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Breeding Scheme Based on Analysis of Community Breeding Objectives for Cattle in North-western Ethiopia

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Abstract

Knowledge of traditional animal breeding practices and techniques is important to develop sustainable genetic improvement schemes under smallholder settings. Unfortunately, inadequate attention has been given to the investigation of these practices. This knowledge gap leads to the setting up of unrealistic breeding goals in the design of livestock genetic improvement programs, the consequences of which can endanger the conservation of indigenous animal genetic resources. This study was conducted to study the existing cattle breeding practices of the study area, and to outline priority areas of intervention for genetic improvement of the indigenous cattle breed types based on farmer trait preferences. A rapid field visit had been conducted to outline sampling framework based on types of cattle breed types, which was used as the basis for the selection of six sample sites. The actual survey included focus group discussions and administration of a semi-structured questionnaire on 20 to 30 representative sample households. Results showed that the indigenous cattle in the study area have multipurpose functions and were preferred mainly for their adaptive traits, including resistance to disease, drought tolerance and low feed requirements. Almost all respondents (98%) employed pure breeding of their local cattle types. In females, the selection criteria are coat color, body size, size of udder and teats and length of the naval flap. However, importance of each of the different traits varies with sites. Farmers have strong desire to improve their indigenous genotypes, and suggested different goal traits for genetic improvement. Based on this, community/village-breeding scheme is proposed, taking into account milk production, adaptation and longevity as goal traits, as the first step for genetic improvement of the indigenous cattle breeds.

Keywords: breeding objectives, breeding scheme, indigenous cattle, Gondar, Ethiopia

Introduction

The traditional animal production in Africa is mainly characterized by subsistence production and it is the largest farming sector in terms of numbers of farmers. It includes pastoral as well as crop-livestock systems in semi arid and wet and cool highlands and landless (requiring little land) production system (Jahnke, 1982; Rege *et al*., 2001). Despite the importance of the subsistence sector, no breeding objective suitable to the system is currently available (Rege et al., 2001; Amer *et al*., 1998). However, natural selection has resulted in animals that are tolerant to prevalent diseases and parasites.

Traditional animal breeding efforts and techniques are important, but more information is needed regarding the breeding population that exists in the system. This background information should precede any major interventions (Cunningham, 1992). Characterization and utilization of local indigenous breeds as stated by Hall (1992) should be considered whenever development of animal production system is discussed. Indigenous genotypes may well be adequate and able to respond sufficiently to reasonable economic improvements in the low-input smallholder production system (Workneh *et al*., 2003). Over many generations indigenous breeds have evolved to perform various functions under local conditions. Unfortunately, inadequate attention has been given to evaluating these resources or to setting up realistic and optimum breeding goals for their improvement. As a result some of the animal genetic resources of Africa are endangered and, unless urgent concerted efforts are taken to characterize and conserve, these resources may be lost even before they are described and documented (Rege and Lipner, 1992).

A coherent and comprehensive breeding program suited to the existing production systems (decentralized breeding program) is required to guide stakeholders in the sustainable management of animal genetic resources. Failure to create effective genetic improvement program for subsistence type of farming may accentuate any decline in the number of indigenous breeds with the added disadvantage of being replaced by other production systems which might not be sustainable in the long run. Knowledge on traditional breeding practices and cattle goal traits are crucial if sustained genetic improvement is to be in place. The objectives of this study were to explore cattle trait preferences in the study area, outline priority areas of intervention for genetic improvement of the identified indigenous cattle breed types based on farmer trait preferences, and investigate the existing breeding practices.

Materials and methods

The study area

The study area, North Gondar and some part of South Gondar, is located in northwestern part of Ethiopia. It is generally divided into three main agro-climatic zones, namely: highland, mid highland and lowland regions. According to the 2002 report by the departments of agriculture of the respective zones, the study area hosts 2.654 million cattle. The altitude ranges from 4620 meters in the Semein Mountains in the North to 550 meters in the western parts of the study area and rainfall varies from 880mm to 1772mm with a monomodal distribution. The farming system is largely characterized by crop-livestock production system both the highlands and lowlands, and in both cases the crop farming is heavily dependent on livestock. Transhumance, from the highlands to western lowlands, is practiced as one of the most important strategies to secure grazing resources for the highland livestock during lean seasons of the year. The average herd size varies greatly, and it ranges from 2.11 to 7.15 animals in the high and mid altitudes to around 65 in the lowlands (DOA, 1999).

