Sustainable breeding goals – a public view

Marco Winters
Director, MDC ***breeding+***, Milk Development Council, Trent Lodge,
Stroud Road, Cirencester, GL7 6JN, United Kingdom

ABSTRACT
Future breeding goals can no longer afford to only consider short term profitability based on animal output. And rather than selection on yield alone, have to present a sustainable alternative that can provide for a profitable dairy farming business in which the animals are fit for purpose. At the same time breeders also have to be aware of new demands from both the environmental and consumer sector. Improvements in individual animal genetics therefore cannot be seen in isolation, but are an important part of a wider industry change. Improvement in the quality and quantity of animal performance data, enhancement of genetic evaluations and the structure of genetic selection indexes are needed to help achieve this goal whilst simultaneously maintain genetic-diversity. Methods to enable the incorporation of non-economic objectives into a breeding goal are being developed. Eventually carefully implemented genomic technologies may provide new solutions to this ever more complex breeding objective, where we are often faced with conflicting genetic desires of animal output vs. sustainability.

INTRODUCTION
Traditionally cattle breeding programmes have had a strong focus on the genetic improvement of the economically important production traits; Milk, Fat and Protein. With the introduction of sophisticated genetic evaluation models and improved genetic selection, the genetic progress on these relatively easily measurable and moderately heritable traits has been very successful. As a result milk yield has more than doubled over the last 40 years and the Holstein breed has seen a transformation from the traditional dual purpose breed to a very efficient high production cow. But as the cow's genetic ability to produce milk has gone up, so her health and welfare have had a greater potential to suffer. This means that nowadays higher standards of management are required to maintain the same levels of fitness, and to a large extent, these higher standards have been achieved. The fact that actual (phenotypic) links between health and production are generally far lower than the genetic links, indicates that farmers are doing a good job of managing these problems. However, if the genetics behind the problems continues to be ignored, the farmer's job in time will become harder and herd health will eventually decline beyond acceptable levels. Furthermore new EU legislation impacting on animal welfare and environment will have a significant impact on the dairy industry. That's why genetic information for health and welfare traits is becoming increasingly more important, and although these traits don't tend to be inherited to the same degree as milk production, it is certainly possible to breed for them since many show sufficient variation to enable selection between animals. In addition, it is important to remember that genetic improvements are very cost effective, are permanent and accumulate over the generations.

Broader breeding goals
With the strong emphasis on the production traits in the past, we have unintentionally been selecting against many of the traits that allowed the cow to sustain high levels of production in the first place. It is a well know fact that unfavourable genetic relationships exist between production traits and fitness traits (e.g. Mastitis, Lameness, Fertility and Longevity) and in addition to this the heritability of fitness traits is often low compared to production traits. In order to balance the necessary genetic progress for all these traits, the breeding goals have had to be widened and appropriate weight has to be given to the traits in the selection index.

A shift of emphasis in the breeding goals has already taking place. Over the last 10 to 15 years the global dairy cattle breeding programmes have seen a substantial move from production orientated goal traits towards fitness traits (Miglior, 2004). However, under European conditions with high costs (for labour, buildings, and land), and high product prices, cow yield continues to be of high importance. Therefore, finding the right balance between efficient milk production and animals that are fit and suitable for this purpose will be the focus for dairy cattle breeding programmes for the near future. Along side these obvious economic goals for the dairy industry, the industry is also faced with new demands that historically it hasn't had to concern itself with. New regulations coming from the environmental sector, combined with a growing interest from the consumers into where and how food is produced, has made it even more important that the dairy industry prepares itself for providing genetics suitable for a sustainable dairy industry. The European Forum of Farm Animal Breeders (EFFAB) has recently taken the initiative to set up a code of good practice for animal breeding as guidance in this area (Code-EFABAR). The terms People, Planet, Profit are often used in this context to describe sustainable developments, and describe the need to consider the Society, Environmental and Economic needs of future breeding goals. It is rare for these three to be in harmony, and often conflict between two or more of these three is likely, making the definition of new breeding objectives more complex.

Developing non-economic breeding objectives

Having touched on the change in emphasis and some of the complexities of issues surrounding the new breeding goals, how do we go about making this adjustment?

