Breeding value estimation of the functional traits

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Introduction

The main emphasis in dairy cattle breeding has for many years been selection for an increase in milk production. However, milk production traits are genetic unfavorably correlated to several of the functional traits such as health and fertility. Therefore, to avoid further deterioration of functionality of the animal the emphasis has moved towards inclusion of functional traits in the selection criteria. This inclusion was done for two reasons; firstly, for economic reasons – in a market situation with milk quota and a stable or a decrease in milk prices the income from a farm can only be maintained by decreasing the costs. Some of the significant costs in a farming operation are veterinary and reproductive costs. Also, due to ethical reasons – a high producing cow may be more susceptible to disease and may have a poorer reproduction compared to cows with a lower production. Scandinavian countries have a long history of recording of functional traits in dairy cattle. These countries have had a national evaluation for these traits for two decades. More and more countries are adding functional traits in their national evaluation. The global interest in these traits has also encouraged the development of international genetic evaluations for these traits.

Recordings – the basis of a genetic evaluation

Accurate data recording and storage of data are prerequisites of having a genetic evaluation. The first union of farmers for recording and collection of milk production data started in Denmark in 1895. The aim was to use this information for future phenotypic selection. Recordings of the functional traits were initiated much later and started with recordings of conformation traits. Absence of recordings of the functional traits has been and is still in some countries a bottleneck for national genetic evaluations.

Databases are most often characterized by national country borders. However, in some cases information are stored in different regions within a country. In the future, across country databases might become more widespread as joint national genetic evaluations evolve.

The Nordic countries do have a unique position in registrations and collections of information about functional traits. All veterinary treatments are performed by the veterinarian, who usually also does the recordings. Information about calvings (date, size of calf and stillborn information) are recorded by the farmer and submitted to a central database, as are culling date of the cow. This information can be used for genetic evaluations of calving and longevity traits. Information about artificial inseminations (AI) is recorded by the AI-technician or by the farmer and can be used for national genetic evaluations for fertility traits. Figure 1 illustrates the data flow to and from a cow database. The central data and pedigree collection alleviates data extraction and is the basis of a national genetic evaluation. It should be emphasized that it is crucial to be able to match data from different sources, especially pedigree information.

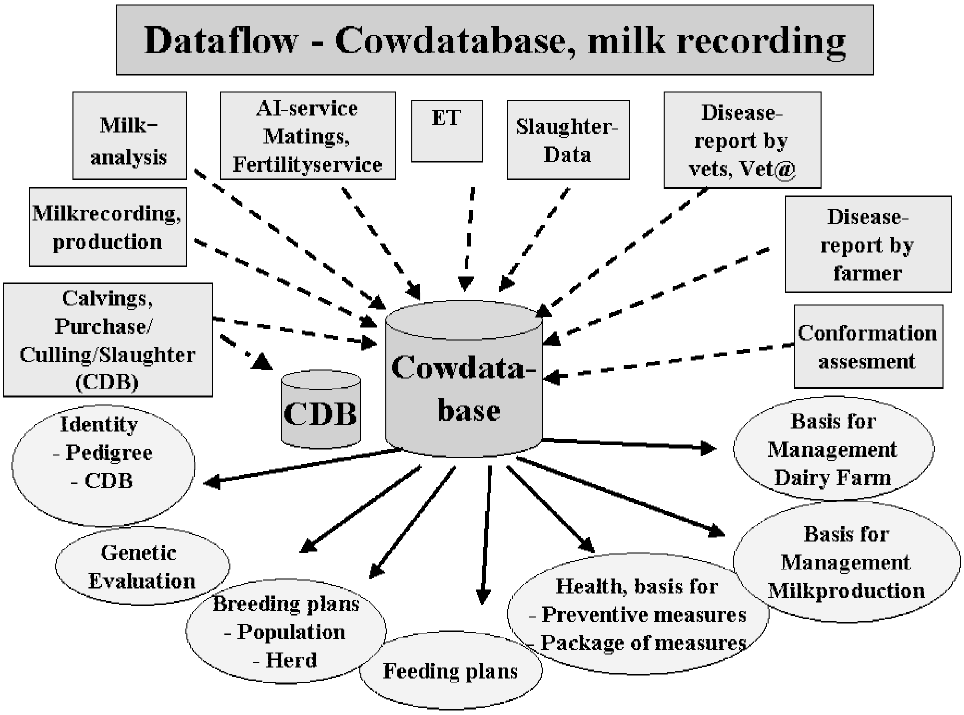

Fig. 1. Illustration of information flow to and from the cow database.

