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ICARDA
International Center for Agricultural Research in the Dry Areas

Guidelines for Setting up Community-based Sheep Breeding Programs in Ethiopia

Lessons and experiences for sheep breeding in low-input systems

Aynalem Haile, Maria Wurzinger, Joaquín Mueller, Tadele Mirkena, Gemeda Duguma, Okeyo Mwai, Johann Sölkner and Barbara Rischkowsky

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BOKU

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Executive Summary

Guidelines for setting up community-based sheep breeding programs in Ethiopia

These guidelines are designed for all those involved in planning and implementing sheep breeding activities with resource-poor farmers in developing countries. This includes research centers, non-governmental organizations (NGOs), farmers' associations and livestock development projects, and government extension officials.

The guidelines address the lack of generic direction on designing and implementing community-based breeding. Community-based breeding programs are proposed as an option for genetic improvement of livestock in developing countries. This new approach has been tested in a few places with promising results (e.g. with dairy goats in Mexico, llamas and alpacas in Bolivia and Peru). They draw on practical experiences from implementing community-based sheep breeding programs in four agro-ecological zones in Ethiopia and provide guidance for continuing and out-scaling the breeding program in Ethiopia and for planning similar projects elsewhere.

The breeding programs in Ethiopia have achieved important ouputs. For example, negative selection has been reverted as fast growing lambs are now being retained for breeding instead of ending up in markets. The acute shortage of breeding rams, observed previously in flocks of participating communities, has also been rectified as farmers are now fully aware of the importance of breeding males.

Preliminary analysis of the recorded data indicates that the market outlet has increased through more births of lambs, bigger lambs at birth and weaning, and reduced mortality rates due to the combination of breeding with improved health care and feeding.

The objective of these guidelines is to:

- Describe the prerequisites and context in which community-based breeding program can be successfully implemented
- Explain how communities can be best engaged to get actively and sufficiently involved in all the critical stages (i.e. definition of breeding goals and decisions on the best implementation options and plans) of the project
- Take the user through the main steps in the design and implementation process leading to operational breeding programs
- Propose appropriate local institutional arrangements within the communities' capacity to effectively manage performance recording, selection, and delivery of improved genetics
- Suggest a system for monitoring and evaluating progress and the impact of the breeding program during and after the project.

The guidelines have five parts:

1. General background information
2. User guide
3. Implementation modalities
4. Issues related to enabling environments
5. Monitoring and evaluation for community-based sheep breeding programs.

While based on the Ethiopian experience, these guidelines propose generic approaches to community-based breeding for resource-poor sheep farmers. As community-based breeding is a new approach, the guidelines will be refined and updated as experience in community-based breeding accumulates and our tools improve.

The project team welcomes inputs and perspectives from interested readers.

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1. Introduction

Genetic improvement of livestock is often viewed as a complex set of tasks requiring a high level of organization and technical sophistication. In Europe, animal breeding has been traditionally supported by the state and implemented by large national breeding programs. Data recording, channeling of the recorded data towards a data processing center, estimation of 'breeding values' with complex statistical methods and central decisions about the use of male breeding animals are ingredients of such breeding programs. In developing countries, the required supportive infrastructure is largely unavailable, so attempts to replicate developed-country approaches have met with little success.

As alternatives, centralized breeding schemes, entirely managed and controlled by governments – with minimal, if any, participation by farmers – were developed and implemented in many developing countries through a nucleus breeding unit limited to a central station. These centralized schemes were usually run by a governmental organization attempting to undertake all or part of the complex processes and breeding strategy roles (i.e. data recording, genetic evaluation, selection, delivery of genetic change, and feedback to farmers). Although well intended, these centralized schemes failed to sustainably provide the desired genetic improvements (continuous provision of a sufficient number and quality of improved males to smallholders) and also failed to engage the participation of the end-users in the process.

Another alternative widely followed by many developing countries or individuals is importing improved commercial breeds in the form of live animals, semen, or embryos. These are crossbred with the indigenous and 'less productive' breeds to upgrade them towards the imports, but in most cases, it is done without sufficient pre-testing of the appropriateness (suitability and adaptability) of the breeds and their resulting crosses to local production systems or conditions. Where indiscriminate crossbreeding with the local populations has been practiced, genetic erosion of the adapted indigenous populations and breeds has occurred.

A new approach is therefore required. One such approach that has recently stimulated global interest is a community-based breeding strategy. Programs that adopt this strategy take into account the farmers' needs, views, decisions, and active participation, from inception through to implementation, and their success is based upon proper consideration of farmers' breeding objectives, infrastructure, participation, and ownership (Mueller 1991; Sölkner et al. 1998; Wurzinger et al. 2011). Designing a community-based breeding program is much more than genetic theories and increased productivity. It is a matter of infrastructure, community development, and an opportunity for improved livelihood of livestock owners through productive and adapted animals and markets for their products.

