WHAT IS SUSTAINABLE FARM ANIMAL BREEDING?

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INTRODUCTION

Livestock production is important for the world’s food supply, and also contributes to other products such as fibre, skins, fertilizer, draught power. Breeding has been an important tool for adapting and increasing the efficiency of farm animal production in today’s agriculture. Breeding is, in effect, a technological development which reduces the consumption of inputs by genetically improving the animals’ production functions with each new generation (Groen, 2001). Depending on the breeding objectives, this implies changes in the biological processes and/or changes in the product. Breeding technology is based on knowledge (especially on breeding, genetics, reproduction and information technology), registration of individual animal data from breeding populations and the organization of the various tasks defined by the breeding programme.

The direction and effects of breeding work are of general political interest, since breeding efforts include and affect a series of factors which involve others than only livestock farmers. These interests include food safety, food security, satisfactory financial and social welfare of producers and consumers, as well as the demand for sustainable production systems in accordance with environmental and ethical standards (Groen, 2001). The aspect of animal welfare might also be an increasingly important issue in the present context (Bakken et al., 1998).

SUSTAINABLE MANAGEMENT OF FARM ANIMAL GENETIC RESOURCES

The ratification of the “UN Convention on Biodiversity” (1992) gave us a general policy document stating the requirements for the long-term management of biological resources in the different countries. As a result of this Convention, several other important political documents have been put forward, stating the direction for future developments. These include:

- Convention on Biodiversity and Agenda 21 (KBM & A21) 1992/93 with requirements of:
  - 1) Sustainable use and development,
  - 2) Conservation,
  - 3) Equitable distribution of profits from added value creation,
  - 4) National sovereignty of Genetic Resources (GR);

- FAO’s global strategy for farm animal genetic resources (1993);

- Declaration of the Nordic Heads of State on sustainable development (1998);

- Nordic Council of Ministers "Strategy for the Conservation of Genetic Resources in the Nordic Countries 2001 – 2004” (2000);
This shows that the several countries (among those the Nordic) have committed themselves to implement the management of genetic resources in accordance with the principles of the UN Convention on Biodiversity.

An important and decisive question for the farm animal sector is: What is sustainable breeding work? At present, the answer to this question is rather complex and has so far not been elaborated in detail. Inbreeding is an important factor for sustainable breeding efforts. New theories and knowledge about inbreeding have been developed (Woolliams and Thompson, 1994). These shed light on the effects of applying the recent methods for breeding-value appraisal (BLUP). Recent research has shown that the estimation of inbreeding based on classic formulas can result in a significant underestimation, when using parental selection and breeding-value appraisals based on the BLUP method (Woolliams et al., 1999 and Meuwissen and Woolliams, 2000). This situation thus includes most of the breeding programmes presently in operation. In certain cases, it has been shown that only 17 per cent of the selected sires in an applied, well-organized breeding programme contribute to the long-term genetic improvement. This is an indication of the inefficiency of BLUP selection, compared to methods that limit selection to those sires that actually contribute to a long-term genetic gain. The costs of rearing offspring from parents that definitely will not contribute to long-term genetic improvement are hidden costs of inbreeding resulting from BLUP selection (Meuwissen and Woolliams, 2000). The accumulation of inbreeding over a period of time will reduce genetic variation and therewith reduce the potential for future genetic improvement.

So far, the possibility of genetic immigration from other breeds has been an insurance against the accumulation of inbreeding. Immigration or upgrading has also contributed to a significant share of the genetic gain that some breeds so far have achieved. In addition, this has put an end to inbreeding and the effects thereof. However, with the gradual disappearance of breeds that can be used for genetic immigration, the problems associated with inbreeding will increase. The fact that genetic improvement increasingly needs to be based on selection within a breed, implies that breeding organizations and companies have to think of long term strategies and make new plans for the implementation of their breeding programmes.

The intensity of the use of individuals as parents and mating between related animals control a population parameter of major importance for inbreeding, defined as effective population size (N_e). When correctly estimating this parameter, the effective population sizes for most current breeding programmes will presumably be surprisingly small. The renewal of breeding programmes during the past decades tends to reduce effective population size. This is due to several factors (Meuwissen and Woolliams, 2000), such as:

- Improvement of reproductive technologies such as artificial sperm transfer and MOET (Multiple Ovulation and Embryo Transfer), combined with deep-freezing. This results in fewer sires and dams being used as parents for the following generation.
- Breeding-value appraisals based on BLUP have led to large sibling groups achieving the same breeding value, and the probability of many of the same family being selected as parents for the following generation.
Short generation intervals by using young parent animals result in: 1) Fewer selected animals per generation, 2) Increased duration of generation interval, 3) Increased number of young animals selected as parents. Several of the new breeding technologies are expensive, and can only be used in relatively small breeding nuclei.

