Sustainability of dairy cattle breeding systems utilising artificial insemination in less developed countries - examples of problems and prospects

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Introduction

In the last two decades total milk production has almost doubled while the heads of cattle have increased by 28 percent in developing countries (FAO, 1999). There is a large variation among regions. The Far East region shows the sharpest production increase, also per capita, while Africa and the Near East show the largest increase in heads of cattle but a continuous decrease in per capita supply of milk. Thus, improved milk production is very important in many of the lesser-developed countries.

The substantially improved yields are due to increased cattle numbers but also improved management and genetic potential of the cattle. In many tropical and subtropical areas the introduction of exotic breeds such as Friesian, Jersey, Guernsey, Ayrshire and Brown Swiss by the use of artificial insemination (AI), mainly through cross-breeding and in certain areas with less climatic stress and good management also as pure-breeds, has led to increased production. However, it is a well-known fact that the initially very promising results obtained in the F_1-generation through cross-breeding in the tropics are usually not as good in the next few generations if one continues to cross with an exotic breed. Thus, long-term breeding strategies are important for sustainable and continuous improvement of production and cattle populations, be it indigenous, exotic or cross-bred cattle.

Strategies and possibilities of successfully conserving indigenous cattle breeds have been examined by FAO and continuous improvement of the indigenous breeds has been stressed as a necessity for future survival as commercial breeds (FAO, 1992).

The purpose of the present paper is to review some cases as examples of breeding programmes utilising AI in developing countries and summarise principally important problems and prospects for sustainable breeding systems.

Cases

Four different cases are reviewed. Two represent indigenous breeds considered to be of relatively high genetic potential and two exemplify the utilisation of exotic dairy breeds in tropical or subtropical conditions.

The Sahiwal breed in Pakistan and Kenya

The Sahiwal breed originated in the central and southern parts of Punjab, Pakistan, which is characterised by a subtropical and arid climate. The dominating position as cattle breed in this area throughout the last century started to change with changed production systems in agriculture and was further accelerated by the introduction of AI and cross-breeding with temperate dairy breeds. Crosses with Sahiwal have been extremely successful in the prevailing conditions and have been much more in demand by farmers than the pure-breed. While the average lactation yield is commonly reported to be 1 500-2 000 kg for the pure-bred Sahiwal, crosses with Holsteins produce 2 500-3 000 kg (Khan *et al.*, 1989).

The rapid decline in the pure Sahiwal breed, mainly due to indiscriminate cross-breeding has led to an estimated total number of about 10 000 cows in Pakistan (Hodges, 1987), out of which 2 000 breeding females can be found in recorded Government herds, the majority found in only three herds. Another 2 000 cows are estimated to be kept in India and 2 500 in Kenya. The latter originate from imports starting in 1939 from India and later from Pakistan. Very little exchange of genetic material has taken place between the different countries in the last three to four decades. AI is used to some extent in all three countries to maintain the pure Sahiwals. A thoroughly designed breeding programme has been applied for a long time for the Kenyan population in Naivasha, while progeny testing programmes were launched already 20 years ago in both Pakistan and India.

Besides a relatively high potential for milk production in harsh conditions, the Sahiwals today are characterised by rather few milk let-down problems and good beef characteristics. These traits have led to an international demand for semen and Sahiwal-crosses in tropical and subtropical countries. Several synthetic breeds have also evolved from the use of Sahiwal in crosses with *Bos taurus*, for example, Jamaica Hope, Karan Swiss (India) and AMZ and AFS (both Australia).

Results from retrospective analyses of the Sahiwals in Pakistan were reported by Dahlin (1998) as follows:

- most Sahiwal herds had been kept rather closed and inbreeding co-efficients were, on average 5 percent, in some farms even more than 10 percent. The effective population size was estimated at about 30 animals only in recorded herds;
- average milk yield was 1 400-1 650 kg in lactations one to three with a C.V. of 43-45 percent. A large phenotypic variation over the years was observed;
- estimates of heritability for milk yield were 0.14-0.20 with as large an additive genetic variation (C.V.) as 12-16 percent;
- estimated genetic trend was close to zero and many bulls with large progeny groups had negative breeding values indicating the application of inadequate selection criteria.

