INTRODUCTION
Milk production in tropical regions is generally characterised by relatively small population sizes, strongly variable environments and a low degree of infrastructural and institutional support. The growing demand for milk and dairy products in those countries represents one part of the so-called Livestock Revolution which has to be seen as a phenomenon and will continue to occur. As the Livestock Revolution proceeds, increments to production will have to come increasingly from higher productivity of meat and milk per unit of land to avoid further degradation of extensive resources. In view of the many opportunities and dangers involved, policies supporting growth, poverty alleviation, and sustainability are required (Delgado et al., 1999, 2001). In the case of smallholder milk production, intensification combined with the establishment of milk collection centres and improvement in the infrastructure and marketing networks as proposed by Bulale (2000) could be a possible approach.

A sustainable increase in milk production per cow could be achieved by improving organisational and management conditions and by genetic improvement. However, conventional breeding strategies as applied in the industrialised countries have shown not to be adequate for unfavourable tropical regions. A new policy is needed which must be rooted in a new way of thinking about cattle and their role in human societies and which must fit the physical and social infrastructures (Payne and Hodges 1997).

Assuming that intensification by using crossbreeding has been applied appropriately where sustainable, pure breeding strategies have to be used thereafter in order to improve or maintain the achieved production levels. Thus, the genetic improvement of milk production in tropical populations using the concept of productive adaptability, implies the identification of genetically superior animals. The objective of this study is to suggest appropriate methods for breeding programmes based on estimated breeding values taking into account unfavourable conditions.

PREREQUISITES
Any sustainable improvement measure has to be based on the participation of the stakeholders from the very beginning (e.g. Trivedi 1998; Tewolde 2000) which requires a thorough acquaintance with the culture and experience of the participants. This could be achieved by communicative action theory, participatory methods and cultural and communicative expertise (Hess 1997). Vocational training should be regarded as an integral part.

A sustainable breeding programme implies the definition of the breeding goal by farmers, and an efficient animal recording system to cover a minimum set of selection traits. Principals for establishing guidelines (e.g. farmers’ participation, meeting the needs of farmers, planners, policy makers, breeding scheme and consumers, combination with service or extension) are suggested by Trivedi (1998). A recording scheme primarily requires a unique and permanent identification of each animal, the organisation and implementation of performance testing,
breeding value estimation and selection. The data comprising key information (animal ID, date of recording, location and person doing the recording, invariable animal data, life history data, recorded data and systematic environmental factors) have to be stored in standardised format (see Simianer et al., 2001).

APPROACHES

Open Nucleus Station Programme versus Open Nucleus Field Programme. Field recording of individual animals is regarded as normally not feasible with cattle in the tropics (Payne and Hodges 1997). Therefore nucleus breeding programmes implying large herd sizes in form of stations are suggested (Smith 1988; Ponzoni 1992). From the point of view of a conventional breeder such stations theoretically are the best options. Breeding plans based on such nucleus herds are still being elaborated without reflecting about their pertinence, expenses and sustainability and finally not to mention the possibly involved genotype x environment interactions (e.g. Kahi et al., 2000). Payne and Hodges (1997) describe following prerequisites for such stations: “The cattle stations proposed are centres where the main objective is the improvement of the local cattle and the welfare of their owners. Such a cattle station is not engaged in research, but in applying genetic improvement to local cattle and associated activities including extension advice, open days demonstrations and in identifying with the local community. …”. However, such a concept yet has to prove itself ans explain how the organisational demands, operational costs, and the effective implementation of breeding activities can be covered. The main constraint is to organise effective animal identification and recording. Not too many successful examples are known, however, field recording has proven to be successful in India (e.g. Unnithan et al., 2000; Trivedi 2000). If animal recording is part of a multipurpose information system for providing benefits to farmers through improvements in production management, selection, and general information to policy makers, as summarised by Flamant (1998), then field recording system should have a great potential.