Weight on individual traits in selection index

Figure 2 shows the relative weight of subindexes in the selection index for Canada (CAN), Denmark (DNK), Italy (ITA), New Zealand (NZL), and Germany (DEU). Among these five countries, does CAN have the highest weight on production and conformation traits. DNK has far the lowest weight on protein yield but much weight on functional traits, in accordance with the Scandinavian profile (Miglior et al., 2005). Dairy production in Oceania is based on grazing, and of the five countries mentioned above is NZL the country with the largest negative weight on size and the largest negative weight on milk carrier, but positive weights on components and fertility. Thus cows with high percentages are favored while large cows are penalized with the aim to control energy requirement for maintenance. The weighting of the traits in the DEU index is with quite some weighting on functional traits and with three times as much weight on longevity as any of the other four countries. And lastly, the main emphasis in the Italian index is put on production, cell count and udder conformation. So in summary, although the direction in selection has been moving from pure selection on production towards simultaneously selection on production and functional traits there exists a substantial variation across countries in number of traits in selection index and relative weight on individual traits. These differences reflect to some extent differences in production systems and economics of production.

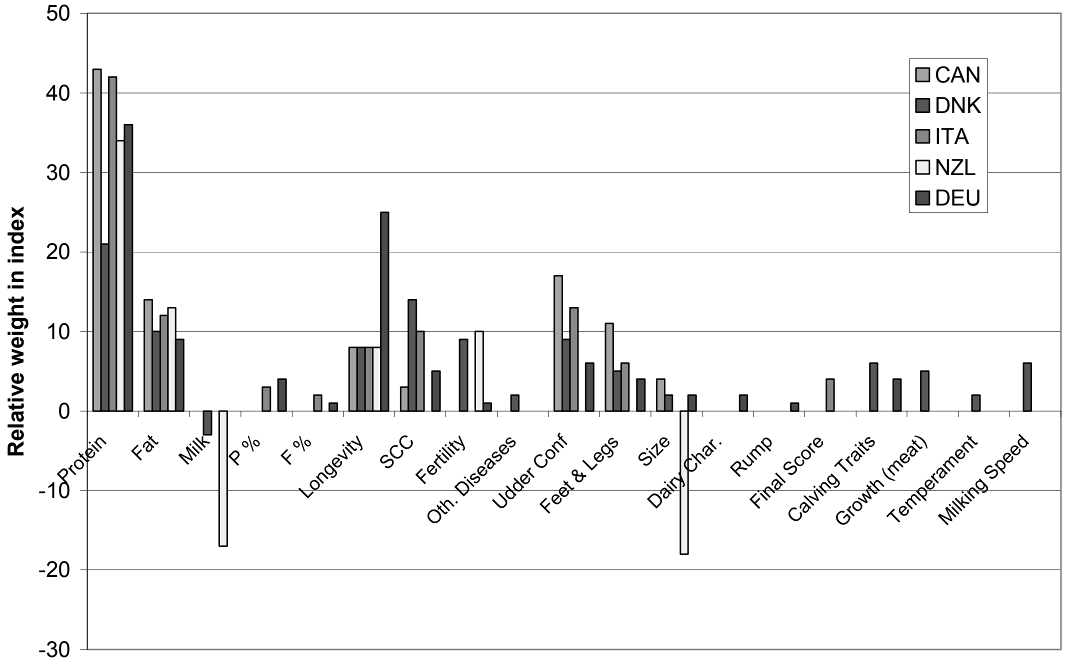

Figure 2. Relative weight of subindexes in selection index for Canada (CAN), Denmark (DNK), Italy (ITA), New Zealand (NZL), and Germany (DEU). From VanRaden (2004).

Genetic trends in female fertility – a result of selection!

Trends in female fertility index for Swedish Ayrshire (SRB) and Swedish Holsteins (SLB) are shown in Figure 3. The figure shows a slight improvement in fertility for SRB and a very remarkable decline in fertility for SLB. The bulls that have been used in the SLB breed are to a great extent imported from countries, where information on fertility not has been available until recently. Bulls used for SRB are mainly only Scandinavian bulls, where selection for fertility has been going on for much longer. These observations indicate the importance of a clear description of genetic potential for all important traits, the importance of having a national genetic evaluation for functional traits, and not at least to include fertility traits in the selection criteria.

