HEALTH AND WELFARE IN GENETICALLY HIGH PRODUCING DAIRY COWS AND ITS ECONOMICAL IMPLICATIONS

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SUMMARY

In many countries the milk production per cow has more than doubled in the last 40 years. The increase in production has been accompanied by declining ability to reproduce, increasing incidence of health problems, and declining longevity in modern dairy cows. Genetic selection for increased milk yield is increasingly viewed as increasing profit at the expense of reducing animal welfare. The welfare problems should be addressed before there is widespread condemnation of breeding and management practices. A sustainable breeding goal aimed at improving fitness and tolerance to metabolic stress is recommended.

Keywords: dairy cows, fertility, health, welfare, genetics

INTRODUCTION

The dairy industry's goal has always been to produce quality milk for the consumer market. In many countries yield per cow has more than doubled in the last 40 years. The dramatic increase in yield per cow is due to rapid progress in genetics and management. The average ECM (Energy corrected milk) yield for Swedish dairy cows increased from 4200 kg to 9000 kg between 1957 and 2003 (1). Data from National Milk Records in the UK show an increase in average yields of dairy cows of about 200 kg/year from 1996 to 2002 and 50% of the progress in milk yield is attributed to genetics (2).

The picture is similar in the US where between 1993 and 2002 the average milk production/cow increased by 1287 kg and 708 kg of this increase, or 55%, was due to genetics. Interesting to note that, until mid-1980s most of the increase in milk yield was the result of improved management, in particular better application of nutritional standards and improved quality of roughage. Since then, genetics became the major factor due to effective use of artificial insemination (AI), intense selection based on progeny testing of bulls and worldwide distribution of semen from bulls with high genetic merit for production.

There are several practical reasons why high production should be viewed with concern: a) the increase in milk yield has been accompanied by declining ability to reproduce, increasing incidence of health problems, and declining longevity in modern dairy cows; b) substantial antagonistic genetic correlation exists between milk yield and fertility and between milk yield and several production diseases indicating that, if selection for production continues unchanged, further genetic deterioration in fertility and health is expected; c) high disease incidence, reduced ability to breed, decreased longevity and modification of normal behaviour are indicative of substantial decline in the welfare of dairy cows; d) the success of dairy industry depends upon public perception of its products and production methods and increased public concerns regarding modern animal agriculture, particularly animal welfare, puts sustainability of dairy industry at risk.

DISCUSSION

Declining fertility, health and longevity of modern dairy cows

Calving interval increased from < 13.0 months to > 14.5 months and number of inseminations per conception from 2.0 to > 3.5 from 1980 to 2000 in 143 US commercial herds (3). A decline in pregnancy rate to first service of 0.5% per year between 1975 and 1997 was reported in the US (4). Poor reproductive performance often leads to premature culling of dairy cows.

The decline in fertility, reflected in increased calving interval, and in longevity, measured by satiability, in Holstein cows in the Northeast US from 1957 to 2002 are shown in Figure 1. Average milk yield per cow over the same period increased from about 5000 kg to 11000 kg at a relatively steady rate of about 150 kg per year. Interesting to note that average calving interval increased by only 0.5 mo from 1960 to late 1980s and by almost 2 mo in the last 15 years and the trend seems to reflect the pattern of rate of genetic gain. Proportion of cows still alive at 48 mo of age (stay ability) decreased from 80% to 60% between 1957 and 2002 indicating a substantial decrease in length of productive life of modern dairy cow.

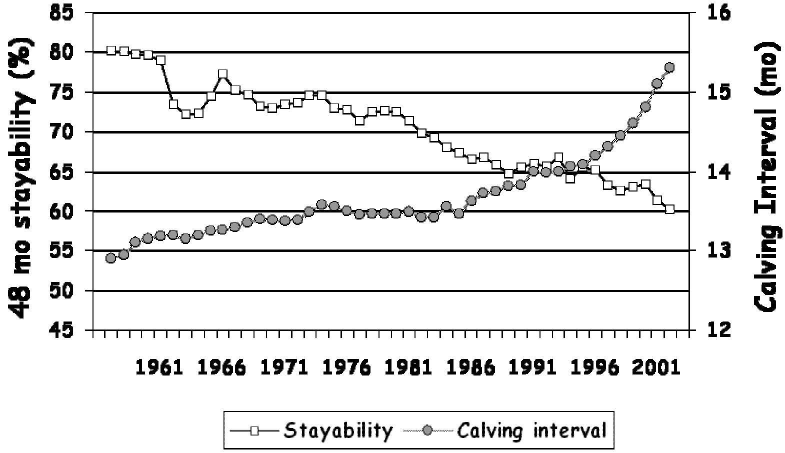

Figure 1. Average calving interval and 48 months stay ability over time for Holstein cows in Northeast US

Declining reproductive efficiency is not limited to the US. In the UK (5) pregnancy rate to first service decreased from 56% in 1975–82 to about 40% in 1995–98, a decrease of about 1% per year. Similar decreases in conception rate and other reproductive measures have been reported in Sweden (6) and many other countries.