In sum, these developments will lead to a considerable increase in inbreeding, which in the long run will lead to reduced genetic diversity and non-sustainable breeding efforts.

As a result of the use of more intensive tools for the maximization of genetic improvement, theories have been developed which in many ways can reduce inbreeding, while at the same time maintaining the effect of selection close to a maximum (Meuwissen and Woolliams, 2000). The breeding organizations should implement such tools in their practical breeding efforts in order to reduce inbreeding and thus maintain genetic diversity also for the future. In all closed breeding programmes, one has to balance between selection and inbreeding, or between short and long term genetic gain. Breeding programmes that maximize short-term genetic improvement by utilizing all available relationship information result in increased degrees of inbreeding, reduced genetic variation and reduced accumulation of mutational genetic variance; which in turn reduces the long-term genetic improvement and fitness. In order to maintain the long-term genetic variance of a population, the degree of inbreeding must be limited to an acceptable level.

WHICH BREEDING OBJECTIVES CONTRIBUTE TO SUSTAINABLE BREEDING?
The selection for individual traits in a breeding programme will maximize the genetic gain for the trait in question, and if the breeding-value appraisal is based on all related animals through BLUP, inbreeding will also increase maximally. Traits that are negatively correlated to the trait being selected will also change considerably in a negative direction. This means that stringent selection for an individual trait results in significant genetic gains for that trait. However, several important health and reproductive traits are negatively correlated with production traits, such as milk performance (Rauw et al., 1998). The effect of a high selection pressure on milk performance will thus lead to an increasing deterioration of health and reproduction traits over a period of time. Since these are "vital" traits for the maintenance of a functional individual for a production system, the breed will in a short-medium term perspective become less functional, and in the long run accumulate a double dose of negative genes which can be detrimental for the recruitment of vigorous and functional individuals. This illustrates how important it is to define breeding objectives in order to ensure safe and consumer-oriented food production in a long-term perspective.

LOSS OF BREEDS IN SUSTAINABLE MANAGEMENT OF GENETIC RESOURCES
Worldwide, as many as 30 per cent of all farm animal breeds are at risk and could become extinct in the near future. The FAO assumes that 50 per cent of the genetic variation can be ascribed to diversity between breeds. Thus, loss of breeds will reduce the diversity within a given farm animal species.
Presently, we lack sufficient knowledge for the evaluation of breeds with regard to their potential value for future use. It is also difficult to predict changes due to future developments of environmental factors and other external conditions. Livestock production that is closely tied to climatic and other natural conditions will to a greater degree depend on the future development of such external conditions. It can thus be assumed that it is especially important to maintain genetic diversity for those species used in such “nature-dependent” production forms, ensuring that populations can be adapted to future alterations of the environmental conditions. On the other hand, maintaining genetic diversity seems less important in the short term for species used in isolated, climate-regulated production systems. Such species are just as dependent on genetic variation in order to achieve genetic improvements as any other species. It has furthermore been shown that genetic immigration is an effective measure to arrest accumulated inbreeding. It is thus important to have access to alternative, independent breeds in the future. The maintenance of a sufficient number of alternative farm animal breeds is an important insurance for future genetic diversity. It should be pointed out that immigration may also have negative effects, especially when breeds are adapted to specific environmental production conditions. At present, the farming industry still focuses greatly on performance and short-term economic gains, and the general trend seems to be going in quite the opposite direction of such goals as maintaining genetic diversity and long term adaption of breeds to specific production systems. The challenges regarding the establishment of a sustainable management of farm animal genetic resources are complex and require cooperation among politics, R&D-environments and the breeding industries that take on responsibility for the maintenance and use of farm animal genetic diversity as a long-term resource.

CONCLUSIONS
In order to facilitate the development of a sustainable genetic resource management, the following measures are necessary:

1. A political framework that stimulates and/or requires the maintenance of genetic diversity, including the allocation of funds for the generation of knowledge that can form the basis for a sustainable development.
2. Research environments need to focus on R&D activities aimed at promoting a sustainable development.
3. The commercial sector and breeding organizations must integrate new knowledge and stimulate the continued development of know-how aimed at creating a sustainable development, for the benefit of producers, consumers and society.

REFERENCES