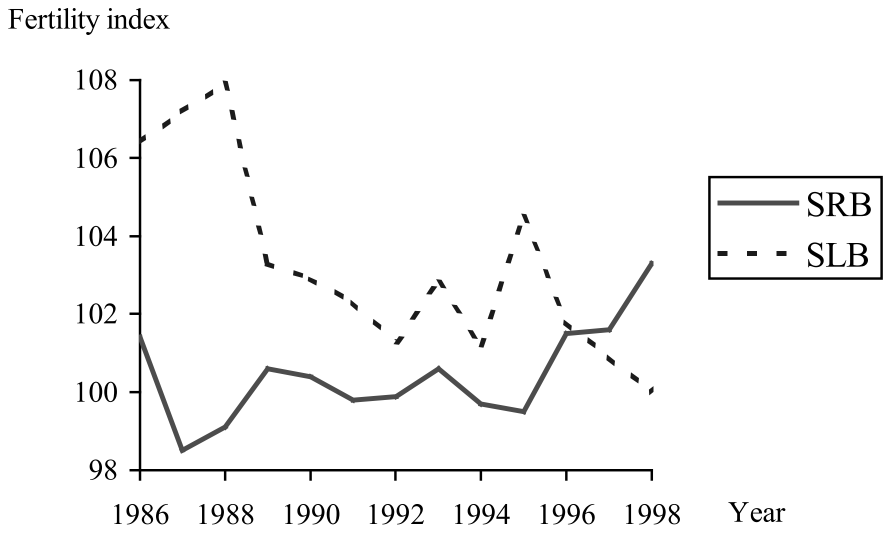

Figure 3. Trends in female fertility index for Swedish Ayrshire (SRB) and

Swedish Holsteins (SLB). The index is expressed as relative breeding values with a mean of 100 and a standard deviation of 7. A high value indicates good fertility.

Numerous studies have found an antagonistic genetic relationship between fertility and production. And therefore, the negative trend in fertility for the SLB is due to the unfavorable correlation to production traits when both traits are not included in the breeding goal. Examples of genetic correlations between production and important functional traits are in Table 1. All correlations indicate an unfavorable relationship to production, but many of these traits are selected for together with production traits in a total merit index to prevent too much of a decline in functional traits.

Table 1. Examples of unfavorable genetic correlations between production and functional traits.

Trait	Genetic Correlation	Reference
Mastitis	0.29	Carlén et al., 2004
Milk Somatic Cell	0.23	Carlén et al., 2004
Fertility	0.16-0.40	Roxström et al., 2001
Persistency (decline after peak yield)	0.36	Jakobsen et al., 2002
Disease	0.52	Jakobsen et al., 2003

Trends in international genetic evaluations

With an increase in number of traits evaluated nationally and a large exchange of genetic material across country borders, the demand for international genetic evaluation of functional traits and rankings for functional traits of foreign bulls on own country scale increases.

The trend in number of participating countries for international genetic evaluation for the five trait groups (production, conformation, udder health, longevity and calving) currently evaluated are shown in Figure 4. The first international genetic evaluation of dairy bulls took place in 1994. This was with participation from four countries, only for milk production traits and only for Ayrshires and Holsteins. Number of participating countries has increased over time as has the number of participating breeds. International genetic evaluations for conformation traits were initiated in 1999 for one breed (Holstein), 10 countries and 17 conformation traits. These numbers have steadily increased and in the first routine run in 2005 to five breeds, 21 countries and 19 traits were evaluated. As Figure 4 shows, the next trait in line was udder health traits that were initiated in 2001. The udder health trait group comprises the two traits milk somatic cell and clinical mastitis. Data from 12 countries and five breeds (Ayrshire, Brown Swiss, Guernsey, Jersey and Holstein) participated from the beginning. Number of countries has since increased to 20. The first international genetic evaluation for longevity traits for Holsteins took place in November 2004 and other breeds than Holsteins were added in 2005. The latest trait group in service is calving traits. The first international genetic routine evaluation for calving traits took place in February 2005 and was for the Holstein breed only. Test evaluations have been performed for other breeds than Holsteins, but routine service is not initiated yet.

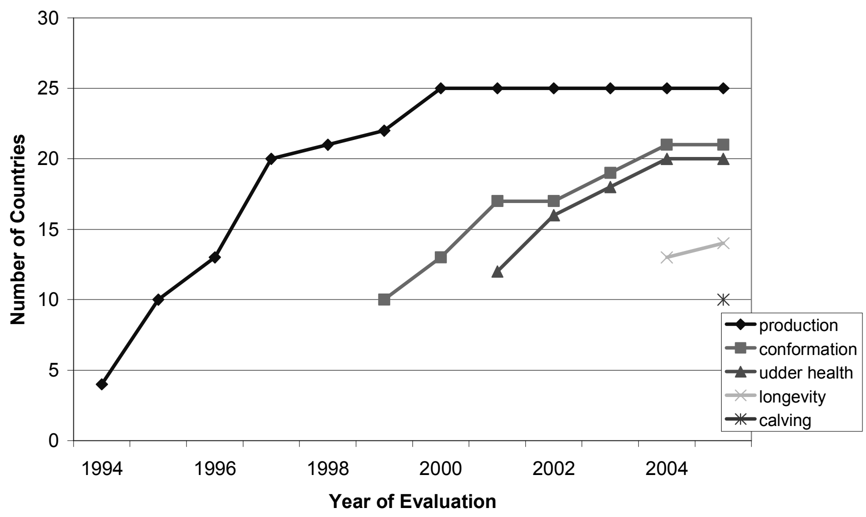

Fig. 4. Number of countries participating over time for production, conformation, udder health, longevity, and calving traits.