The incidence of production-related diseases has increased greatly over the last decades. A case in point is lameness. Its incidence increased in UK dairy herds from lactational incidence rate (LIR) <10% reported prior to 1980 to >20% after 1990 (7). For the US, Guard (8) reported a 38% LIR and estimated direct cost due to lameness in a 100-cow herd to be $7,600.

Ingvartsen et al. (9) reviewed the literature on the relationship between milk performance and health in dairy cattle. The review dealt with production diseases as defined by Kelton et al. (10): dystocia, parturient paresis, ketosis, displaced abomasum, retained placenta, ovarian cyst, metritis, mastitis and lameness. The review of 11 epidemiological studies showed clear evidence that cows with high yield in the previous lactation are at increased risk of mastitis and ovarian cysts in subsequent lactation, but for other diseases the phenotypic association was weak due to the large variability between studies. These results led Ingvartsen et al. (9) to conclude that examining the relationship in terms of cause (level of milk production) and effect (disease incidence) is inadequate as cows producing more milk are also likely to eat more and make greater use of their body reserves in early lactation (11).

Unfavourable genetic association of milk yield with fertility and health in modern dairy cows

Many published studies (2, 5, 6) reported strong unfavourable genetic associations between milk yield and fertility measures – indicating that the decline in fertility observed on the dairy farms is, at least in part, an unwanted consequence of successful selection for higher yields.

Ingvartsen et al. (9) reviewed 14 genetic studies on the relationship between milk performance and health in dairy cattle. These studies showed an unfavourable genetic correlation between milk yield and incidence of ketosis (0.26–0.65), ovarian cyst (0.23–0.42), mastitis (0.15–0.68) and lameness (0.24–0.48) indicating that continued selection for higher milk yield will increase LIR for these production diseases.

Declining adaptability of modern dairy cows

It is clear that selection for production may lead to problems in health and fertility. As animals tend to adapt to the environment they are selected in, it is likely that selection for increased yield may also lead to environmental sensitivity expressed as genotype × environment (G × E) interaction. Castillo et al. (12) and Kearney et al. (13) showed that the magnitude of the antagonistic genetic correlations between milk yield and somatic cell score and between milk yield and conception rate were significantly higher in a poor environment relative to a good environment. Dairy producers in several grazing countries have expressed concern regarding the declining fertility of cows with increased Holstein genes. Harris and Winkelman (14) and Verkerk et al. (15) reported significant differences between cows of New Zealand origin and North American origin for conception rate, services per conception, and days to first service. These changes in the genetic correlations between traits are indicative of genotype by environment interaction; suggest a decline in fitness and adaptability associated with selection for increased production and leads to welfare problems, especially when the animals are exposed to a poorer environment.

Major welfare performance indicators

One definition of animal welfare put forward by Broom (16) states that “The welfare of an individual is its state as regards its attempts to cope with its environment”. Animal welfare ranges from poor to good and an objective way to assess it is in terms of directly measurable biological functions such as reproductive success, disease incidence, survival and behavioural changes (17). Duration, prevalence and severity are aspects that need to be considered to assess the importance of any welfare indicator. A total of 22 scientists participated anonymously (Delphi method) to develop a conceptual framework for assessment of farm animal welfare, to identify the major welfare performance indicators and rank them in order of importance. For dairy cattle the major welfare indicators in order of priority were: lameness, mastitis, other metabolic disorders, sub-fertility, and longevity (17).

Sustainability of dairy industry in a changing culture

For the most part of the 20th century the goals for animal agriculture were increased production and increase efficiency to satisfy a consumer market that demanded an abundance of animal products at low cost. Under these circumstances, it is not surprising that the main aim of dairy cattle breeding for the last 50 years was to improve production and efficiency, with genetic selection focused on increasing milk yield. This goal has received wide support because, other things being equal, it should optimize the use of resources, increase farm profit and reduce cost for consumers. However, this approach has also led to undesirable and ethically problematic consequences, particularly with respect to welfare and adaptability of modern dairy cow. Today, the attitude toward farm animals in the developed countries has changed and other issues, particularly animal welfare, are of primary public concern. Genetic selection for increased milk yield is increasingly viewed as increasing profit at the expense of reducing animal welfare. The sustainability of dairy industry is directly related to public acceptance of its production practices. Unless remedial measures are taken, there is a real danger for the dairy industry to find itself out of steps with public values, loose market share and experience serious economic hardship.

