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# Genetic Improvement for Milk and Meat Production in the Tropics

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# GENETIC IMPROVEMENT FOR MILK AND MEAT PRODUCTION IN THE TROPICS

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## INTRODUCTION

Theoretical and practical ways to improve meat and milk production in the tropics by selection within local Bos indicus breeds, within Bos taurus x Bos indicus composite populations, upgrading of Bos indicus with Bos taurus breeds and through different crossbreeding programs have been discussed by various authors and summarized by Mason and Buvanendran (1982), Gregory et al. (1982) and Hickman (1979). Only few publications (Auriol, 1984; Chacko et al., 1985; Donegan and Roberts, 1984) exist on successful programs but numerous reports in developing agencies (FAO, 1985; SDC, 1985) indicate that many possibilities have been exploited and that various breeding programs in the tropics resulted in a considerable improvement of meat and/or milk production. The problem is that many reports are based on small numbers of animals kept under various conditions and observed over a short period. Main reasons for the realized improvement are generally crossbreeding programs which combine the adaptability of Bos indicus breeds to harsh environments, the production potential of the Bos taurus breeds and lead to large heterosis effects characteristic for Bos taurus x Bos indicus crosses. The problem of the appropriate breeding policy, the optimum Bos taurus inheritance in tropical cattle populations, the suitability of different Bos taurus breeds to be crossed with local zebu breeds have been discussed in a large number of reports (FAO, 1984; FAO, 1985; SDC, 1985) and publications, for example Meyn and Wilkins (1974, 1975), Mason (1974), Cunningham (1979, 1981) Frisch and Vercoe (1982), Hickman (1981), Cartwright (1982), Syrstad (1985) and many others. The main conclusion is that Bos taurus inheritance should not exceed 50 to 75 %. In other words, the existence of genotype x environment interactions is generally accepted. There is no consensus about breeding policies and merits of different Bos taurus breeds for crossbreeding programs in the tropics.

The application of new techniques like artificial insemination, embryo transfer and eventually transgenic animals open new ways to improve milk and meat production in the tropics. For consultants involved in practical breeding programs, the choice of the appropriate breeding strategy will not become easier. In addition, more than in temperate countries, animal production in the tropics is generally not just a business, but rather part of a socio-economical and ecological complex.

In relation to the large number of contributions on possible breeding policies, there are only a few scientific publications in which tropical breeding programs are analyzed in retrospect (Acharya and Lush, 1968; Franklin et al., 1976; Baker and Morris, 1984).

The experience is that, in most situations, breeding strategies applied in temperate countries cannot be transferred to tropical conditions without modifications. The main reasons are:

- it is not possible to simply transfer Bos taurus breeds to the tropics because of climatic and health problems,
- the breeding objectives for cattle in the tropics are often not identical with those in temperate countries and there is limited experience in selecting for these objectives,
- the infrastructure required for data recording and processing is often not available,
- due to a large number of more or less planned crossbreeding programs, a high proportion of the tropical cattle population consists of crossbred animals, and there is little experience in selecting within composites,
- genetic and physiological aspects in improvement of specific traits are not necessarily similar in the tropics as in temperate zones.

The purpose of this paper is to discuss some problems related to breeding programs for meat and/or milk production in the tropics, rather than results of well designed experiments. A few examples will be chosen to illustrate specific aspects. We chose them from our own involvement in tropical breeding programs or from well documented reports. Main emphasis is given to developing countries.

## Transfer of Bos taurus to the tropics for specialized milk or beef production

Bos taurus breeds have been transferred to the tropics since the beginning of the colonial period and, in some cases, kept as purebred populations for many generations to be utilized for milk and/or meat production only or for crossbreeding programs. The European origin of the Criollo cattle of Latin America, for example, is well known (Salazar and Cardozo, 1981). The imported breed was generally connected with the nationality of the settlers and, after the colonial period, with the nation involved in the bilateral developing program (Alstrom, 1977). We estimate that in the last years, 20'000 to 40'000 pregnant heifers have been exported annually from European and North American countries to the tropics. Considering also the exported semen doses, the gene transfer of Bos taurus to the tropics is considerable.