Cognizant of this, the International Center for Agricultural Research in the Dry Areas (ICARDA), the International Livestock Research Institute (ILRI), and the University of Natural Resources and Life Sciences (BOKU), in partnership with the Ethiopian National Agricultural Research System, have designed and implemented community-based sheep breeding programs in Ethiopia. Ethiopia was selected as a case study because sheep play an important role in the livelihoods of resource-poor farmers/pastoralists there. The current level of productivity of the indigenous Ethiopian sheep breeds under the smallholder production systems is low. The average annual off-take rate and carcass weight per slaughtered animal for the years 2000–2007 were estimated at 32.5% and 10.1 kg, respectively, the lowest even among sub-Saharan African countries (FAO 2009).

In parallel, the demand for sheep products has increased due to a growing human population and urbanization. There is, therefore, an urgent need to improve productivity in order to raise smallholders' incomes and meet the demands of the growing human population. Furthermore, recent assessments of the views of farmers and research and development views in the highlands of Ethiopia have shown that genetic improvement should receive a similar priority to feeding and health issues (Edea 2008; Getachew et al. 2010). Therefore, an integrated approach is needed, taking into consideration genetics, nutrition, health, input supply and services, and markets.

The guidelines presented here are therefore based on the experiences gained from the research project titled 'Designing community-based breeding strategies for indigenous sheep breeds of smallholders in Ethiopia'. The project is funded by the Austrian Development Agency and operates in four regions representing different agro-ecologies that are the habitats of four indigenous sheep breeds: Afar, Bonga, Horro, and Menz (Table 1). The project is being implemented with the full participation of farmers and pastoralists, and to date, about 500 households (120–125 households per breed) owning about 8,000 sheep have been enrolled in the project.

The guidelines consist of the key requirements of, and implementation modalities for, community-based small ruminant breeding in low input systems, with specific reference to Ethiopian conditions.

Table 1: Characteristics of the four sites

Breed	**Habitat**	**Production system**	**Major use**
Afar	Hot to warm arid plains (565–1542 m.a.s.l.)	Pastoral/agro-pastoral	Milk, meat
Bonga	Wet, humid (1070–3323 m.a.s.l.)	Mixed crop–livestock	Meat
Horro	Wet, humid (1600–2800 m.a.s.l.)	Mixed crop–livestock	Meat
Menz	Tepid, cool highland (1466–3563 m.a.s.l.)	Sheep–barley	Meat, wool

2. User Guidance

2.1 Purpose and objectives of the guidelines

The guidelines are intended to assist users with planning and implementation of community-based breeding programs for resource-poor sheep and goat farmers. They draw on practical experiences from implementing a community-based sheep breeding program in four agro-ecological zones in Ethiopia and provide guidance for continuing and outscaling the breeding program in Ethiopia and for planning similar projects elsewhere.

More specifically the objectives of the guidelines are to:

- describe the prerequisites and context in which community-based breeding program can be successfully implemented
- explain how participating communities can be best engaged to get actively and sufficiently involved in all the critical stages (i.e. definition of breeding goals and decisions on the best implementation options and plans) of the project
- take the user through the main steps in the design and implementation process leading to operational breeding programs
- propose appropriate local institutional arrangements within the communities' capacity to effectively manage performance recording, selection, and delivery of improved genetics; and
- suggest a system for monitoring and evaluating progress and the impact of the breeding program during and after the project.

2.2 Target groups

The guidelines are intended for use by all persons and organizations interested and involved in planning and implementing breed development activities, in particular research institutions, non-governmental organizations (NGOs), private institutions (e.g. farmers' associations and livestock development projects), and government officials. In the case of the Ethiopian sheep breeding program the target group for the guidelines included livestock keepers, national and regional research institutions, the extension system, universities, NGOs, and policy makers. As the guidelines target a diverse group of actors, knowledge of the principles of animal genetics and breeding would be an advantage but is not essential for using the guidelines.

2.3 Conditions under which the guidelines should be used

The guidelines are designed for users that wish to develop breeding programs in situations where:

- a developed infrastructure for animal genetic improvement under smallholder production system is not in place, thus precluding direct adaptation of approaches from more developed situations
- systematic processes for identifying and delivering genetically superior breeding stock from the local populations are lacking; and
- national research and development organizations have limited experience and a limited number of qualified staff.

Although most of the elements described here are applicable beyond the local Ethiopian situation – and hence can be easily adjusted to specific cultural, social, economic, or ecological conditions and similar production systems – the guidelines specifically address the situation of resource-poor sheep keepers in four different agro-ecological zones in Ethiopia. The guidelines describe the steps to be taken to develop and implement a straight breeding program but are also applicable to organized crossbreeding programs in local communities.

The guidelines can be used in connection with the guidelines provided in 'Breeding Strategies for Sustainable Management of Animal Genetic Resources' which were developed and tested by FAO (2010). Once national stakeholders have completed the decision-making process described in the FAO guidelines and prioritized local breeds for breed improvement programs, the guidelines presented here can help to plan and implement the breeding strategies with the livestock keeper communities.