The most common breeding system in the study area is pure breeding. Crossbreeding between indigenous and exotic Holstein-Friesian and Jersey, however, is practiced in some parts of the mid and mid-highland region of the area with the purpose of improving milk production. The livestock feed is predominantly derived from unimproved pasture, fallow land grazing, hay, crop residues, non-conventional foodstuffs and to some extent also agro-industrial by-products. The extent of relative use of these feed resources depends on proximity to town. Foot-and-mouth disease (FMD), Blackleg, Anthrax, Lumpy skin disease, Contagious Bovine Pleuropneumonia (CBPP), Trypanosomosis, Mastitis and Dermatophilosis are commonly found. Infertility and Tuberculosis (TB) are also reported (DOA, 1999).

Sampling framework and data collection procedure

Initially a rapid field visit had been conducted to identify the types of cattle breed types and thereby to outline sampling framework. Based on the outcome of this survey six sample sites were selected:

a. Semien: Semein Mountain area, consisting of Beyeda and Janamore districts
b. Wegera: highlands of Debark, Dabat, and Wegera districts of North Gondar
c. Dembia: mid-altitude areas of North Gondar districts (Dembia, Chilga, Gondar zuria)
d. Fogera: eastern flanks of Lake Tana, Fogera and Dara districts of South Gondar
e. Western lowlands: Western lowlands of North Gondar, Quara, Metema and Tachiarmachiho
f. Monastery: Mahibere Sillasie Monastery, an Orthodox Church monastery, located in the western lowlands of North Gondar

Actual survey work included focus group discussions and administration of semi-structured questionnaire. Semi-structured questionnaires were prepared, pre-tested and administered on 20 to 30 (except at Site 6, the Monastery) representative sample households. Data were analyzed using simple descriptive statistics.

Results and discussions

Purposes of keeping cattle

Cattle in the study area have multipurpose functions. These include traction power (traction), milk production, income generation, manure, reproduction and meat production (Table 1). Similar results were reported earlier by Mukasa-Mugerwa (1989) in Ethiopia and Rege *et al*. (2001) in Kenya. Multiple functions are particularly relevant in high-risk production environments. According to Scarpa *et al*. (2002) in developing countries, especially in low input smallholder production systems, the most valuable livestock attributes are often those that successfully guarantee multi-functionality, flexibility and resilience in order to deal with variable environmental conditions.

The relative importance of these functions varies between the sites. For instance, traction was most frequently reported in Semein Mountains, and less frequently in Wegera and Dembia. In Fogera, milk was reported more frequently than was traction (Table 1). Despite the general assumption that only male cattle are used for traction, it was found out in this study that cows are also used for traction. This appears to be due to shortage of male animals. Especially in Semien and Wegera areas using horses for traction on light soils is common tradition. According to the sample farmers the contribution of the latter as power animal is so significant. On average, horse traction is estimated to cover around 35-40 % of the traction requirement of the area. It seems that the ox is giving way to the horses to be used as a traction animal thus leaving more land for cows to graze. This may pave a road for the creation of specialized breeds and/or gives better opportunity for dairy breed improvement. Similar event was observed in Europe at the end of 18th century (Mason and Buvanendran, 1982).

Table 1. Reported frequency of purposes for keeping cattle (percentage)

Purposes	Semein	Wegera	Dembia	Fogera	Western lowlands	Monastery
Income	28.1	27.1	21.2	27.9	30.1	40.0
Meat	16.6	23.6	18.2	16.6	23.1	0.0
Milk	40.1	54.7	57.9	60.0	62.0	7.0
Manure	26.6	25.8	28.9	27.8	27.6	3.0
Reproduction	26.4	35.3	26.9	22.7	25.7	23.0
Draft	93.5	78.4	75.9	50.0	54.5	27.0

Cattle trait preferences

The communities have preferences for certain traits of their cattle, and these traits are again multiple, suggesting that multipurpose rather than specialized breeds are more suitable for the kind of low input – low output production system of the study area (Table 2). The local breed types were preferred mainly for their adaptive traits, including resistance to disease, drought tolerance and low feed requirements. Similar findings were documented, for example, by Rege *et al*. (2001) for the Kenyan Zebu breeds. Further, Davis (1993) in northern Australia and Moyo (1996) in Zimbabwe reported the relative significance of adaptive traits of tropical/indigenous breeds compared to temperate breeds.