The majority of the imported herds are kept in a favourable natural or artificial environment. We chose the following two examples for illustration. Near Medellin, in the Colombian highlands, the mean 305 days lactation yield of purebred registered Holstein Friesian cows kept on pasture and fed with additional concentrate is 5097 kg (Montoya, 1983). At Digada, in the United Arab Emirates, Holstein Friesian cows realized a 305 lactation milk yield of 4570 kg in the second lactation (Ansell, 1976). In the first case, the natural environment was favourable, in the second case, the unfavourable natural environment was compensated by high inputs in infrastructure, management and feeding.

The situation is different in other locations where the climate, for example, is semiarid and the seasonal fluctuations in temperature, humidity, fodder quantity and quality are large and cannot be eliminated through high inputs. The perfor-

ce of 400 Bos taurus heifers imported between 1974 and 1978 to the Bolivian lands (Santa Cruz de la Sierra) have been analyzed by Kropf and Hautle (1981) partly by Wilkins et al. (1979). The breeds involved were Brown Swiss (imted from the USA), Braunvieh (imported from Switzerland) and Holstein Frien (imported from Argentina with North American ascendants). The 305 days lacion yields in the second lactation for the different groups were: Holstein: 3 kg (n = 192); Brown Swiss: 2804 kg (n = 70; 58 % of the performance reed by contemporaries in the USA); Braunvieh: 2813 kg (n = 106; 77 % of the rformance realized by contemporaries in Switzerland). These results show that der conditions suitable for ranching and beef production, milk yields of Bos urus do not reach European or North American standards without high inputs. rthermore, they indicate that it is difficult to predict the production level a breed at a specific location in the tropics based on the performance in the untry of origin. This is true also for the breeding value of sires. Different thors have shown that the correlation between the breeding value of sires rough progeny testing in temperate and in tropical countries is low. Buvanenan and Petersen (1980) found a correlation of 0.08 between the breeding value Red Danish sires based on their daughters in Denmark and their daughters in i Lanka. The heifers imported to Bolivia had to be inoculated with Anaplasmois marginale, Babesia bigemina and Babesia argentina. The experience has shown at their calves, and also the calves from females born in Bolivia, had to be oculated between 3 and 6 months of age. This means that the rearing costs for ch animals are high with regard to daily milk yield which is only about 8.5 9.5 kg per day and cow in lactation (SDC, 1985). Only higher and expensive puts would allow to increase significantly this production level. Economically, ansfers of Bos taurus to the tropics can only be justified by high milk prices. t is well known that in most tropical countries the ratio milk to meat price s increased in the last decade. For this reason Bos taurus dairy herds (mainly olstein Friesian) are built up in tropical countries. It is possible that embryo ansfer with sexing of embryos will allow to build up large female herds in a hort time and reduce the costs of such operations.

ilk yields and other performances of Bos taurus breeds kept in the tropics ave been summarized by Nagarcenkar (1982) and Pearson de Vaccaro (1973, 1974, 975). The observed variation in milk yields between different breeds kept at he same location or between herds of the same breed kept in different locations re large and are due to differences in environmental conditions or to genotype environment interactions.

he advantage of importing temperate zone cattle to the tropics is the access superior genetic animals for production traits without running a selection rogram.

he transfer of Bos taurus breeds to be kept as purebred populations for beef roduction in the tropics is of minor importance. In the tropics, most beef herds re Bos indicus breeds or their crosses with Bos taurus. The low meat prices and he fact that actually only little attention is given to meat quality will not ontribute to promote the number of purebred Bos taurus beef herds in the tropics in the next years.

t can be concluded that Bos taurus dairy breeds can be kept with success in he tropics if a series of conditions are fulfilled: natural or artificial favourable environment,feeding and a good management. The direct impact of impor-

ted animals (production of crossbreds excluded) on the national milk production is low (Hickman, 1983). If crossbreds are produced with purebred Bos taurus bulls, the impact can be considerable (Chacko et al., 1985), but actually the production of F1 Bos taurus x Bos indicus females can be achieved by semen importation.