Setting up a selection index is not a new concept (Hazel, 1943), but the assumption of selection index theory has always been to maximise economic response. However, we have already identified that it is logical to accept that future breeding goals need to be aware of more than pure economic farming objectives and an element on non-economic desires have to be considered. These non-economic factors are often hard to define in relation to the economic needs and discussions revolving around a desired, rather than a pure economic, breeding goal can stir up much debate. The ultimate discussion is often related to how quick we want to progress on the fitness traits or how much we are willing to sacrifice our other economic objectives, for the benefit of the wider breeding objectives.

Different approaches on setting up, so called, desired gains indexes are available and are being developed with varying degrees of imposed desires on the fitness traits. However, as is the case with any desired gains index, these rankings no longer describe an economic optimum ranking and the desired gains are often a compromise of true economic needs and perceived needs to accommodate the various (subjective) desires within the industry. The difficulty of quantifying this subjective desire is that a breeding company may have different desired goals than a milk processor or consumer organisation with interest in the industry.

The next section illustrates some of the possible ways of setting up desired selection indexes.

A reasonable first step is the desire to halt the further decline of any of the fitness traits, and restrict the negative trend to no further change. For this purpose, the 'restricted index' has been designed. The outcome of selection on this type of index will result in an improved response to fitness traits compared to an index with no restriction, but this constraint is at the expense of production gains, and will often lead to a loss in total farm profitability using the assumptions of cost in the current model. Under UK conditions, adopting such an index will result in an estimated cumulative cost to the industry of £2.5 million per annum, using economic assumptions from 2003 (approx. 3.7 million Euro) (Wall *et al*., 2007). More recent estimates under current financial assumptions are less costly, but never-the-less are still showing a reasonable economic sacrifice to the industry (RobustCow project 2007, personal communications). These incurred losses arise because farmers are not yet compensated fully for addressing consumer or environmental concerns.

An alternative method to the 'restricted index' is a pure desired gains approach, where the relative weights in the index are adjusted to achieve a desired predetermined outcome. This approach needs to have a clear idea of the ideals from the start and fit the index to this. However, in many cases this approach is not flexible enough to satisfy everybody's needs.

Making the process of setting up a desired gains index slightly more flexible, another method has been suggested, whereby index weights are again derived for non-economic traits. The 'retrospective-selection index' starts by estimating all possible combinations of genetic progress (the so called progress space) based on different combination of index weights, and subsequently allows the user to select a set of weights that results in the most desirable combination of relative index weights and responses in the traits (Kanis *et al*. 2005). However, there still is a significant degree of subjectivity needed to pick the desired goal.

Finally, yet another method has been suggested in an attempt to guide the optimal desired gains discussion. This method is perhaps the least subjective, and has a starting point from the other end, by indicating how far we are initially willing to sacrifice production for the benefit of the fitness traits. The starting point therefore is an optimum economic index with given economic values for each trait, already identified under a pure economic breeding goal (Nielsen *et al*., 2006). By reducing the response in yield by say five percent, the formula will spread the released selection intensity among the other traits in the index. The gains therefore are initially more evenly spread across the remaining selection traits, rather than forced on a particular trait or traits as is the case with a restricted index approach described above. However, this approach does also allow further restrictions to enable a more forced desired gain, leading to an increased level of subjectivity. More work however is needed to fully utilise the capabilities of such an approach.

Easier said than done

The previous section shows that setting up a selection index isn't a trivial exercise. Deciding what our goal is in the first place is a significant task. Whereas in the past we have used the economic market forces to indicate the breeding goals, nowadays we also need to concern ourselves with non-economic pressures on the dairy industry. And even if we managed to set ourselves a goal, predicting how we get there isn't that straight forward either. Not only do many of the fitness traits have undesirable genetic relationships with yield traits, but often have not very well understood genetic relationships between the traits of interest at all. For example, many countries have no direct measure of mastitis resistance available, and therefore improving mastitis resistance will have to be predicted by using traits that we know are genetically correlated, such as Somatic Cell counts or various udder traits. However, to what degree mastitis relates to other traits under selection, such as feet and legs or calving ease is often less well understood, and yet these are all traits we are selecting for, and want to improve, at the same time. The obvious solution would be to start recording and evaluating mastitis resistance directly. But the reason that many countries haven't got direct measures of disease trait is that unfortunately, these traits are often difficult or costly to measure on a national scale; which of course is essential for a national evaluation.

The above complications highlight some clear constraints in the process. However, what is of critical significance here is that we should not allow these complications to be used as an excuse not to react at all.

