Introduction

Developing American countries produced more than 58 million tonnes of milk in 2006 (Faostat 2007). Transboundary *Bos taurus* breeds, such as the Holstein, Jersey and Brown Swiss, are largely utilized in Latin-America mainly in crosses with *B. indicus* breeds, predominating in the warm tropical environments, or as straight breeds, especially in the temperate areas and the high-altitude tropics, where heat is not the main problem The Holstein is the predominant *taurus* breed in the region, with some local exceptions, while the predominant *indicus* breeds used for crossing are the Gir, in Brazil (where the Guzerá is also important), and the Brahman, in other tropical countries. There are of course many other minority breeds. As an example, the results of a survey in the State of Minas Gerais, Brazil showed that 89% of dairy farms had *B. taurus/B.indicus* hybrid herds, more than 90% used mostly Holstein and more than 80% used mostly Gir (Table 1).

Breeding aspects

The Brazilian Gir was developed locally from stock imported from India early last century, and so was the Guzerá (Kankrej). After empirical selection by individual breeders, beginning in the 1950s, a conventional progeny testing programme was initiated in 1985 by Gir breeders supported by some research organizations and universities. The programme nowadays samples 30 young bulls/yr. Breeding values of 161 bulls have been published and another 114 are in the pipeline. Genetic evaluations using standard animal model-BLUP methods are run at the National Dairy Cattle Research Centre, EMBRAPA, the Federal Research Organization (Verneque et al 2007). In the period 1997-2005 the genetic trend for 305-d milk yield was about 37 kg/yr, or 1.34% of the mean of 2752 kg.

Table 1. Predominant breeds in dairy herds in Minas Gerais, Brazil (89% of herds surveyed having *B.indicus/B.taurus* genetic composition)

Breed	Number of farms	%
Bos indicus		
Gir	214	78.1
Gir and other indicus breed[1]	8	2.9
Guzerá	9	3.3
Guzerá and other indicus breed[2]	1	0.4
Other indicus breed[3]	7	2.5
Non-descript	35	12.8
Total	274	100.0
Bos taurus		
Holstein	255	90.7
Holstein and other taurus breed[4]	11	3.9
Brown Swiss	3	1.1
Jersey and Jersey and non-descript	2	0.7
Non-descript	10	3.6
Total	281	100.0

[1]Guzerá, Indubrasil, Nelore; [2]Indubrasil; [3]Nelore, Indubrasil; [4]Brown Swiss, Jersey, Caracu
Source: Madalena et al 1997

A similar programme, but incorporating also a MOET scheme, was initiated in the Guzerá in 1994. The genetic response for 305-d milk yield during the initial screening phase (1997 to 2000) was very high, 183 kg/yr, corresponding to 8.8% of the 2065 kg population mean (Peixoto et al 2006). Thereafter the genetic trend declined to 9.3 kg/yr, following attempts to widen the genetic base (V.M. Penna, personal communication).

In the main-stream breeds, such as the Holstein, Jersey and Brown Swiss, genes flow mostly from North America and Europe to the elite herds at the top of the local countries pyramids, so these herds act as multipliers of imported germplasm that is then passed on to the commercial herds mostly as natural service bulls. Modern local breeding programmes are practically inexistent for these breeds.

Problems of high-yield genetics

Continued selection for high milk yield in the first world countries has led to a substantial worldwide deterioration of fertility and health of the international Holstein population and other main-stream breeds. (e.g. Dematawewa and Berger 1998, Rogers et al 1999, Hansen 2000, Svendsen and A.-Ranberg 2000, de Jong et al 2001**,**Washburn et al 2002, Wall et al 2003, Weigel et al 2003, Diskin et al 2006, Hare et al 2006, Kuhn et al 2006, Moore and Thatcher 2006, Shook 2006, Evans et al 2007).

High annual culling rates of 34 to 38% and high adult mortality rates of 6 to 11%, as reported in many studies (e.g. Smith et al 2000, Quaiffe 2002, Hadley et al 2006), would render dairying unsustainable and uneconomic.

It is now well established that less than half the extra energy requirements due to the genetic increase in yield are met by the correlated increase in intake, leading to negative energy balance, reproduction and health problems (e.g. Harrison et al 1990, van Arendonk et al 1991, Veerkamp et al 2000, Banos et al 2005).

Selection for angularity or dairy form has been identified as an important factor in the decline of fertility and health, contributing to the negative energy balance, as this trait is practically the same as body condition (e.g. Rogers et al 1999, Pryce et al 2000, 2002, Dechow et al 2001, 2002, Lawlor et al 2005). Incidentally, this is just another example of a major flaw in the history of animal breeding where selection was based on form rather than function.

An announced tragedy

The genetic antagonism between high yield and reproduction has long been documented, yet the short term economics called for selection on yield. A logical emphasis of 5:1 or 6:1 for milk yield and calving interval based on economic values and genetic parameters for those traits could be recommended, tantamount to ignoring selection for calving interval altogether, although the genetic correlation of 0.5 between those traits indicated that fertility would decline with increased yield (Schmidt and Van Vleck 1974).