Adaptation traits as defined by FAO (1999) are complex traits related to reproduction and survival of the individual in a particular production environment. Adaptation traits contribute to the individual's fitness and to the evolution of animal genetic resources. A similar study by Kamuanga *et al*. (2002) in West Africa also showed that farmers commonly give higher ranks for such traits as fitness for traction, disease resistance, fertility and fecundity. Thus, to be consistent with those preferences, breed improvement programs should ensure that improved genotypes are also selected for these traits (Kamuanga *et al*., 2002). Some farmers rated traction capacity of local cattle in the very cool and highland areas high. In addition to these, milk production (mostly quality, taste), reproduction (related to asset and social values), and body conformation were identified as important cattle traits. The order of preference of these traits varied considerably between sites (Table 2).

Table 2. Reported frequency of cattle trait preferences (percentage)*

Reason for preference	Semein	Wegera	Dembia	Fogera	Western Lowland	.Monastery
Milk production	0.0	48.8	50.0	48.0	50.0	10.0
Meat type	-	-	-	-	-	-
Adaptation	90.3	96.0	58.8	73.3	80.9	20.0
Conformation & size	50.0	38.5	70.6	32.2	54.5	20.0
Traction capacity	50.0	50.0	75.0	33.3	-	10.0
Reproduction	34.6	30.4	37.8	31.5	44.4	40.0
No alternative breeds	36.4	35.3	27.8	0.0	-	-

* Proportions derived from less than 5 respondents are omitted

Mating system and selection of breeding animals

Almost all respondents (98%) employ pure breeding of their local cattle types. Even though artificial insemination (AI) and exotic bull services for cross breeding of local cattle with exotic dairy breeds have been promoted for the last nine years, only a very small proportion of farmers (around Wegera, 14%) are utilizing the services. Mating is totally uncontrolled in Semien Mountains and partially controlled in Wegera. But in in Dembia and Fogera plains as well as the western lowlands, cattle keepers practice selection of male and female breeding cattle based on preferred traits (Zewdu, 2004). The majority of farmers in all study sites obtain their breeding animals from their own farm and from their relatives and neighbors. In some instances, farmers buy female breeding animals from the nearby open markets using certain selection criteria. These are coat colour, body size, size of udder and teats and length of the naval flap (Table 3). Besides, fertility, dewlap width and temperament are considered as secondary criteria. Other traits mentioned as useful in selecting females are long neck, small size of head, and short calving interval for females and long preputial sheath, large hump and medium tail length for males.

Importance of each of the different traits varies with sites. For instance, solid colour is not preferred in mid and low altitude areas for which scientific explanation cannot be given. In Semien Mountains and Wegera area, however, plain coat colour pattern, red coat colour, and spotted patchy combinations of red and white colour are preferred. According to the respondents from lowland areas, flies are more attracted to plain coat colour pattern of their cattle, and hence they do not prefer plain coat colour. Furthermore, coat colour preferences influence market prices of cattle and this becomes more important in light of the relative significance of cash income generating functions of cattle (Table 1). These preferences for coat colour pattern actually match the observed patterns in sample herds, whereby mixed colour were more common than solid plain colour in the low and mid altitude areas. Another important trait, probably the most important in all sites, is body size (Table 3), which comprises body length, height and pelvic width. In this case also relatively small size is preferred in the very cool highland areas and larger animals are preferred in the rest of the sites. This is purely associated with the available feed reserves.

The importance of colour and fertility is high in Semien Mountains, Wegera and the western lowlands, whereas low in Dembia and Fogera (Table 3). The relative importance of sizes of udder, teats and naval flap tends to increase as we go down from highland to lowland areas. This might be related to the emphasis given to milk since the traits are assumed to be milk traits.

Table 3. Reported frequency of traits used to select breeding female (percentage)

Selection traits	Semein	Wegera	Dembia	Fogera	Western lowlands
Colour	34.6	53.0	25.9	23.9	35.9
Dewlap	0.0	25.0	25.0	23.3	0.0
Body size	58.7	93.0	95.6	70.6	68.0
Fertility	60.0	44.0	29.2	26.7	50.0
Temperament	33.3	35.5	0.0	0.0	28.6
Udder, teat and naval length	28.6	32.9	40.0	42.3	56.0
Others	22.8	21.4	25.0	20.8	22.2

Breeding objective

Development of any genetic improvement strategy requires description of production environment, setting appropriate breeding objective, selecting traits to be improved based on their influence on returns and costs to the producer and consideration of stockholders. In addition, available infrastructures and organizational set up established in the target area have to be considered. Thus, designing a breeding program needs decision on a series of such interacting components. Similar approaches were followed by Sölkner *et al*. (1998), Amer *et al*. (1998) and Rege *et al*. (2001).