Some main results from genetic studies of the well-known Sahiwal herd at Naivasha, Kenya, covering a 20-year period (1964-83), were reported by Wakhungu *et al*. (1991) as follows:

- average lactation milk yield was 1 662 kg with a C.V. of 34 percent;
- differences in average production within the herd amounted to more than 500 kg between years;
- heritability for milk yield was estimated to 0.27 but an annual genetic trend of only +3.65 kg revealed inefficient breeding value estimations and / or selection procedures.

Problems

1. As a result of indiscriminate cross-breeding by inseminating Sahiwal females with exotic breeds in Pakistan, the main problem of the breed is its small and declining population size. The lack of gene flow between countries, as well as between the nucleus herds, contributed to a rather high degree of inbreeding.

2. AI has mainly been used for cross-breeding but not as efficiently to develop the breed itself. Fluctuating environmental conditions call for more efficient methods for genetic evaluations and selection.

3. Despite the fact that AI has also been applied to Sahiwal bulls, the international demand for semen has not been met.

Prospects
Due to its high potential in harsh conditions, the Sahiwal breed was soon pointed out by FAO to be given high priority for conservation by management, in order to develop the breed for further global use. Important pre-conditions are that all countries seem to practice good recording routines as a basis for genetic evaluations and selection. Also the necessary infrastructure and some competence among people to conduct a breeding programme seem to exist. Thus, a conservation scheme could follow the normal procedure of developing a breeding programme. However, in this case the cooperation between countries, both for exchange of germ plasm and for future joint genetic evaluations, needs to be developed.

Successful cooperation between countries, in order to make efficient use of the few Sahiwals available in breeding herds, is essential for the survival of the breed. This includes the effective use of AI and a BLUP-Animal Model for genetic evaluations, in order to account for the large environmental effects, as well as optimum use of all information. Such a development would greatly enhance the possibilities for efficient selection of bulls for pure-breeding, as well as for production of cross-breds to the benefit of much larger tropical areas of the world than is presently the case.

2. The Kenana-case of Sudan

The Kenana breed is a true Zebu of Sudan with the main habitat in the hot, arid zones of the central parts of Sudan, south of Khartoum between the Blue and White Niles. In an FAO study, the total population was estimated at about 3 million (Cunningham, 1987). The production systems range from pure nomadic to more settled systems for milk production in urban areas.

The Kenana breed has the reputation of being one of the most productive indigenous African milk breeds. While field data are hardly to be found, lactation records from experimental stations on average show yields of about 1 500 kg (Wilson *et al.*, 1987; Ageeb & Hillers, 1991). Mature cows weigh around 400 kg.

Since AI was introduced on a larger scale in Sudan in 1976, only imported semen of the Holstein breed was made available to the farmers during a ten year period. Progressive farmers joined the AI-scheme and were happy to note a considerable increase in production from their F_1-animals, which seemed to function well in the prevailing environmental conditions.

Problems
Results from experimental stations have shown, as could be expected, that ¾ and 7/8 Holstein crosses did not keep up with the F_1 animals, but had problems with resistance to diseases and suffered from environmental

stress. However, the AI-scheme did not for some time offer any long-term breeding strategy but just crossing with imported semen. Progressive farmers had no alternative and would gradually experience poorer results if staying with the original AI-scheme.

The development of more intensive settled production systems near the urban areas of Sudan, results from a great need to improve the food supply. Such a demand called for the use of exotic breeds in cross-breeding with the Kenana. However, the lack of a long-term strategy for cross-breeding became a threat to the breed. As a result of such a situation, neither the pure-breeding nor the cross-breeding programme would be sustainable.