Luckily with ever improving quality of existing data, thanks in part to international harmonisation of trait definition and data collection, and the increased availability in affordable computing power, we have managed to make great strides in providing genetic information for fitness traits on bulls. The recent introduction by INTERBULL of International genetic evaluations of Female fertility is further evidence of this.

Genetic improvement for fitness traits in dairy cattle is undoubtedly held back by long generation intervals, and the added complication that these traits are not only difficult to measure, but are typically not measurable at all early in life (e.g. Longevity). In order to get accurate genetic information on these traits, predictor traits can be used. But for us to enhance the power of this predictive information larger progeny groups are desirable. The downside of this of course is that this in turn results in extra cost to the breeding programmes that operate under their own economic pressures in a very competitive marketplace.

New developments

Identifying new traits is an important part in improving the effectiveness of our selection. For that reason, traits that can help us to more accurately select for more 'robust' cows are constantly being proposed. For example ongoing work in metabolic energy balance and the introduction of milk urea nitrogen indexes in some countries are two of many recent traits under assessment and these traits may help us to fine tune our selection indexes in response to new needs. Further enhancements of tailor-made 'farm specific' breeding indexes are another area of interest to further fine tune the suitability of dairy genetics to specific farming conditions.

It is hoped that with the advent of Molecular genetics the opportunities to accelerate genetic improvement for difficult to measure traits will increase. Developments it these new technologies are happening at a fast pace, and with the rapid reduction of the cost of genotyping individual animals, dairy cattle breeding programmes are being geared up to make best use of the opportunities that are expected of Genome-Wide selection strategies (Meuwissen, *et al*, 2001, FABRE-TP). However, the challenge on how to incorporate this new information effectively in genetic evaluations and in the context of a wider breeding goal remains. As with any improvement, there are also some words of caution, as new difficulties are also introduced with the use of genomic selection. Intense selection on specific genome regions has the potential to accelerate the fixation of favourable genes, which consequently results in a loss of genetic variation.

Sustainable breeding programmes therefore have to focus on more than just individual animal performance. This in itself isn't new, as ever since the introduction of Artificial Insemination and the ability to freeze semen, the genetics industry has seen an enormous change in the impact of single elite bulls and as a consequence has led to a concentration of blood lines in the dairy cattle populations. As a result of narrowing bloodlines we have increased inbreeding, which in some cases can lead to inbreeding depression. This in turn will inevitably result in the industry encountering and discovering new genetic defects which arise from accumulating naturally occurring unfavourable DNA mutations. In the much wider context, sustainable breeding goals, therefore also have a duty to manage the genetic-diversity within the population. Farm animal genetic resources are already being monitored on a global scale and are no longer only of interest to the farming sector.

Role of herdbooks

Herdbooks have an important role to play in improving the genetic gains in a population. Clearly, correct animal identification and pedigree information is crucial in genetic evaluations, but herdbooks can also facilitate the debate on future breeding goals and should guide their members on best genetic selection policies for future needs. Constant harmonisation of trait definition and recording will aid the sharing of information between global breeding population and help genetic progress. Further improvement in the collection of genetic defect information, combined with standardisation and more sophisticated analysis of this data is needed to better identify undesirable side effects of past and current selection. If data is only collected and stored, but not interrogated and shared between populations this is a waste of valuable resources that herdbooks hold. Finally, it is important also that herdbooks recognise that just as overall breeding goals are changing, the desired 'true type' also has to adept to the new goals. The challenge here is to ensure this 'true type' serves to support of the wider industry breeding objectives. A global move to harmonising the definition of 'Dairy Strength', and more recently the introduction of some countries in scoring 'Robustness' are indications that this process is already taking place.

Discussion

Sustainable breeding goals are very topical, and to talk about it is very easy. However, the challenge remains on how we identify future needs which are influenced by clear economic needs, and new non economic pressures on the dairy industry. For a long time, adaptation of farm management has been able to cushion the effect of the negative genetic trend in some of the fitness traits very effectively, and will probably be able to do so for some time yet. However, the breeding sector has to realise that it will have to adapt its breeding goals to steer the genetic change within the population to favour fitness traits. If we ignore the importance of 'fitness' traits in our national breeding goals, this will inevitably lead to disappointments and increased problems in the future; especially when the expectations of the environment and consumer sector will be greater.

The good news is that the Holstein breed is by far the largest recorded dairy breed in the world, and for all the traits we are currently interested in, we can identify a sufficient amount of genetic variation within the breed. Therefore, once we have decided the new course to take, it will be a long term, but relatively straight forward task to get us there.

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