Selection for high production and metabolic stress

As the genetic ability to produce milk increases, more cows have sub-fertility or production diseases. As more cows are culled for health or fertility reasons, the productive life of modern cows is rapidly declining. The associations between increasing production and deterioration of the most important indicators of welfare are well documented, but less is known about the biological mechanisms behind these relationships.

One of the first attempts to explain the negative collateral consequences of selection for increased production were presented by Goddard and Beilharz (18) who suggested the "Resource Allocation Theory". The resources an animal have are limited and as a result, if output is increased through one biological process, such as producing more milk, other functions will be affected such as fertility, maintenance, movement, immune defence, etc. The resources that one process demands can be increased to a certain extent. Due to management, such as increasing access to feed and nutrients, fitness of the animal could increase until resources became limited again. Any further increase in fitness would imply a reallocation of resources and thus modify other outputs such as disease resistance or behaviour (19). Reviewing the negative side effects of selection for high production Rauw et al. (20) concluded that "when a population is genetically driven towards high production,"…" less resources will be left to respond adequately to other demands like coping with (unexpected) stressors; i.e. buffer capacity is [negatively] affected".

To address the growing perception that the pursuit of ever-increasing milk production is detrimental to cows' welfare, Ingvartsen et al. (9) developed a framework for future research. The framework links the genotype, nutritional environment and management of the cow through its metabolic status to fertility and disease susceptibility and suggests that mobilization of body reserves has the potential to be the key factor. High producing dairy cows need to mobilize body reserve to support their milk production. In early 1/3 of the lactation period, until energy intake catches up with the requirements, high producing cows enter a state of negative energy balance (NEB) losing excessive amounts of body condition. The terms "metabolic load" (ML) and "metabolic stress" (MS) are used to describe the effects of high production on dairy cows. The ML is defined as "the burden imposed by the synthesis and secretion of milk" and MS as "that amount of ML which cannot be sustained, such that some energetic processes, including those that maintain good fertility and general health, must be down regulated." The extent and type of down regulation would be indicative of the degree of MS. The term ML is often used to describe only the part of the total energetic burden of lactation that is met by mobilization of body reserves, i.e., ML is the same as NEB.

Selection for yield increases the demand for energy and also shifts the priority in partitioning of energy to support milk synthesis. It also increases feed intake but, with a genetic correlation between yield and feed intake ranging from 0.46 to 0.65 (11), the gap between energy input and output during early lactation is increasing. There is little evidence for more efficient digestion or utilization of metabolizable energy in high-genetic-merit cows; so, the correlated response to selection for yield is increased body-tissue mobilization and increased ML. Unfavourable genetic correlations were reported between NEB and interval to first luteal activity (21), incidences of digestive (milk fever, ketosis, displaced abomasum, diarrhoea and indigestion) and locomotive (laminitis, leg problems, hock problems, and inflamed thigh) problems (22), and average somatic cell count (23). These reports suggest that a major part of the decline in health and fertility observed over time is the result of the increased MS associated with the success of the genetic selection for milk yield.

Management practices that may also increase the gap between energy input and output are expected to increase the MS and negatively affect fertility-health-welfare complex. Strategies such as increased milking frequency or administration of BST should be carefully evaluated with respect to their impact on the welfare on modern dairy cow before being widely implemented. Another risk of increased MS would occur when cows are not in optimal condition at parturition. This risk may not be high in an intensive dairy system where high concentrate feeding is the norm. However, within European Community there is increased pressure towards more extensive and sustainable dairy production systems that maximizes the use of forages. The protocol for organic dairy farming in Sweden and other Nordic countries includes restrictions concerning concentrate feeding and stipulates a high proportion of dry matter intake from forages. The risk of cows not being able to recover the condition lost in early part of lactation prior to next calving is greater in these systems. This would especially be the case when the cows within such a system were those which had previously been intensively selected for milk production in intensive systems. Restoring adaptability may be required if organic dairy farming is to expand and prosper.

There is even greater concern that, if the single-goal genetic selection for milk production continues unchanged, the future welfare of the dairy cow may be severely compromised. Consideration of animal well-being in any livestock production system is a determining factor for its social acceptability and, therefore, its sustainability (24). The double-edged sword of genetic yield improvement and associated metabolic-stress symptoms raises important challenges for sustainability of the dairy industry.