2.4 Structure of the guidelines

The main part of the guidelines consists of three sections:

- Implementation of the program (Section 3)
- Creating an enabling environment for a community-based breeding program (Section 4)
- Monitoring and evaluation of the breeding program (Section 5)

Section 3: covers the three most important steps in the implementation process, and hence forms the core of a breeding program:

1. Identifying the target site and target group(s)
2. Developing the breeding plan, including:
   a. Definition of breeding goals and selection criteria, and
   b. Assessing alternative breeding plans
3. Building adequate breeding structures

For each step, the activities that need to be undertaken are described and appropriate tools introduced.

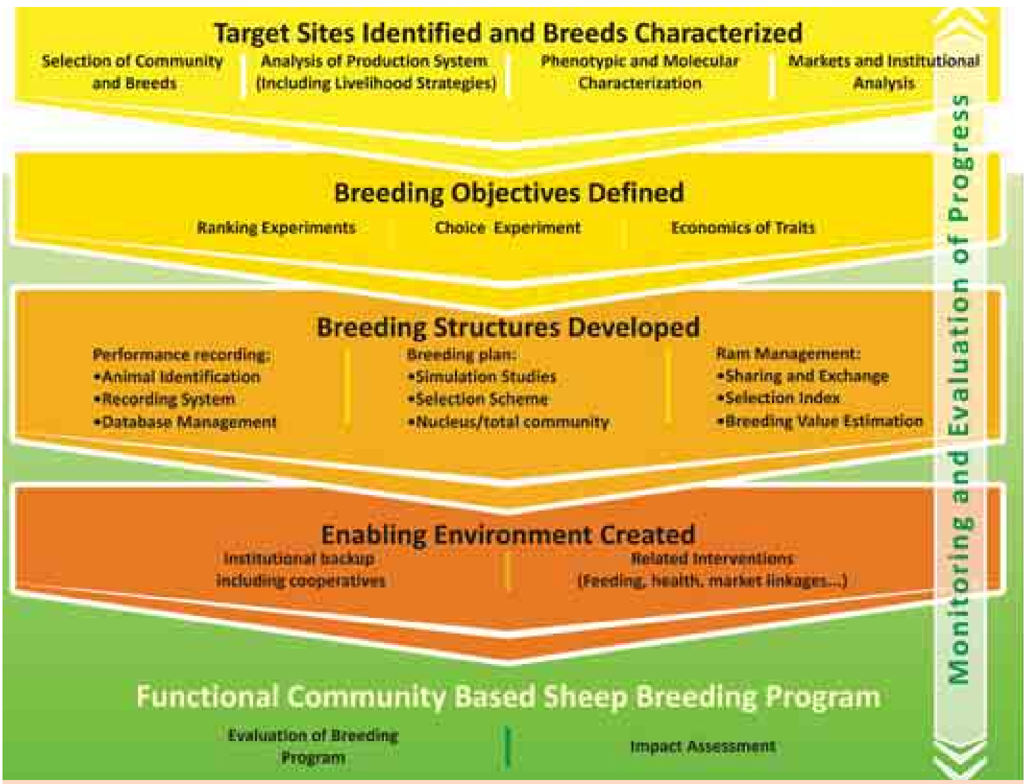


Fig. 1 Logical sequence of steps to implement community-based sheep breeding

Section 4: explains the support required from different institutions to initiate, implement, and sustain a breeding program in the long term. It also proposes complementary activities to be undertaken and tasks to be implemented in order to create enabling environments for the breeding program.

Section 5: describes and discusses the monitoring- and evaluation-related activities required to continuously assess progress being made and the final success of the breeding program and its impact. In this section the various actors are mapped and their roles at the different levels described.

2.5 Using the guidelines

Developing any livestock breeding program requires teamwork of a number of actors at community, regional, and national level, each with different expertise and institutional backgrounds. The guidelines are intended to provide a practical and technical roadmap for participating teams and team members, including support for taking the decision whether community-based breeding is an option (or the appropriate option) under the prevailing conditions.

The guidelines are presented in sections arranged in a logical sequence to help users to follow the steps in implementation. However, as outlined in Section 4 genetic improvement is only one component of population breed improvement and development. Strategies aimed at improving nutrition, marketing, health, housing, and the welfare of the animals, as well as other related services have to be taken into consideration when developing a breeding program.

Although the guidelines outline the necessary requirements and the implementation process, they also point out and discuss the limitations. Embarking on the development of a breeding program, no matter whether community based or centralized, is not simple and therefore should not be taken lightly. For a breeding program to be successful and sustainable, long-term commitment of all stakeholders is crucial as success and tangible impact will only be achievable after several generations and many years of consistent collaboration among the key actors.