Prospects

The FAO-study referred to (Cunningham, 1987) considered the high potential of the Kenana breed and its crosses for milk production in rather stressful environmental conditions and in an area with a large human population. Thus, the pure Kenana breed needed to be conserved by management.

In order to establish a sustainable system, an open nucleus breeding programme was suggested to be run at one of the experimental stations with about 200 pure-bred cows. About ten percent of the cows should be recruited annually among good females in village herds. The aim would be to further develop the genetic potential for milk production including good fertility of the pure-breed. Thereby, high quality bulls of the pure-bred, as well as cross-bred bulls, could be guaranteed available for both AI and natural service.

As a result of local semen production, cross-bred bulls were introduced in 1986 and also from 1990 locally bred bulls of the exotic Holstein and Jersey breeds and from the indigenous Kenana and Butana breeds (Mohammed Osman Hamid, 1999).

By establishing a nucleus herd for the Kenana breed as the basis for the conservation plan at an experimental station, and another one for cross-bred animals, a sufficient infrastructure and personal competence to conduct a sustainable breeding programme could be guaranteed. This has resulted in a semen production system supporting both a long-term conservation policy and the needs of the farmers to have commercially viable and well adapted cattle.

3. The West Indies-case of exotic breeds

This case concerns a small Caribbean island which is one of the most heavily populated in the world. Agriculture is dominated by its sugar industry. Dairy and beef products are in shortage and it is a Government policy to diversify the agricultural sector, for example, by more animal production.

The stress to animals of the tropical environment is to some extent alleviated by the maritime climate. However, tick-born diseases are common and require appropriate management controls.

The population of 3 500 head of dairy cows is dominated by exotic breeds, mainly Holstein (70 percent), Jersey and Guernsey. A Governmental AI service is available with domestic semen production from a few bulls of the breeds mentioned. The Government questioned whether it would be possible to continue with the pure exotic breeds due to the disease situation and climatic stress or if an introduction of Zebu crosses would be necessary. A shortage of females for herd replacements had been noted and was assumed to be due to poor reproduction as a result of heat stress and lack of resistance to diseases.

Survey of status and problems

The need to improve production, totally and per cow, led to a survey on production and reproduction results with analyses of records made available from individual farms (Philipsson, 1981). Some important findings were:

- exotic breeds were producing rather well (Holsteins: 3 500 kg; Jersey and Guernsey: 3 000 kg per lactation);
- calving intervals were 15 months and reproduction problems occurred due to tick-born diseases and an unreliable AI-service without appropriate supervision;
- officially reported non-return statistics indicated high fertility, but this was explained by the use of village bulls when AI failed;
- low turn-over rate of AI-bulls causing inbreeding in the commercial herds;
- the farmers had no influence on the quality and kind of AI service offered to them.

Prospects

This case clearly demonstrated fairly good production of exotic breeds, but also the need to apply reasonable management tools for tick control, rather than bringing in Zebu-genes for increased resistance to diseases and climatic stress.

Also the shape-up of a mismanaged AI-scheme, both technically and genetically, could improve reproduction results, without the use of a sophisticated ET-programme, which was offered by a donor country envisaged to alleviate some shortage of replacement heifers.

If farmers were given more responsibility for the services requested, these activities would be more efficiently carried out provided Government policies changed and training was offered to farmers and those working with the AI-service. Importation of semen would be less costly than the domestic semen production as exotic breeds seem to be suitable for this environment.

The Kenya-case of a modern AI breeding programme

The climate of the central parts of Kenya allows a rather advanced milk production system, even with pure exotic breeds such as Friesian, Ayrshire, Guernsey and Jersey, when a reasonable management standard is kept. Milk-recording and AI-schemes were applied early in Kenya as a means of continuously improving production. For example the average production of recorded Friesian herds amounts to 3 500 kg milk (Rege, 1991a), while some reach an annual production per cow of 5 000-6 000 kg.