Production system, stakeholders and infrastructures of the study area

The production system of the study area is basically subsistence-oriented production system, and not market-oriented. As reported by the farmers, feed shortage and animal diseases are the most important limiting factors. Lack of marketing facilities was also mentioned. There is no performance or pedigree recording. Farmers live with low level of education. The typical herd sizes are small; there are no farmers' associations specifically equipped for livestock development. The involvement of other stakeholders (non-governmental organizations and government bodies) in genetic improvement of local indigenous cattle genotype was very minimal or none. Infrastructures such as artificial insemination services are established for some of the mid and high altitude districts though frequent shortage of liquid nitrogen and lack of trained manpower are constraints of the service delivery system.

Goal traits for genetic improvement in the study area

The goal traits, which are used in designing of the upcoming breeding program, should logically be based on preferred traits identified by farmers (Table 4). Only few traits that represent breeding goal, easy to measure, heritable are considered. Traits, if not easily measured, must have a high genetic correlation with measured indicator trait, and desirable economic value, either as a marketable commodity or as a means of reducing production costs. Previous works done by Sölkner *et al*. (1998) and Rege *et al*. (2001) used similar approaches.

Some of the farmers' preferred traits (Table 4) have low heritability values and others, like post weaning growth and mature body weight, have contradictory role to the existing management system, as such traits need better management and require additional feed, which may compound the already existing problem. One of the adaptive mechanisms of local indigenous cattle in stressful tropical environment is to keep their body size small (Payne, 1990; Hegde, 2002). So care should be taken to ensure that the traits selected are those of real economic importance to the farmers. Thus both traits (post weaning growth and mature weight) are excluded. Improvement on the growth performance through selection should aim at having faster growth but not oversized animals. High growth rate will produce cows that require heavier body weight to achieve puberty. This can prolong the age at first calving, thereby further increasing the already extended age at first calving. Reports by Hegde (2002) and Rege *at al*. (2001) also gave similar justification for not considering high growth rate.

Female fertility is also suggested by farmers for improvement. Reproductive rate in most tropical breeds of cattle is low. Yet, this trait is very important not only in the economics of production but also in genetic improvement because of its influence on selection intensity. Though the heritability of the various measures of reproduction is low, rigid culling to eliminate animals with low fertility may improve fertility in Zebu cattle. However, as most of the improvement resulting from such selection may be non-genetic, fertility may decline in subsequent generations unless the practice of culling on reproductive performance is sustained. Another trait selected by farmers for genetic improvement was tolerance to diseases, especially trypanosomosis. Development of disease resistant breeds is not an easy task and needs time and mobilization of huge resources. Thus, the most important and practical way is to concentrate on selection for production traits in the presence of environmental stress, thus allowing animals to be selected while responding also to the stressors. A similar approach was suggested by Rege *et al*. (2001).

In addition to these, almost all farmers have included milk production traits in their goal traits. Since milk was mentioned as one of the most important functions of the local cattle and one of the primary reasons for keeping indigenous cattle, its inclusion as one of the goal traits is justifiable. An increase in milk yield will bring additional income from the sale of butter and in some cases, e.g. in Fogera plains, from the sale of raw milk. More milk production also means better-fed calves that will have better pre- and post-weaning survival rates. These calves will also grow better and hence reach puberty earlier thus reducing age at first calving. Farmers also preferred to see short calving intervals of their cows, which can also be improved to a certain extent by improving feeding and health management. However, at this stage, it is advisable to work on very few selected priority traits to allow quick realization of the benefits from genetic improvement.

Finally, longevity in terms of length of productive life in a herd was identified as a preferred target trait. This is definitely important since animals that stay longer under production help to lower the cost of raising replacement heifers. Animals with longer productive life should be identified so that their close relatives could be selected. Earlier works done by Mason and Buvanendram (1982) and Sölkner *et al*. (1998) reported that for marginal areas, long term reproductive performance of female animals will clearly be of higher value.