3. Implementation Guidelines

3.1 Selecting target breeds and communities

3.1.1 Selection of breeds

When initiating and implementing community-based breeding programs it is important to pick the right breeds, populations, and locations to work with. There are a number of criteria to follow in selecting target breeds and communities. In our sheep project we selected four breeds for the following reasons:

- The breeds are the most populous in Ethiopia with a wide area coverage, thus interventions would have far-reaching impact
- The breeds are kept by resource-poor farmers/pastoralists
- The breeds are genetically diverse as evidenced by previous phenotypic and molecular characterizations
- There is a good potential for genetic improvement of the breeds
- Regional research centers with relevant expertise and interests are available within reasonable reach of the communities who keep those breeds
- Reasonably good background information is available on the breeds and production systems, on which the planned and future research and development work could be based
- The areas are comparatively easily accessible.

3.1.2 Selection of community

Selection of the right community has been recognized as key to success of community-based programs. Some essential factors to consider in selecting target communities for a community-based breeding program include:

External factors

1. Market access: distance to market, transportation of products, and quality of roads. This is also critical as the market is the major driving force for improvement and development projects
2. Consider potential or possible negative or positive impacts by other projects: e.g. irrigation might result in more cropping and less livestock activities. A crossbreeding program could jeopardize the breeding program as farmers would see impacts in the short term that trigger their interest and cause them to abandon or disregard the agreed breeding plans
3. Synergies with other projects: it is important to scan for possible involvement of other stakeholders, if available allow room for their participation; for example a development program, that could actually provide the enabling environment for the realization of the project ideas
4. Government support: although this applies to the whole sector and not to a specific community, it should be considered what local developments are occurring in relation to policies and government priorities; e.g. the development of abattoirs and feed producing plants
5. Support from NGOs
6. Availability of inputs and services (public vs private): existing or potential for development. These include forage seeds, feeds (roughage and concentrates), veterinary drugs, veterinary services, drug vendors, extension systems (technical advice), and market information systems.

Community-related factors

1. Willingness/interest of the community to participate in the project
2. The key species of interest, in this case sheep, should be a priority: a substantial portion of income should be generated from targeted livestock species. Set a minimum percentage for selection in relation to the importance of the target species at the national level
3. The community should have a sufficiently large (combined) sheep flock (> 500 ewes): the distribution of the flock within the community should be fairly equal (disparities should be avoided, e.g. situations where one farmer has 400 ewes and a few farmers have 10 ewes each).
4. Existence of communal/shared resources or institutional arrangements. For example, common grazing land or watering points, and or common use of breeding rams, herding or marketing facilities. These indicate that already some common facilities exist that require collective actions; the existing institutional setup could be therefore used as the starting point for developing the institutional structures of the breeding program
5. Presence of community leaders (elders) and champion farmers/ pastoralists who are very important in social and traditional structures in the region. They should be involved as community-level facilitators to work closely with the project's team. It is critical to identify such persons as early as possible with the help of farmers/pastoralists and also extension workers, researchers, and NGOs that have previously worked in the area or are still working in the area. Religious leaders could also play important roles.

Suggested steps to follow for selecting the communities

1. Consult with extension people, researchers working in the area, former livestock specialists who know the area, NGOs, and development projects. It is useful to build an inventory of stakeholders, and a map of actors including roles and responsibilities. Let these resource persons suggest the potential or candidate communities to visit
2. Visit the communities, if possible accompanied by people that have already developed trust (provided they agree with your goals)
3. Organize a participatory workshop – this is a very important key step. The beneficiary community as well as key stakeholders including public sector (extension, researchers, cooperatives, microfinance, and administration) and private sector (NGOs, traders, brokers, butchers, export abattoirs, feed suppliers, and drug vendors) should be carefully identified for participation. Gender balance also needs to be considered. Such workshops should be organized when the community is not occupied by farm activities and facilitated by somebody who knows the culture and language of the community
4. Document the whole process, preferably done by a communications expert.

3.2 Characterization of target sites and breeds

3.2.1 Description of the production system

Assuming that some broad information on the production system is already available from secondary sources, the characterization of production systems for the purpose of the breeding program should concentrate on additional issues, including:

- Importance and function of livestock in the system and use of livestock products
- Economic evaluation of production (production costs and returns from sales)
- Current breeding practices (management of males and females, herd structure, gene flows, including exchange and/or acquisition of new breeding animals)

- Marketing channels and opportunities for marketing animals and animal products
- Institutional settings that affect breeding and animal management, including marketing (decision mechanisms within the community).

This information should be collected by standard methods such as Rapid Rural Appraisal and farm monitoring, with active participation of farmers to provide the answers to the 'what' type of questions, followed by workshops with focal groups to provides answers to the 'why' and 'how' type of questions. This will help in more precise design of surveys and to validate information collected at household level.

Mixed crop livestock production system in Menz, Ethiopia

3.2.2 Breed characterization

Populations of livestock species in developing regions are traditionally recognized as distinct types by ethnic group or geographical locations, from where they often derive their names. Preliminary identification of breeds or populations involves phenotypic characterization of distinct populations using a combination of stratified and purposive sampling strategies. Qualitative and quantitative descriptions, including morphometric measurements of animals, are collected through farm-level surveys to identify and describe the representative samples of animals from the targeted populations or breeds or breed groups. For this purpose, a comprehensive list of animal descriptors was developed by FAO (1986) and Ayalew and Rowlands (2004).