After the country's independence in the mid sixties, the number of small-scale producers increased tremendously and so did the demand for semen. The cow population largely became a product of up-grading the indigenous Zebu cattle, using semen of exotic dairy breeds. The demand for semen was initially covered by bulls being imported from various countries. The AI service expanded to as much as about 0.5 million inseminations per year in the early seventies. Due to high costs of bull and semen importation and the possibilities of a genotype x environment interaction, the domestic recruitment of bulls was started. A specially designed progeny testing programme (PTP) was launched in 1969 followed by a contract mating scheme (CMS), in order to use imported semen of top bulls with superior local dams and bring the sons produced into the AI-stud. The whole AI-scheme was initially set up by experts from a number of donor countries, which further supported it while it was run by the Kenyans as a Government service to the farmers.

The overall effect has been tremendous as regards increased milk production from large as well as small-scale producers. The increased production by up-graded cows was, for example, a key to the school lunches with milk offered in Nairobi. The *planned* breeding programme was indeed as advanced as in any developed country. Thus, the same infrastructure, equipment, competence of staff and other resources was assumed to be available. However, in reality that was not the situation.

Problems

An analysis of 20 years of experience and results of the AI and breeding scheme in Kenya was performed by Philipsson *et al*. (1989) and has been further analysed in some detail by Rege (1991a and b). Some main findings were:

1. The different parts of the breeding programme (AI and milk-recording) were managed by different ministry departments and were totally disintegrated. They lacked the organization with farmer influence and leadership needed, in order to comply with the objectives outlined for the breeding programme.

2. The participation rate of milk-recording gradually declined due to lack of feedback information to the farmers. The PTP- and the CMS-schemes were severely affected, thus resulting in continuously fewer bulls being recruited for AI. The age structure of the AI bulls became unfavourable and semen production decreased, so that the demands could not be met.

3. Progeny test results obtained with a herd-mate-comparison method (HMC), were usually not available until after the death of the bulls.

4. Genetic studies revealed good genetic progress during the first ten years and a decline thereafter. The HMC-results were poorly correlated with later produced BLUP-values of the bulls (Rege, 1991b).

5. Breeding goals and selection practices were too influenced by international standards favouring big cows and of conservative breed societies judging cows at shows, rather than the limitations of the Kenyan markets and environments. Thus, unrealistic requirements of possible bull dams kept the recruitment of young bulls low.

6. The field service was too dependent on the effective transportation of AI technicians. As a Government service it did not function properly.

As a whole the programme was too sophisticated at the available level of infrastructure and competence to run the scheme. The split responsibilities of AI (Veterinary Department of the Ministry), recording (Animal Production Division) and herd books (farmer organizations) was detrimental to the understanding and implementation of a fully integrated breeding programme.

Prospects
Although the very ambitious breeding plan collapsed, no doubt the AI service as such, offering bulls of various breeds to large- as well as small-scale farmers, proved its value in a process of up-grading local cattle for better production and to maintain pure exotic breeds in areas with a good environment.

The future existence of the AI field service relies on the possibilities of privatising it into farmer cooperatives. Such a move started in 1990. Similar privatisation seems also to be a necessity for the AI-stud, which needs to integrate its selection schemes with recording and evaluation of the animals.

As regards the selection scheme, a much simpler approach should be taken with just a young bull programme, based on imported bull sire semen used with superior local cows, but without a complicated and demanding progeny testing scheme. Such a programme could be gradually developed as the level of infrastructure and competence to run the programme increases.

General findings affecting the sustainability of breeding programmes

The problems being mentioned from these four examples are of a very broad nature. However, some experiences are commonly noted and therefore seem to be of strategic importance. The problems found could rather easily be divided into matters regarding:

- Breeding objectives and utilisation of genetic resources;
- Methodological, technical and operational issues;
- Policy and organizational aspects.