## Breeding objectives in the tropics

In temperate countries, the breeding objectives are clearly defined, at least from a theoretical point of view: specialized dairy or beef breeds or dual purpose breeds with more or less emphasis on milk or beef traits depending on the economical circumstances. Hoffmann et al. (1982) showed the relative importance of beef and milk production for a dual purpose breed under given economical conditions. More recently, Cunningham and Mulvihill (1985) demonstrated that the economic weights for milk and dairy traits under a quota system for milk are different for different quota systems and derived the optimum breeding objective for each situation. Mason and Buvanendran (1982) examined breeding objectives for specialized milk or meat production in the tropics and discussed the traits to be selected for in both situations. It has to be noticed that draught is an important trait for tropical cattle besides meat and milk production, principally in Asia and Africa, and that in the tropics more emphasis has to be put on the adaptability of the animals to the environment and to the management practices. For specialized dairy and beef breeds, the breeding objectives are similar for tropical and temperate countries. But due to differences in environment, management and infrastructure, more emphasis is to be put on the adaptability and the breeding method can differ.

The situation is not the same for dual purpose breeds. In a temperate dual purpose breed, the calves are weaned at birth and the cow milked like specialized dairy cows. In most tropical regions, the cow suckles her calf and is milked. Such a system is the dairy ranching which is applied in parts of South America and was described by Kropf et al. (1983). In this system, the cows are milked once a day in the morning, suckle their calf during the day and are separated from their offspring during the night. The cows are kept only on pasture and are fed with little concentrate. The recorded milk yield is equal to the total milk yield less calf consumption: i.e. the saleable milk production. Therefore, milk production potential affects growth rate of the calf and saleable milk production of the cows. As shown by Hagnauer and Kropf (1978), the weight gain from birth to weaning (37 weeks) in a traditional beef production system is superior for calves with a Bos taurus x Bos indicus crossbred dam than for those with a purebred Bos indicus dam (the preweaning weight gain of calves with a Brahman dam is 150 kg, that of calves with a crossbred Bos taurus x Bos indicus dam 156 to 163 kg depending on the Bos taurus breed). On the same farm, in a dairy ranching system (Kropf et al., 1983), the purebred Bos indicus dams wean the heaviest calves but produce less saleable milk than Bos taurus x Bos indicus crossbred dams (the saleable milk production of Brahman cows is 473 kg and the total preweaning weight gain of their calves 120 kg; corresponding values for 1/2 Brown Swiss x 1/2 Brahman for example are 972 kg and 106 kg). It is evident that the maternal ability decreases and the milk production potential increases with increasing Bos taurus inheritance or, as suggested, with increasing milk production potential even within Bos indicus breeds. In such a situation, the breeding objective should consist in selecting based on an index including saleable milk production and preweaning weight gain. The economic weights for both traits are

not easy to derive as too high saleable milk yields require more inputs or, if cows are milked without considering that they have to suckle their calf, lead to higher preweaning losses. For this reason, farmers often adopt a selection procedure with independent culling levels for both traits. These levels can be adapted to the market conditions or to the situation of the individual farmer. Up to nowadays, no large scale, systematic and long-term breeding program is running for this type of dual purpose cattle in the tropics.

In some cases, cows which suckle their calf are selected like dairy cows and the calf consumption is neglected. This method may be suitable for specific conditions but various factors can affect the estimation of the total milk yield. In Kerala (Chacko et al., 1985), the value of a female calf is higher than that of a male one. For this reason, the saleable milk production per lactation of a cow with a male calf is about 60 kg (4 %) superior to that of a cow with a female calf. The reason is that breeders allow female calves to suck their dam longer than males. In such a situation, selection on milk yield can be achieved only if saleable milk yields are corrected for this effect.