Genetic trends in international evaluated traits

Genetic trends for protein production and milk somatic cell for Danish (DNK), American (USA), Dutch (NLD), Canadian (CAN), and Italian (ITA) bulls on Italian scale can be seen in Figure 5, and Figure 6, respectively. Trends are rather different between traits. All countries show approximately the same positive trend in protein production, and it is remarkable that slightly less progress is seen for Canadian bulls compared to bulls from the other countries. This does not reflect the relative weight on protein production for CAN as illustrated in Figure 2. But it is important to keep in mind the time lag between generations and the time it takes from a decision is taken of changing the breeding goal until the change is expressed in the population.

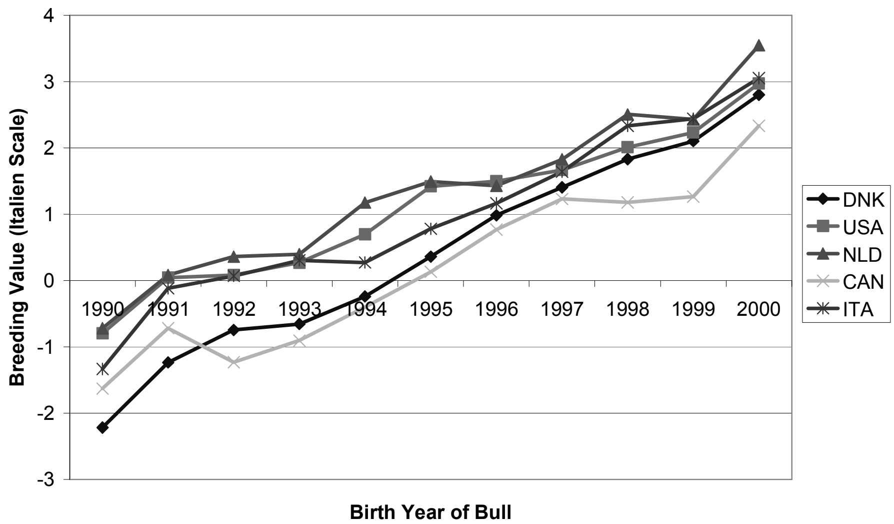

Figure 5. Trend in standardized breeding values for protein yield on Italian Scale.

Udder health is considered as the most important functional trait by most countries. Only the Nordic countries do have a national genetic evaluation for mastitis resistance. Other countries use milk somatic cell evaluation as best available predictor for mastitis. Trends for this trait are remarkable different from trends for protein production. Low values are desirable for milk somatic cell on the Italian scale and indicates a decrease in number of cells. The figure therefore shows a slightly unfavorable trend for all countries except the Netherlands.

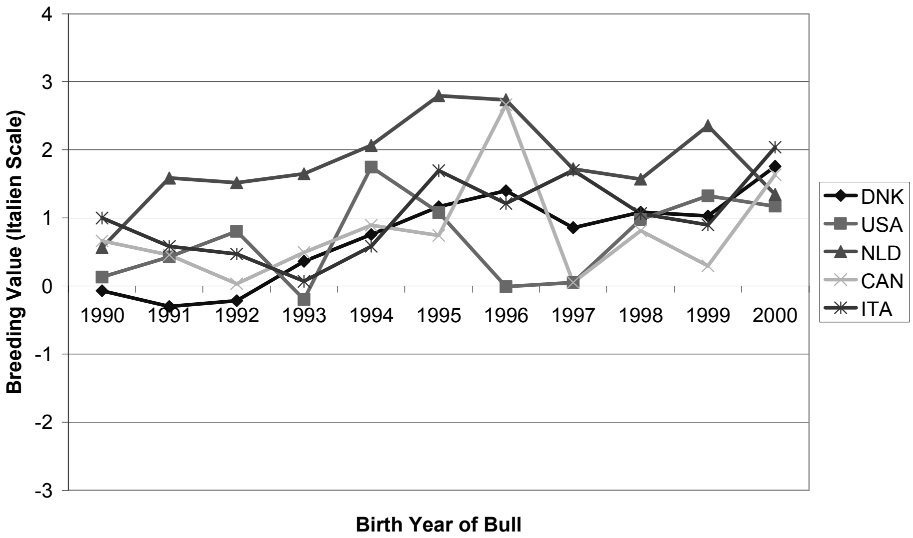

Figure 6. Trend in standardized breeding value for milk somatic cell count on Italian Scale. A low value is desirable and indicates a decrease in milk somatic cells.