Phenotypic characterization

Qualitative and quantitative variables to be observed and recorded include:

- Phenotype: qualitative variables such as coat color, fiber type, face profile, presence of horn, and tail type, and quantitative characters to be measured are body weight, withers height, body length, and heart girth
- Phenotypic performance characteristics, such as body weights of adult males, daily milk yield at onset or peak lactation, and lactation length
- Flock/herd-level reproductive performance data (e.g. ewe fertility, lambing rates, prolificacy, and pre-weaning survival rates).

Means for each quantitative measurement are calculated to describe each population sampled. Related indigenous knowledge systems can also be collected at this stage.

Horro ram, Ethiopia

Molecular genetic characterization

Molecular genetic characterization of populations broadly involves assessment of the level of genetic diversity within and between populations. Genetic characterization tools include biochemical (protein) polymorphisms and molecular polymorphisms. Polymorphic molecular genetic markers include microsatellites, single nucleotide polymorphisms, restriction fragment length polymorphisms, randomly amplified polymorphic DNA, mitochondrial DNA markers, Y-specific alleles, and amplified fragment length polymorphisms. Microsatellites have become markers of choice for diversity studies because of their co-dominant nature, ease of amplification, and hyper variability. FAO (2007) recommends about 31 microsatellites markers for characterizing sheep. Recently, SNPs have been used extensively.

3.3 Definition of breeding objectives

The breeding objectives and the selection criteria or traits, on which the livestock keepers wish to improve and base their selection, have to be understood. In this regard the homogeneity and heterogeneity of breeding objectives and selection criteria among community members, as well as between neighboring communities, should be assessed. Uniform and consistent views of farmers facilitate the creation of a common understanding and working towards a clear formulation of common objectives.

As the market demand is of utmost importance for the long-term economic benefits from keeping a certain breed or breed combinations, information on current and predicted consumer demands (e.g. size of carcass and meat quality) from different markets need to be collected. Valuable market-related information from key market agents such as traders, abattoirs, butchers, food industries, restaurants, and in some cases also individual consumers (end-users) are important as well and should be collected and analyzed.

A cross-check of the current breeding objectives of the communities and the market demands allows a validation of the suitability of current objectives. The findings from the market study have to be presented to the involved communities, and in the case of discrepancies required adjustments have to be discussed and decisions taken.

Different participatory approaches can be used to describe breeding objectives of communities. Some of these methods are briefly described below, and advantages and disadvantages of each method are summarized (Table 2).

3.3.1 Personal interviews

One option, often the starting point in defining breeding objectives is to interview individual farmers and ask each of them to list and describe the traits that are of economic interest to them, and what selection criteria they respectively employ toward achieving the stated objectives. This process is best done with key and knowledgeable, not necessarily all, local villagers. The listing of preferred traits is then followed by asking or facilitating the producers to independently rank or assign a score for each of the traits or trait categories. The respondents should not be influenced by a pre-defined format. If a person does not recall any criteria, the facilitator can help them by suggesting some points; however, forced answers must be avoided.

3.3.2 Workshops (focus group discussions)

A group of 8–15 persons can be invited to discuss their opinion on breeding objectives and selection criteria. Such a workshop has to be facilitated by at least two persons: one moderating the discussion and one recording the information on a flip chart or a board. Where necessary, an interpreter, should be used to ensure clear and common understanding is maintained. The information should be clearly presented and made visible, and where necessary diagrams or charts should be used to illustrate the issues during the whole workshop to all participants. The task of the moderator is to ensure that each participant can freely express his/her point of view. In such discussions it is usual that long lists of preferred traits are compiled initially; however, the facilitator should help the participants to shorten/limit the list to key and most valuable traits only, by pooling related traits, ranking all the re-listed, agreeing on the ranks, and then finally ranking the final listed traits ensuring that traits that are valued most are captured.

Farmers' group in Bonga, Ethiopia, discusses breeding objectives

3.3.3 Choice cards experiment

To design choice cards experiments, valuable information about farmers' preferences for different traits should be gathered from the survey questionnaire results. Respondents are presented with a series of choice sets, each containing five or six alternative traits. For example in our sheep project, six traits for ewes (body size, coat color, mothering ability, lambing interval, twinning rate, and tail type) and five traits for rams (body size, coat color, tail type, libido, and presence or absence of horns) were used, with the exception of one sheep breed (Afar) where one additional trait (milk yield) was included for ewes. From each choice set, respondents are asked to choose their preferred alternative. The attributes used are common across all alternatives. Each of the traits is grouped into contrasting classes (i.e. 'good' or 'bad'). There is also the possibility for opting out. The trait categories are described to interviewees using drawings of hypothetical types of sheep (Figure 2). For those traits that cannot be described using drawings, trade-offs between the different trait categories are described verbally. Additional information, often picked up from group discussions could be added to the choice cards to investigate interactions between such information and the traits presented in the cards.