Welfare assessment is based on establishing norm values for animal related parameters (health, fertility, longevity, behaviour, etc.). With selection, the genetics of the entire dairy population is continuously and cumulatively changing and the genetic improvement for production is accompanied by genetic deterioration of major welfare indicators. Unless this deterioration is stopped, appropriate norm values with long term relevance can never be established.

Selection for improved welfare in dairy cattle

In regard to breeding programs, The United Kingdom's Farm Animal Welfare Council (25) in its report on dairy cow welfare, recommended the following:

> *“Achievement of good welfare should be of paramount importance in breeding programs. Breeding companies should devote their efforts primarily to selection for health traits so as to reduce current levels of lameness, mastitis and infertility; selection for higher milk yield should follow only once these health issues have been addressed.”*

Broom (26), pointing out positive correlations between milk production and the major welfare problems in dairy cows (lameness, mastitis, impaired reproduction, inability to show normal behaviour), stated:

> *“Genetic selection has not taken adequate account of the adaptability and welfare of cows. Current trends towards ever greater milk production should not be continued unless it can be insured that welfare is good. It is important to the dairy industry that welfare problems should be addressed before there is widespread condemnation of breeding and management practices.”*

The major advantages of genetic improvement for any trait are that changes are cumulative, permanent, cost-effective and sustainable. This is true for the selection trait as well as for correlated responses on other traits. As pointed out, these very advantages have facilitated a rapid increase in milk yield per cow and detrimental effects on the welfare of the animals when breeding objectives have centred on production, with little attention given to fitness traits, such as fertility and health.

PRACTICAL IMPLICATIONS

The unfavourable genetic relationship between milk production and welfare indicators means that the most effective route to stop the decline or even improve welfare is by developing and adopting a selection index in which welfare related traits are included and appropriately weighted. With such an index the genetic progress for any of the traits considered is smaller then if selection is for a single trait, but overall economic response is greater than in single trait selection.

Animal welfare is often portrayed as opposed to animal production (27) and selecting for welfare traits is assumed to be uneconomical. This is not the case. The current breeding goal in the UK includes milk, fat and protein yields plus lifespan. These traits are combined into Profitable Lifetime Index, or £PLI. Calculations suggest that expansion of £PLI to include mastitis resistance and measures of fertility (calving interval) could increase economic response to selection by up to 80%, compared with selection for milk production alone (28). Selection on such an index could also halt the decline in fertility and mastitis resistance, compared with selection for milk production alone. This example illustrates that it should indeed be possible, through genetic selection to address the welfare without a reduction in profitability.

One example of a successful multitrait selection comes from Sweden and other Nordic countries where breeding goals have been formulated to include not only production but also fertility and health for the last 20 years. By implementing a more balanced selection goals it has been possible to limit the decline of fertility in SLB breed to about half of what has been observed in other Holstein populations and prevent it in SRB breed which is much less influenced by germplasm from outside Scandinavia. Resistance to mastitis follows similar trends.

Short term, all breeding organization should use available records to include fertility, health and longevity in the breeding goals. The selection method should by via a selection index in which greater emphasis should be placed on all fitness related traits relative to production traits.

Management strategies to reduce the negative effect of metabolic stress should be developed and implemented. For example, reduced fertility resulting from long anoestrous postpartum or low conception rate may be just consequences of cows coping with MS. Hormonal treatments used more and more, particularly in North America, to kick-start the reproductive cycle or to solve fertility problems may not be good solutions as they may further compromise cows' welfare by preventing them from using one of the few coping mechanisms left. Extended lactation is increasingly used to manage high yielding cows and it may represent a better strategy to manage low fertility in modern cows without additional welfare cost.

In order to improve the welfare and adaptability of dairy cows through genetic selection long term, the cooperation of breeding experts, geneticists, epidemiologists, nutritionists, ethologists and others concerned with animal welfare problems is required. Sustainable breeding goals aimed at improving fitness and tolerance to metabolic stress is necessary to prevent the decrease in the quality of life of the animals and, perhaps, enhance it. The effectiveness of a selection program to improve welfare should be enhanced if selection acts directly on causes of poor welfare and not only on its symptoms. To implement such a program, research is needed to clarify the relationship between production, NEB, MS and welfare indicators and to develop practical methods for measuring NEB and MS. This research should identify traits directly related to welfare status, such as NEB, body condition score, onset of cyclicity after calving, etc., and, ultimately, provide better selection tools to improve welfare status in dairy cows.

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