These areas are all equally important, if one really aims at developing the genetic resources available. In analysing real life cases, as those above, it could first of all be noted that the breeding programmes applied have seldom emerged from a well thought of theoretical plan, except for the Kenya-case, but were merely the result of implementing new technologies, for example, AI, without much of a long-term strategy.

Breeding objectives and utilisation of genetic resources

Commonly faced problems regarding *utilisation of genetic resources* concern the neglect of the value of many indigenous breeds and the necessity to conserve and develop them. The real threat to such breeds comes when cross-breeding through AI with exotic breeds shows such good results in the short-term that most producers want to benefit from cross-breeding and nobody takes the responsibility for the pure indigenous breed and its future development.

The need to apply long-term strategies in cross-breeding programmes is apparent. Too often what happens in the long run with both the pure-breed and the cross-breds in second and third generations is neglected. The *choice of breeds* and *definition of breeding goals* are matters that need serious consideration in relation to the prevailing environmental conditions. Especially in areas of serious environmental constraints, it may not even be advisable to produce any F_1 cows, but just cross-bred bulls for slower up-grading of the cattle stock.

The questions related to *breeding objectives* concern, for example, desired size of the cow, single-purpose versus double- or triple-purpose animals and the need to combine production, reproduction and health traits in order to consider adaptability in the breeding objectives. Such questions are quite important to clarify, before embarking on a semen importation programme from an exotic breed in relation to national goals and environmental and management constraints.

Methodological, technical and operational issues

Any sustainable breeding programme requires development and improvement of the breed in order to *ensure its future competitiveness*. This will require that aspects of inbreeding and relationships can be kept under control, especially in breeds with a small population and where the genetically superior animals can be identified. In countries with harsh climates, the environmental conditions might fluctuate considerably. This means that rather *efficient statistical methods for genetic evaluation* are needed, so that non-genetic effects can be removed and that optimum use can be made of, for example, the pedigree information. Practical applications of BLUP-animal models have shown their value in such circumstances.

For small breeds, *nucleus breeding schemes* should be preferred where the resources available can be concentrated on a single or a few herds. Good evaluation methods are still needed, but the organization of recording and handling of data is rather uncomplicated.

For larger breeds where AI is readily available, progeny testing may be an alternative, but considering the resources it takes it seems rather questionable in most cases. A much simpler approach would be the application of just a *young bull AI-programme* with a quick turn-over rate of bulls. Such a programme could either be linked to nucleus herds of a domestic breed, or to the use of imported semen of continuously selected top bulls with well-known characteristics, used as bull sires with locally identified superior cows to produce the young bulls. However, progeny testing has too often been considered a compulsory, almost “magic”, component of a breeding programme, even if it has no relevance. This has been an educational problem since simpler and more relevant methods are often prevented from being applied.

Policy and organisational issues

The policy and organisational questions greatly concern the lack of knowledge or understanding of the full concepts of an *integrated breeding programme*. Not only must the long-term genetic strategies be carefully chosen, but also an integrated set of activities with harmonised decision-making procedures in order to achieve the defined breeding goals is needed.

As farmer participation is essential it is equally essential that *farmers influence* the establishment of the breeding objectives and services rendered. The development of *livestock recording schemes* is a necessary pre-requisite for any genetic evaluation of data to be used for selection purposes. It is important that such schemes are developed to fit the most essential purposes and could often be kept quite simple.

The strategic importance of the *educational components* of any development programme must be stressed. The competence level of the staff of the developing country determines the level of advancement of the programme to be implemented. Increased personal competence and its continuity in the programme, adds to the possibilities of achieving the aims of the programme. Even more important, it leads to a better position of the developing country to choose its own strategies and to better evaluate the various kinds of offers that possible donors, experts, semen agents, etc. are presenting.

Finally, a strategic point of any development programme, involving support from some kind of aid agency, is that it must include follow-up activities on a long-term basis. These should involve advisory services as well as some research for analyses and evaluations of results so far obtained, revision of future strategies and a human capacity building component.

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