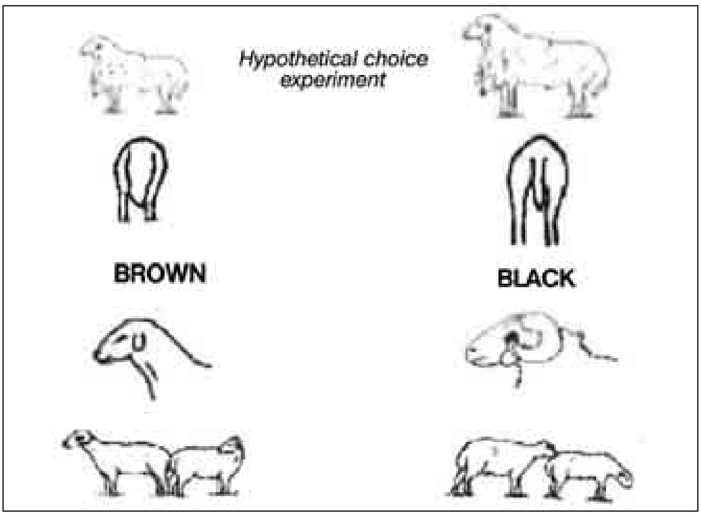


Fig. 2 Example of a 'choice card' tool used to describe breeding ram trait preferances

3.3.4 Ranking of live animals

Ranking of own animals

The sheep owners are asked to rank their own animals (female and males) from the 1st (best), 2nd (second best), 3rd, and worst, and to indicate reasons for their ranking. After receiving detailed information from the owners, linear body measurements including body length, chest girth, heart girth, tail length, tail circumference, body condition, and dentition are taken on each individual ranked animal. This is to assess the correlation between the farmers' rankings and the actual quantitative measurements taken on animals of same age or age groups, and what such relationships/ correlations mean. All family members can participate in this exercise. Often there are not many rams in the flocks and therefore it is difficult to accomplish this exercise with males.

Horro, Ethiopia. Farmers do ranking of their breeding ewes

Ranking of animals not known to farmers

Another option is to ask farmers to rank animals which are unknown or unrelated to them (i.e. other peoples' animals). These animals could originate from a research station or from other, distant farmers. For this method, the focus is first on the phenotypic appearance of the animals. The test persons can then be provided with additional facts on production and reproduction on each animal to further inform his/her decision. It is important that each test person is provided with identical information on a given animal (Box 1) .

Box 1. Group ranking of sheep

In the ICARDA–ILRI–BOKU sheep breeding project, 15 ewes and 15 rams were randomly selected from the communities' flocks at each study site, marked and randomly assigned into five sub-groups and then penned together. A total of 30 sheep owners from each site were moved to the other site (each location has two sites) so that farmers were ranking animals with which they were not familiar. Each interviewee was asked by an enumerator to rank the animals within each pen according to his/her own preferences and give the reasons why s/he had chosen the animals as 1st, 2nd, and 3rd. Then they were provided with a life history of the animals, including information on productive and reproductive traits to determine whether they would change their rankings.

Menz, Ethiopia. Farmers rank sheep not known to them

3.3.5 Comparison of methods

The different methods described for defining breeding objectives have advantages and shortfalls (Table 2). One has to analyze the practical situation on the ground before decding on the methods to be used.

In general, to make sure that no selection traits are overlooked, a combination of at least two methods is recommended. Selection traits should have the following features:

- Relate either directly or indirectly to the breeding objectives
- Easy to measure under field conditions
- Heritable
- Not too many (not more than three under smallholders situations)
- Relationships between selection traits should be understood, as antagonistic relationships (i.e. traits which are negatively genetically correlated) between two traits mean improvement in one trait will result in deterioration of the other trait.

In the Ethiopian community-based sheep breeding programs, we followed the different methods described and defined breeding objectives and selection traits of the communities (Table 3).

One difficulty is how to include adaptive traits of local breeds to various stress factors of the environment (e.g. diseases, internal and external parasites, water scarcity, and walking ability). These traits are often difficult to record under field conditions. However, given that these are extremely important traits for small ruminant production in tropical and other harsh environments, mechanisms should be sought to include them in selection decisions. For example, resistance to internal parasites could be measured by fecal egg counts (easy to measure) and has been shown to be heritable (Baker 1998). Because all animals are equally exposed to the same stress factors, often to similar magnitudes, one can assume that the best performing animals under the given production environment must be the best adapted to the prevailing conditions. For example, under conditions where animals all graze on poor quality pastures the fastest growing animals, among those grazing the same pastures, must be those able to cope best with such forages, and hence should be selected as the future sires and dams.