In temperate countries, selection for adaptability is not so important as in the tropics. In tropical countries, there is a natural selection for resistance to tropical diseases, ticks and for tolerance of harsh and changing climatic conditions. If animals are tested in the environment in which their offsprings have to be kept, a selection for a specific trait leads to a selection for adaptability. Frisch and Vercoe (1978, 1982) have shown the importance of genotype x environment interaction in growth rate: on a high plane of nutrition selection on growth rate is the result of an increase in appetite, on a low plane of nutrition the increase of growth rate by selection is due to a reduction in maintenance requirements and under no tick control to an improvement of the tick resistance. The possibility to select for tick resistance has been presented by Seifert (1971) and is applied in the selection program of the AMZ (Australian Milking Zebu) as described by Donegan and Roberts (1984). The young bulls are first tested for heat tolerance in a climatic chamber and in a second step on tick resistance by artificial infection with tick larvae determining the proportion surviving to the adult age. Only bulls which show good heat tolerance and tick resistance are progeny tested for milk yield.

These examples show that breeding objectives for specialized dairy and beef breeds are quite similar in tropical and temperate countries. The breeding objectives for dual purpose tropical cattle are not so clearly defined. Adaptability is an important trait and has to be tested artificially if animals are not proven in the environment in which their offsprings will be kept.

## Recording systems

An efficient recording system is a condition for the success of a breeding program. The possibilities and the problem of recording systems for milk and beef traits have been discussed in many reports (FAO, 1985; SDC, 1985) and by Mason and Buvanendran (1982). In many tropical countries, sophisticated systems suitable for temperate countries can be applied. The problem is different for programs run in developing countries under difficult conditions. If a breeder involved in such a field program tries to record all traits discussed by Mason and Buvanendran (1982), he will have some practical difficulties. An example for an integrated recording system has been presented by Poivey (1985). Brumby and Trail (1985) showed the possibilities to record, handle and store data and make them

available to people interested in animal breeding in the tropics. This effort is praiseworthy. Actually numerous informations are recorded, but only a small part of them are processed, utilized for breeding and management purposes and published.

Experience shows that the basic problem of data recording in the tropics is not only a question of the lack of infrastructure but also the misunderstanding of the production system and the lack of feed-back to the practical breeder. A lot of survey programs have been started in the tropics (FAO, 1985; SDC, 1985). In various reports, consultants affirm that the main problem is the reliability of the recorded data, the technical aspects of the record-keeping and the difficulty to process data. It is possible that new developments in informatics will help to resolve this last problem, but only this one. To be able to determine the records which have to be kept, it is necessary to understand and systematize the production system and, as proposed by Cartwright (1982), a model has to be set up. A simulation program allows to determine the important traits and those which have to be recorded for selection and management purposes.

As data recording in the field is difficult, several authors have proposed to reduce data collection to a nucleus herd, to select within it and to improve the population in the field through selected bulls from the nucleus (Cunningham, 1979). This author proposed a practical solution which consists in recording a lot of information in the nucleus and reducing the recording program in the field. This would allow, for example, to record the calving sequence (a trait easy to record but with a low heritability) in the field population and to introduce fertile females into the nucleus. Another possibility would consist in utilizing F1 Bos taurus x Bos indicus bulls, assuming that Bos taurus inheritance should not exceed 50 %, that Bos taurus x Bos indicus bulls will transmit both production potential and adaptability, and to put less emphasis on data recording (Hickman, 1981).

Nevertheless, the problem of data recording for breeding purposes in the tropics is often the consequence of a thoughtless transfer of recording and data processing systems utilized in temperate countries to tropical countries. This fact has been accepted.

It is known that European and North-American companies try actually to extend their market for PCs with software for herd management and breeding programs to the tropics. Small computers will not help to resolve the problem if the available software is not adapted to the circumstances and simply imported. A good example is the KLD x MMB dairy breeding project in Kerala (Chacko et al., 1985) for which the data processing programs have been developed mainly by indigenous scientists and are handled by indigenous collaborators (SDC, 1985).

It can be concluded that recording systems for breeding programs in the tropics have to be developed. They have to consider the breeding objective, the available infrastructure and the mentality of the involved farmers. As a rule: too much records are kept, often without relation to the breeding objective and the management requirements, and only few of them lead to an efficient selection.