Table 4. Frequency (%) of reported traits for genetic improvement of indigenous cattle

Traits	Semein	Wegera	Dembia	Fogera	Western lowlands	Monastery
Longevity and adaptation	34.5	13.4	27.3	15.0	15.5	100.0
Fertility of breeding females:						
Age at first calving	86.2	41.4	54.5	8.3	9.2	0.0
Calving interval	100.0	27.6	63.6		22.2	0.0
Growth and mature weight	86.2	44.8	77.3	33.3	68.9	0.0
Milk production (yield)	100.0	96.5	100.0	50.0	94.4	0.0
Traction	27.6	58.6	18.2	0.0	28.7	0.0
Other traits	0.0	12.7	0.0	0.0	6.7	0.0

Proposed breeding program

Analysing all these major components shows that genetic improvement is not an easy task. However, there is still a possibility to devise appropriate genetic improvement programs for the existing production systems. The most important advantage was the availability of indigenous cattle breeds adapted to a wide range of harsh environments. Farmers in the study area showed great interest to improve these genotypes and suggested traits for improvement (Table 4). It is important that such breeding programs are monitored for success and failure.

Sustainable use and improvement of such traits is the most effective way of conservation of indigenous genetic resources. These populations could be potential sources of the so-called transgressive or cryptic alleles (Notter, 1999), that are superior genes for some productive traits found ‘hidden’ in unselected breeds. Nucleus breeding programs employing large herd sizes maintained in stations are suggested (Smith, 1988; Ponzoni, 1992). Such a concept, however, is criticized for its heavy operational costs, high organizational demand, for lacking pertinence, sustainability and possible genotype by environment interactions (Sölkner *et al*., 1998; Zumbach and Peters, 2002; Olivier *et al*., 2002).

Thus, for the study sites community/village-breeding program is proposed, taking into account milk production, adaptation and longevity as goal traits for genetic improvement of the indigenous cattle breeds. This should be designed to be carried out by rural communities under most likely unchangeable environments, e.g. feed resources will not be improved, large seasonal variations among the years will continue, disease prevalence will persist, level of organization is low, data recording is difficult and flow of information between hierarchies is not functioning. Previous work by Sölkner *et al*. (1998) also suggested similar approach. In this system the herds of the communities, which shared large common environmental effects will be clustered, in what is known as Herd-as-Village concept. In this approach the whole herd of the village will be considered as one herd and used as a foundation stock for selection. From these herds young untested bulls are selected based on evaluation results of their ancestors' performance. This is similar to what is known as young sire program suggested by Syrstad and Ruane (1998), and Philipsson (2000). Some of protocols for the proposed schemes are listed below:

a. This system is believed to work with full participation of the communities. So discussion of the issue with the communities and organizing community members is the vital and first step. Farmers establish community-breeding groups, which will be responsible for execution of the program.
b. Farmers are advised to indicate their trait preference from which the goal traits will be determined.
c. Basic training on recording and importance of breed improvement programs as a whole should be delivered regularly. This can be taken up by the existing extension services. Moreover, the livestock development extension service will be responsible for the day-to-day activities and monitoring of the whole program.
d. Seed money in the form of revolving fund, administered by the community, is necessary. Along with this, government bodies, and relevant nongovernmental organizations can take part in its implementation to the extent that their services are found relevant for effective implementation of the scheme.
e. Based on the communities' goal traits, selection of young untested sires in reference to their ancestors' performance will be executed; then the owner of the bull will enter into a written undertaking. When the bull reaches to age at maturity, it can be used in one of the two schemes, such as:
    a. Community bull scheme where the community will own the bull and provide service to breeding females of all community members at a reasonable charge.
    b. Bull service scheme where an individual maintains the selected bull and will provide the service at a fixed service charge

The use of multiplication center as a source for breeding bulls in other similar schemes is indicated. However, the use of such a center may lead us to Open Nucleus Breeding System (ONBS), which is heavily criticized for its relevance and the possible environment by genotype interaction effect. This village breeding scheme is based on the transfer of selected bulls within communities under the direct supervision of the organized groups. Continual monitoring of the suggested breeding program should be an integral part of this breeding program too.

This scheme is believed also to offer a powerful approach to overcome the structural problem of small herd size. It requires simple organizational set up and minimum technical backstopping. This scheme is probably the only method suited to the existing situation and could enable genetic improvement of local indigenous cattle breeds of the study area. It is hoped that the use of untested bulls for natural mating in the participating herds leads to a substantial reduction in the time lag required for dissemination of the genetically superior animals.

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