Table 2: Advantages and disadvantages of alternative methods of defining breeding objectives

Properties	**Personal interviews**	**Workshops**	**Choice cards**	**Ranking of live animals**	
				Own animals	Unknown to farmers
Advantages	• A large number of persons can be interviewed • Possible to verify the consistency of the responses • Additional information can be gathered at the same time	• Information from different persons collected at once • Differences can be directly discussed	• Large sample size • Enumerator introduced bias likely to be lower than in interviews • Price can be included as a characteristic	• Relatively easy to handle • Closer to reality than choice cards: Seeing a live animal is better than a picture • Information from different family members can be considered	• Easily done by farmers • Closer to reality than choice cards: seeing a live animal is better than a picture
Dis advantages	• Language barrier • Enumerator-introduced bias may be high • Important traits may not be mentioned	• Some people (e.g. with higher social status) might dominate the discussion	• Limited number of animal profile choices can be made per person • Visual illustration of some traits can be complicated or impossible	• There may not be enough animals of the same category available in small herds	• Large 'pool' of animals often not readily available Hypothetical life history provided with a given animal may not be compatible with the visual appearance according to farmers' experience • Limit to the number of additional traits that can be included
General comments	• Access to farmers is often difficult • Clear sampling strategy needed • Unclear results, if farmers have no common breeding goal				

3.4 Assessment of alternative breeding plans

There is no single most suitable method for designing breeding plans that fits all possible circumstances. Thus, one option is to evaluate the results of alternative designs through modeling in order to choose the best under the given circumstances. There are two basic approaches for modeling and evaluating breeding programs: deterministic and stochastic models.

Stochastic simulation is the easiest of the approaches. Its advantage is that one can mimic the true breeding program in detail with more precision because the individual animal is simulated. Its disadvantages relate to time/computer power requirement and the user does not gain much insight compared to the deterministic approach. Simulation of a large number of replicates of a large breeding scheme may take from several hours to days, making the approach less suited as an operational tool to quickly evaluate alternative schemes. Since stochastic simulation does not explicitly model mechanisms (e.g. accuracy and generation interval) the user may not be able to appreciate the relationship between the determinants. Hence it is difficult to extend results to other breeding schemes that have not been simulated. Examples of the stochastic computer programs include ADAM, EVA, and SixS.

The deterministic method does not mimic the breeding program on the individual animal level but use deterministic equations and population parameters to predict gain and inbreeding. Hence it requires more insight into quantitative population genetics than stochastic simulation. Advantages of deterministic methods are short computation time (many alternatives can be computed within a limited time) and it gives a lot of insight into gain and inbreeding within breeding programs because the mechanisms are modeled explicitly. Software packages available for deterministic calculation include ZPLAN, ZPLAN+, and SelAction.

In this guideline we limit ourselves to the most widely used deterministic model, ZPLAN, which was developed in 1980s at the University of Hohenheim, Germany. It was designed to optimize livestock breeding strategies by deterministic calculations. It evaluates both the genetic and economic efficiency of breeding programs considering one selection cycle. ZPLAN is written in FORTRAN and allows flexible modification of existing subroutines to model desired breeding scenarios as realistically as possible. The optimization of a particular breeding program in ZPLAN is based on three functional core areas: selection index procedure, gene flow method, and economic modeling. Important outcomes of ZPLAN include annual monetary genetic gain for the aggregate genotype, annual genetic gain for each single trait, and discounted return and discounted profit for a given investment period.

Depending on the particular situation, in the design and evaluation of a potential breeding program, the following basic decisions must be taken and selected in ZPLAN:

- Defining of tiers in the breeding plan
- Defining of sexes in the selection group
- Indicate paths of gene transfer from one group to the other.

Then input parameters (input files) such as population, biological, and economic cost parameters are defined by the users. Furthermore, phenotypic and genetic constants are required for modeling alternative breeding plans (Box 2).

Once a breeding program is operational, the realized genetic improvement over the period of interest can be compared with the predicted values. Reasons for the observed differences, if any, can be examined and new strategies developed to rectify or accelerate progress towards the desired outcomes.

Box 2. Input parameters required to run ZPLAN

Input parameters: input parameters (input files) are defined by the users and can be subdivided into:

1. Population parameters
   - Population size (females)
   - Number of proven males/year
   - Proportion of male and female animals in different tiers
2. Biological parameters
   - Duration of breeding females' and males' use (time unit)
   - Mean age of females and males at birth of first offspring (time unit)
   - Mean time between subsequent lambing/kidding/calving (time unit)
   - Mean number of offspring per litter (e.g. litter size in sheep and goat)
   - Mean number of offspring per female per time unit
   - Survival to weaning/yearling
3. Economic/cost parameters for a given investment period
   - Fixed and variable costs/breeding female: increased cost per unit should be discounted when calculating relative economic values. These values may vary from breed to breed or from region to region within the same breed. Only additional feed or labor costs spent over the normal husbandry practices have to be included during simulation.
   - Interest rates of return and costs: have to be based on real rates of interest/cost (i.e. bank account interest rates of specific region or country). It is commonly recommended to use slightly higher discount rates for returns than for costs, because returns are realized later than costs.
   - Investment period is defined in time unit. For instance, for cattle and sheep one time unit is one year and for pigs it is six months. It has been quite common in animal breeding studies to define the investment period as three or four times the mean generation interval of the particular species under consideration.