Studies have also showed that genetic improvement of yield was accompanied by a deterioration of health, although the increased health costs were more than compensated by the increased profit (eg: Table 2).

Table 2. Lifetime traits in Holstein daughters of high and average Predicted Differences Milk USA sires[1]

	High	**Average**	**100 (High- Average)/ Average**
Lifetime milk, kg	20,514	17,277	19
Reproductive costs, US$	138	85	62
Total health costs, US$	268	182	47
Mammary+discarded milk costs, US$	82	53	54
Total feed costs, US$	2574	2346	10
Total profit, US$	1,415	1,158	22

[1] *Source: Bertrand et al 1985.*

Being trained as a student on the notion that profitable animal production must be based on healthy, fertile animals, I must confess I had difficulties in understanding the Tab. 2 results. How is it possible to increase profit while ruining the herd health and fertility in the process? It is tempting to speculate that the low emphasis on traits affecting cost may be due to support subsidies.

Increased yield *via* herd "Holsteinization" resulted in higher profits in Irish farms, in spite of increasing fertility problems and culling rate (Evans et al 2006), whilst in New Zealand the lower yielding, more fertile, smaller, local Friesians, were more economic (Harris and Kolver 2001). In a simulation study for the production and market circumstances of Argentina New Zealand Friesian x Jersey criss-crossing was the more economic breeding strategy in a 20-yr horizon, followed by upgrading to these breeds, while upgrading to international Holstein was the less profitable, on account of it larger size and lower milk solids concentration (Lopez-Villalobos et al 2001).

Problems carry over to the importing developing countries

Low fertility and short herd life are known to occur in Holsteins in Latin-America, even in well managed herds. Cienfuegos-Rivas et al (2006) reported that some 30% of cow culling in Mexico was due to low fertility.

They found a 0.10 genetic correlation between milk yield in the USA and calving interval in Mexico, and estimated a 2.4 day calving interval increase per 1000 kg increase in lactation milk yield from imported genetics. Average first lactation milk yield was 7454 kg.

Wolff et al (2004) reported that the number of days open in Holsteins in the State of Paraná, Brazil, increased from 96 to 101 d between 1991 and 2000, while calving interval increased from 378 to 383 d. These averages and changes are likely to be underestimated because calving intervals longer than 450 d were omitted.

Silva et al (1998) found a genetic correlation of 0.75 between milk yield and calving interval in a sample of more than 118,000 Holstein lactations in Brazil, and estimated a 39.7 d calving interval increase per 1000 kg increase in yield. Grossi e Freitas (2002) reported a genetic correlation close to one between the same traits in crossbred Holstein-zebu herds, indicating that the unfavourable correlation is also present in the zebu crosses. Average milk yield for Holstein cows in Brazil was 6049 kg (Costa 2005).

Molina et al (1999) reported 30.3% prevalence of lameness in free-stall Holsteins in the Belo Horizonte-MG area, in Brazil.

The health and fertility problems are of course more serious in hot regions. Vaccaro (1990) reported that Holstein cows in Venezuela produced only 0.7 first-calving daughters in their lifetime, so they were not able to sustain their numbers. More recently, the elegant results of the Georgia University group have clearly shown negative genetic correlations between heat tolerance and milk yield and fertility in Holsteins (Ravagnolo and Misztal 2000, 2002, Bohmanova et al 2005).

Globalized inbreeding

The narrowing of the genetic base in the major dairy breeds in the first world has been a concern. Wickham and Banos (1998) reported that just five bulls sired 50% of the more than 73,000 Holstein bulls evaluated by Interbull, born in 1990. Van Doormaal et al (2005) reported that almost all (94.2 to 99.7%) proven sires in 11 major dairy countries in Northern America, Europe and Oceania, born in 1999, descended from Round Oak Round Apple Elevation, and 31.9 to 85.0% descended from his son, Hanoverhill Starbuck. A somewhat lower influence of Elevation was found in New Zealand and Ireland bulls (89.1 and 82.3%).

Because of the strong dependence of elite herds, on the top of the pyramid, on imported genetics, the bottleneck also occurs in developing countries. For example, Elevation and Pawnee Arlïnda Chief were the paternal grand sires of 24% and 22%, respectively, of Brazilian Holstein cows in a sample of more than 82,000 (Zambianchi 2001).

Funk (2006) reported 6.8% average inbreeding coefficient in USA Holsteins, projected to increase to 9.7% in 2020 and attributed to the highly competitive nature of the AI industry, and the large costs associated with progeny testing, the cause for AI companies to mostly sample only the highest genetic merit young sires, which tend to be highly related to the breed and among AI studs. This author indicated that “the response from customers in the marketplace for outcross bulls has generally been lukewarm, not a strong endorsement for the AI companies to risk sampling many lower genetic merit, outcross pedigrees”. However, in Brazil, the relationship with famous ancestors was more important than genetic merit in determining the prices of imported semen (Table 3).