Breeding scheme. The breeding scheme applied in most industrialised countries is based on progeny testing where bulls are evaluated mainly on their daughters’ performances. Early maturing cattle in temperate regions with big population sizes allow high selection intensities and accuracy justifying a generation interval of 6 to 7 years on the bull path. In the tropics, however, the minimum age of proven bulls is about 9 to 10 years (Syrstad and Ruane 1998; Jaitner and Dempfle 1998) and accuracy presumably will hardly surpass 0.7-0.8. “However, progeny testing has too often been considered a compulsory, almost “magic” component of a breeding programme, even it has no relevance”, as Philipsson (2000) states. Instead a young sire programme with a quick turn-over rate of bulls seems to be most adequate in tropical cattle breeding (Syrstad and Ruane 1998; Jaitner and Dempfle 1998; Philipsson 2000). In such a programme the bulls are evaluated regarding their ancestors’ performances, i.e. milk yield of dam, and maternal and paternal half sisters of sire and dam. Accuracy in this system is rather low (about 0.4), but the generation interval is low as well (minimum 3-4 years for tropical dairy populations). In the study of Jaitner and Dempfle (1998) a half sib programme, i.e. bull selection based on his ancestors’ and half sibs’ performances, was as effective as the young sire programme with regard to the projected genetic response per year. The gain in accuracy in this system compared to the young bull system is nullified by the prolongation of the generation interval. Considering also the practicability of the schemes applied to tropical animal breeding the preference has to be given to the young sire programme which as Jaitner
and Dempfle (1998) write “is by far the simplest of the three schemes, and it is easy to operate and the least expensive one.”

**Herd-as-village concept.** Smallholders generally hold 1 to 5 cows which are often mated to one bull per season. Thus, the conventional effect “herd-farm” is confounded with the genetic effect of the bull, and any genetic evaluation will be biased. Bruns (1992) suggests to cluster farms according to some factors, describing the production level of the farm (e.g. farm size, rainfall, location, production system, etc. In tropical countries villages share a large degree of common environmental effects and allow the use of several sires for breeding. So, one form of clustering farms could consist in connecting the concept of herd to the village like in the Dairy Improvement Programme Actions (DIPA) in Gujarat, India (Trivedi 2000a, b).

**Recording frequency.** In conventional breeding programmes milk recording takes place once a month. Taking into account the strongly variable environmental conditions prevailing in the tropics a higher recording frequency could lead to more reliable results. If farmers who are actively participating in the breeding programme are provided with the necessary materials, they presumably are also willing to daily record the performance of their cow(s). With a monthly official recording (for control) and additional own recordings, environmental effects could be identified and corrected to a large degree.

**Test-day versus lactation yield model.** The breeding value of a cow is generally based on the milk yield of the whole lactation, projected from the test milkings (lactation yield model). If environments drastically change within one lactation period and the recording frequency is too low, the estimated breeding values could be considerably biased resulting in the selection of genetically inferior animals. Genetic evaluation based on a test-day model, however, allows to fit environmental effects in the model specific to the daily yield, records in progress need not be extended to standardised lactation yields but can simply be included for all lactations giving earlier and more accurate proofs. Furthermore, the shape of the lactation curve can be accommodated in the model at both the phenotypic and the genetic level to account for differences in lactation curves between cows and problems associated with persistency. They can also facilitate a cheaper and more flexible recording scheme and perhaps allow the inclusion of owner samples records in genetic evaluation (e.g. Brotherstone et al., 2000; Olori et al., 1999).

**DISCUSSION**
Field recording should not be excluded as a basis for a genetic improvement programme, on the contrary it should be secured with sustainable participation of dairy herd owners. This requires generally that communities are organised and skilled in working together, solving problems, and resolving conflicts (Hazell and Haddad 2001). So, “Participatory research should go hand-in-hand with participatory community development that can help improve access to credit and markets and can teach local people the skills they need to organize themselves, analyze and solve problems as a group, and resolve conflicts” (Kerr and Kolavalli 1999). This should also satisfy vocational training needs required for recording and breed improvement as part of community development. Community based approaches are also supported for the management of Animal Genetic Diversity (e.g. Köhler-Rollefson 2000). Provided the necessary prerequisites for a sustainable breeding programme, as outlined above, the herd-as-village concept not only offers a powerful approach to overcome the structural
problems of small herd sizes. It could also be tool for supplying relevant information to the farmers by facilitating comparison between farmers with regard to management improvement as shown in the DIPA programme in India. (Trivedi 2000b). Strong environmental variation prevailing in tropical regions, particularly under field conditions, could be accounted for to a large degree by additional own recording and the application of a test-day animal model, thus improving accuracy of selection. A young sire programme seems to be the most appropriate breeding scheme for tropical dairy populations. Genetic response, disseminated by the provision of genetically superior village bulls or semen, could be shifted considerably (nearly doubled) when using a test-day animal model and additional own recording compared to the lactation yield model based on monthly milk recording as shown in a simulation study by Zumbach and Peters (2001).

REFERENCES