Variation in national evaluated traits

One of the most recent internationally evaluated traits is direct longevity. Correlations are in general higher for production traits compared to longevity traits (Table 2). There can be different reasons for this difference in size of correlations. Firstly, definition of production traits is much more harmonized in measurement units and time of collection.

Table 2. Genetic correlations between countries for longevity (above diagonal) and protein yield (below diagonal) for Denmark (DNK), United States of America (USA), The Netherlands (NLD), Canada (CAN) and Italy (ITA).

	DNK	USA	NLD	CAN	ITA
DNK		0.82	0.85	0.76	0.74
USA	0.92		0.79	0.88	0.72
NLD	0.94	0.88		0.75	0.70
CAN	0.92	0.93	0.90		0.75
ITA	0.88	0.92	0.86	0.91	

Longevity traits have been defined as risk of culling, length of productive life, and survived as a zero-one trait (see Figure 7a). Also, some countries do correct for milk production to get a measure of functional herd life, while others do not do this correction. Secondly, some countries use a linear mixed model while others use survival analysis (Figure 7b). The difference in trait definition along with the differences in national evaluation models can be the causes of the lower correlations compared to production traits. But a non-illustrated aspect is that culling reasons may differ between countries – where poor fertility may be the main cause of culling in production systems with seasonal calvings, mastitis may be the main culling reason in countries where veterinarians do perform all disease treatments.

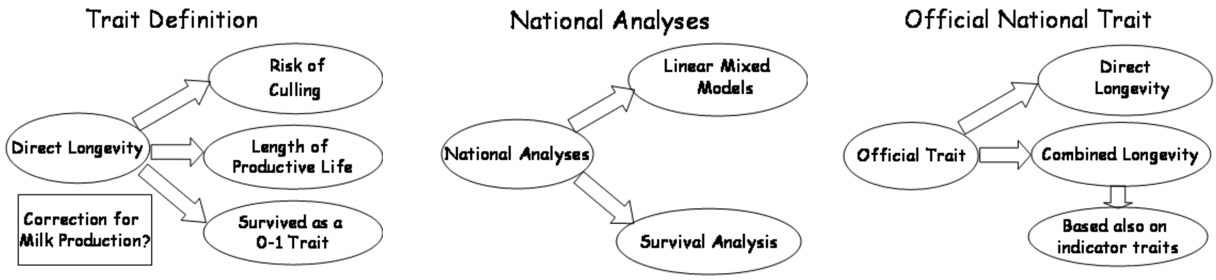

Figure 7. Trait definitions (a), national analysis models (b) and official national trait (c) for longevity.

Figure 7c illustrates that some countries do have direct longevity as their official trait while others do have combined longevity as their official trait. What is special about longevity is the expression of the trait late in life. Therefore, several countries combine longevity with information from indicator traits to achieve a reliable breeding value for longevity at an earlier point in time.

More functional traits to come

Female fertility is expected to be the next trait in line for international genetic evaluations. A research study on this trait group is ongoing and genetic correlations are moderate to high for similarly defined traits (Jorjani, 2005). Many countries have in recent years developed procedures for genetic evaluation of female fertility. Due to the unfavorable genetic correlations between production and fertility it seems urgent that all breeding programs include fertility and that proper genetic evaluations are developed and utilized for international evaluations.

It can be speculated which trait will be the next to follow for international genetic evaluation. A steady increase in advanced technology in modern dairy cattle operations has made an increase in data recordings and monitoring traits from farms. These can for example be electronic recordings of feed intake, hormone or conductivity measurements from milk. Collection of these data will make genetic evaluation possible for a new area of traits. Evaluations for locomotion or behavior may be of interest in the future, but also traits that serves as limiting pollution factors or increases the quality of the animal productions may be in line.

Concluding remarks

A demand for a detailed declaration of genetic material imported from other countries and expressed on own country scale is the reason for the expansion of international genetic evaluation services to include several functional traits. But it is important to keep in mind that accurate international genetic evaluations only can be performed from a good quality of input data supplied from participating countries. And a good quality of input data requires good recordings, good data collection and a good national evaluation model.

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