Table 3. Coefficient of determination (R^2) in multiple regression analyses of prices of semen imported to Brazil[1]

Dependent variables	R^2
Predicted differences for milk and fat yield, type, reliability and combinations of these variables	0.43
Coefficients of relationship with famous ancestors and combinations of these variables	0.69
All	0.79

Source: *Madalena et al 1985*

Changes in breed preferences (in Brazil)

The changes in semen sales per breed in Brazil, from 1997 to 2005, are shown in Table 4. The data in Figure 1 show the trends, relative to the number of dairy cows in the Country, and divided by two, *i.e.*, the proportion of cows inseminated on the assumption of two semen doses used per cow. It may be seen that the total proportion of cows inseminated showed a slight decrease between 1997 and 2005, remaining at about 7%. However, while Holstein and Brown Swiss semen sales declined continuously, those of Jersey and Dairy Gir markedly increased. Girolando (a Holstein/Gir composite) and Dairy Guzerá also increased but accounted for a much smaller proportion of total inseminations.

Table 4. Number of dairy cattle semen doses sold in Brazil in 1997 and 2005

Breed	1997		2005	
	Number	%	Number	%
Holstein	1,844,590	77.0	1,431,364	50.3
Jersey	233,496	9.8	500,315	17.6
Dairy Gir	181,713	7.6	659,596	23.2
Brown Swiss	100,516	4.2	45,103	1.6
Girolando	13,949	0.6	116,041	4.1
Dairy Guzerá	18,218	0.8	61,530	2.1
Other breeds	902	0.0	31,218	1.1
Total	2,393,384	100.0	2,845,167	100.0

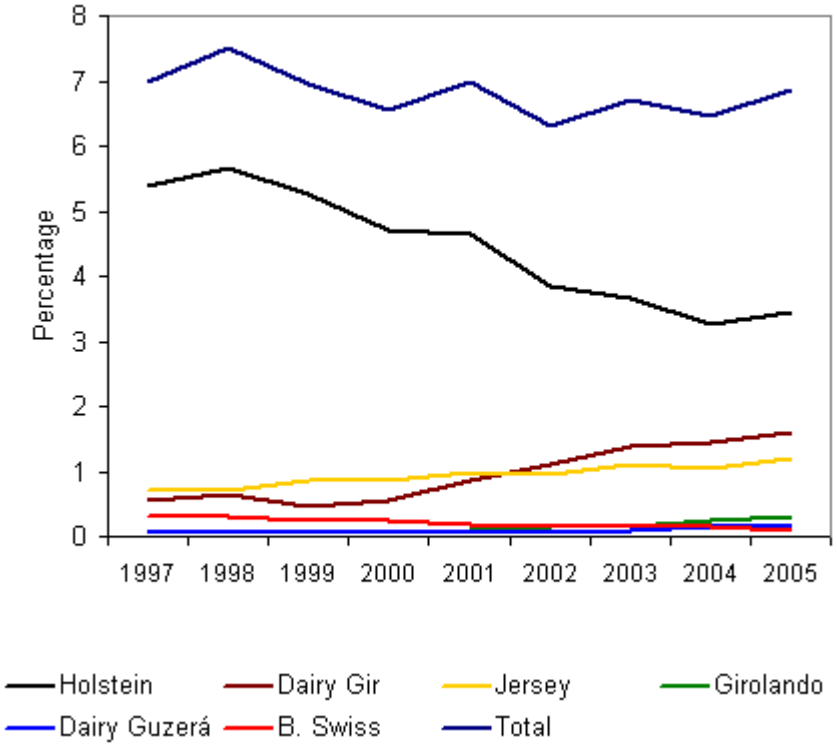

Figure 1. Number of annually sold dairy breed semen doses x 100 /(2 x number of dairy cows in Brazil)

Thus, the Holstein and Brown Swiss are clearly loosing space to the other four breeds. The Jersey and the Dairy Gir are being used mostly for crossing, as the numbers of straightbreds in those breeds are far less than the numbers of doses sold.

Concluding remarks

Selection for high milk yield in first world countries resulted also in a correlated decrease in health and fertility, which was carried over to the Latin-American countries importing genetic materials.

Although the decline in health and fertility was predictable from genetic parameters already known three or four decades ago, most breeding programmes worldwide failed to accommodate the long term consequences of overemphasizing high yield, illustrating the limitations of dairy industry models where the genetic supplier sector is driven solely by short term profits. However, some countries (e.g. Scandinavian countries) did apply the brakes early on and put weight on selection for health and fertility to stop their deterioration, so the interesting question is what made it possible? Hansen (2006) noted that the Scandinavian countries "have practiced more of socialistic approach to breeding their red dairy cattle" rather than "brutal competition" focusing on short term profits.

Crossbreeding, breed substitution and selection on functional traits may all be used to improve health and fertility. In Brazil, the increased popularity of more fertile and adapted breeds indicates that farmers are at least partially aware of the economic set back associated to high yield genetics, although nonetheless more research on the better alternatives, and wide dissemination of the results, are needed to aid farmers to take faster and sounder decisions, properly taking into account unprovoked substantial propaganda. Unfortunately, research and information are too often directed more towards attending vendors' interests than the farmers' needs.

Any eventual decline of major breed numbers or inbreeding causing genetic erosion need not be a cause of concern in respect to biodiversity loss, as there is plenty of frozen semen and embryos available for cryo-preservation.

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Go to top