## Selection within crossbred populations

Due to a large number of crossbreeding programs (FAO, 1985; SDC, 1985) an important percentage of the tropical cattle population are crossbred animals. The success of these programs is due to the large difference in genetic potential between the breeds involved and to a large heterosis effect for Bos taurus x Bos indicus crosses. This effect can be explained assuming a 2 locus model as proposed by Elzo (1985), provided that one locus is responsible for production potential and the other for adaptability. This model allows to show why heterosis effects for Bos taurus x Bos indicus crosses are larger in harsh than in favourable environments, as shown by Cunningham (1982). For practical reasons, systematic 2 or 3 way as well as rotational crossbreeding systems, which allow to exploit direct and maternal heterosis (Gregory et al., 1982) are not suitable for most breeding programs in the tropics. Therefore breeding policies which consist in upgrading to a certain level, e.g. 62.5 % Bos taurus inheritance and selection therefrom are recommended (FAO, 1985; SDC, 1985).

Different aspects of selection in a crossbred (or composite) population have been discussed by Lopez-Fanjul (1974) and are experimentally investigated at the MARC in Nebraska (MARC, 1983). It is possible to estimate the heterosis retention, but not the additive genetic variance of a composite breed based on population analysis of the parental breeds or their crosses. Thus, the selection response in a composite can only be estimated if genetic additive and non-additive parameters are estimated in the population concerned. In most new breed formations there is no random mating during several generations before selection starts. Bos taurus breeds are introduced stepwise into the population and F1 Bos taurus x Bos indicus bulls are progeny tested together with composite bulls (Chacko et al., 1985). If the required parameters are known, it is theoretically possible to predict the realizable genetic progress in a multi-breed selection program (Kinghorn, 1982). In most cases, these parameters are not known accurately and difficult to estimate. Therefore, selection programs are started without reliable prediction of the expected selection responses (FAO, 1985; SDC, 1985).

Selection on milk yield within a composite breed with a continuous introduction of Bos taurus genes from different breeds - through F1 Bos taurus x Bos indicus bulls is actually running in Kerala (Chacko et al., 1985), 30'000 cows are involved in this large-scale program. The introduction of genes from different Bos taurus breeds (Braunvieh, Jersey, Brown Swiss, Holstein) and the progeny testing program for F1 and composite bulls allows to compare the production of progeny from different sire groups and to adapt the breeding strategy to the results obtained under field conditions. Results obtained in such programs will contribute to design more adequate breeding programs.

Another example of selection within a composite breed is the selection program of the Australian Milking Zebu (AMZ), a Jersey x Zebu cross. AMZ bulls are selected for heat tolerance, tick resistance and milk yield. As indicated by Donegan and Roberts (1984), the results are encouraging.

Because of difficulties in running breeding programs in the tropics, no results about genetic progress realized in selection programs in composite breeds in the tropics have been published. On the other hand, a large number of programs are run (FAO, 1985; SDC, 1985).

## Selection within local breeds

The arguments in favour of selection within indigenous breeds have been summarized by Mason and Buvanendran (1982): a) they are adapted to the environment, b) if no selection takes place, these breeds will disappear (Cunningham, 1979), c) local breeds are an integral part of breeding programs. Various reports (FAO, 1985; SDC, 1985) show that many selection programs for local breeds in institutional herds are inefficient because the selection herd is too small and there is no continuity in the breeding work. There is a large number of local breeds which should be improved: the Criollo in Latin America (Salazar and Cardozo, 1981), the N,Dama in Africa (Trail et al., 1984) and the Sahiwal in India (Nagarcenker, 1983) for example. The practical situation is that the selection program for the trypanotolerant N'Dama breed started in 1979 in Boke (Guinea) has difficulties to find good animals for the foundation stock and that low fertility and disease problems hinder an efficient selection (Devillard, 1984). On the other hand, the Criollo herds in Turialba (Costa Rica), at the CIAT (Colombia) and in other experimental stations are relatively small to permit a long-term selection program. The only successful breeding program within a local breed, about which scientific papers have been published, is the selection program for Sahiwal cattle in Naivasha (Kenya). The breeding scheme was described by Meyn and Wilkins (1974, 1975) and many reports (FAO, 1985) indicate that genetic progress has been realized at least until 1980.

Since 1980, a large scale selection program for Nellore cattle is running at the Faz. Rio Cristalino, Para (Brazil). In two herds of 1500 breedable females all animals are selected for pre- and postweaning weight gain or weaning and 600 days weight. The selection procedure was described by Hautle et al. (1984). Recorded data are: birth weight, weaning weight, 600 days weight, identity of the dam and of the sire group. As artificial insemination is not an economical technique for beef herds in Latin America, natural mating is practised. As a rule, 250 breedable females are exposed to 10 to 15 bulls. The realized standardized selection differentials are about 1 for males and .5 for females for weight gain or weight at a given age. This selection intensity is similar to that realized in experiments summarized by Koch et al. (1982) and more recently by Baker and Morris (1984). Only cows which did not conceive in two consecutive years are culled. As the fertility of Nellore cows is high (Kropf et al., 1985), pregnant cows have to be eliminated at random. The labor required to record and process data and to manage the herds in which selection is practised is considerable.

Experience shows that selection within local breeds is necessary but that it is difficult to run large scale selection programs in the tropics. If the infrastructure is given, the breeding objective defined and both are compatible, practical selection programs for local breeds can be run with success in the tropics. But these conditions are seldom given and thus, systematic selection within local breeds in the tropics remains to be practised.

## CONCLUSION

Theoretical and practical aspects of the improvement of milk and meat production in the tropics have been discussed in a large number of reports and publications. Many attempts have been undertaken in institutional or private herds and in the field. The transfer of Bos taurus populations to the tropics without high inputs in infrastructure and management is only possible in few specific regions with

favourable environment. The direct impact of imported herds to local production is low. Breeding objectives are not principally identical in the tropics to those in temperate countries because the environment and the production systems are different. Therefore, the traits to be selected for differ. In a large number of breeding programs, data recording and processing are limiting factors. They have to be considered in the formulation of breeding programs. The experience shows that too many data are recorded and too few data processed and utilized for breeding decisions. As a high percentage of the cattle population in the tropics are crossbred animals, selection has to be operated within composite breeds but only little experience is available in this field. Furthermore, the population structures are often very complicated, mainly because genes from temperate breeds are introduced stepwise into the populations. Few practical breeding strategies have been analyzed under such conditions. Selection within local population is the only way to conserve them. This is only possible if the herd size is large and if the infrastructure and the will of cattle holders to collaborate in a breeding program is available. In order to improve milk and meat production in the tropics, efforts have to be made to develop breeding strategies adapted to the circumstances and in agreement with the basic rules of animal genetics and biology.


## SUMMARY

In this paper, some aspects of the improvement of meat and milk production with cattle in the tropics are discussed: transfer of Bos taurus to the tropics for specialized milk and meat production; breeding objectives in the tropics, recording systems, selection within crossbred populations and selection within local breeds. The authors have discussed ways and conditions for successful breeding programs under field conditions. They conclude that a genetic improvement in the tropics is possible, if animal breeders are able to develop breeding strategies adapted to the environment.



## RESUME

Cette contribution traite différents aspects de l'amélioration de la production de lait et de viande dans les tropiques: transfer de races Bos taurus dans les tropiques pour une production spécialisée de lait et de viande; objectifs de la sélection dans les tropiques; système de collecte des informations; sélection à l'intérieur de populations dites synthétiques ou de populations locales de race pure. Les auteurs ont tenté de discuter les possibilités et les facteurs limitants pour les programmes d'élevage réalisables dans des conditions pratiques. Ils concluent qu'un progrès génétique dans les tropiques est possible si les généticiens engagés dans la pratique sont capable de développer des stratégies d'élevage adaptées au milieu.

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