Phenotypic and genetic constants:

- Phenotypic and genetic standard deviations for goal traits
- Phenotypic and genetic correlations between each pair of goal traits
- Heritability estimates (heritable fraction of the variance in each trait)

Estimates for phenotypic and genetic constants are lacking for most indigenous breeds in low input systems. In that case, literature-based information estimated from breeds found in similar production systems or production environments should be used.

3.5 Developing adequate breeding structures

3.5.1 The breeding program

In Sections 3.1 and 3.2 the aspects critical for the target community, farmer group, and breed were indicated and discussed. Also discussed were how to target the animal population to be genetically improved. This section on the breeding program considers the identified animal population in terms of its biological characteristics, together with husbandry practices under which it is raised, the prevailing and anticipated infrastructure, as well as the constraints and opportunities – all of which, if appropriately considered, enable the design of a program which maximizes both genetic gain and profit for the community.

The simplest and most straightforward design is one in which the best males and females are selected as replacements (i.e. future parents of the next generation) from the whole population. This means that all the herds/flocks would be monitored and be involved in screening for these 'best' individual animals. The problem with such a design is that each member of the participating community would have to be involved, somehow, in the selection process. Each farmer therefore will undertake performance recording, pedigree recording, and rearing of male candidates; the latter, at least up to some defined age, which may not always be practical.

Performance recording may be kept at a minimum or performed in stages. Rearing of male candidates, at least post-weaning, may be centralized at a test station or may be entrusted to a few selected members of the community.

An alternative design would be to have some farmers with 'best' animals and often 'best or average practices' to breed males for use by the whole population. Such designs with structured populations are called 'nucleus systems'. Nucleus farmers concentrate on maximizing genetic gains while the remaining 'base' farmers can concentrate on production. In this case best males and females are mated in the nucleus, in order to produce the 'best' next generation of young animals, thus increasing the probability of having better gene combinations in the progeny at the nucleus compared to the rest of the population.

For the designs above to deliver, the nucleus must be functional, that is nucleus farmers not only have to make genetic progress but also have to consistently produce and disseminate appropriate number of genetically superior males to nucleus and base populations (farmers' flocks/herds). Thus, the size of the nucleus, or proportion of females to the total community herd/flock which should be in the nucleus, depends on the number of males needed by the entire system – taking into consideration a desired selection pressure or intensity. A minimum effective population size is also required to avoid inbreeding at the nucleus. For example if we desire an annual rate of inbreeding to be $< 0.5\%$ in a nucleus with average generation length of 3 years, effective population size must be > 33 (for example 9 males and 100 females).

The nucleus can be either closed or open. A closed nucleus means no upward (from base to nucleus) gene flow is allowed, while an open nucleus allows the best sheep to enter the nucleus from the base population (Figure 3).

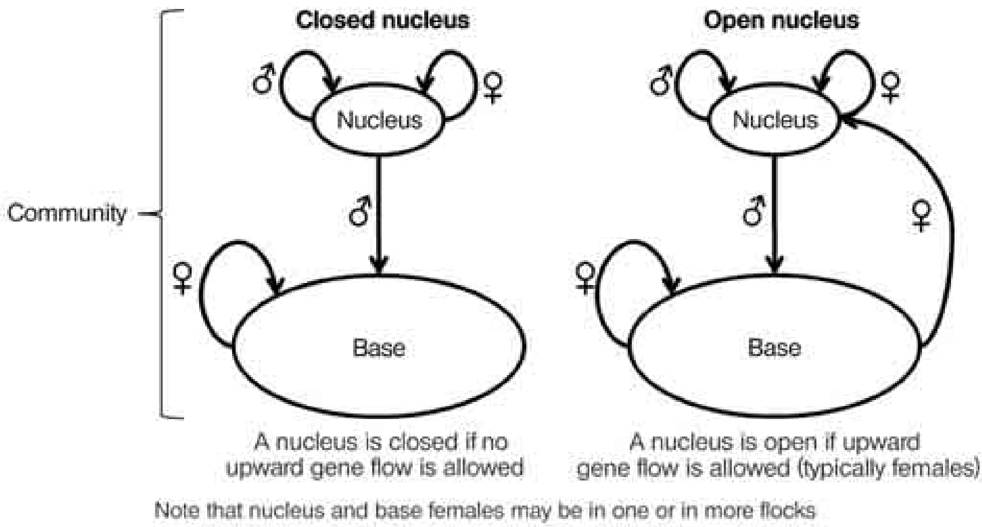


Fig. 3 Open and closed nucleus schemes

Open nucleus systems (Figure 4) require base farmers to do some selection, usually on the females. Usually females for the nucleus are supplied in exchange of males, but other arrangements are possible (e.g. cash, in kind, or percentage of sales). A very important feature of open nucleus systems is that adaptation traits and other breeding objective preferences in the base population are secured in the males produced since these are born from 'best' base females (Box 3).

Box 3. Open Nucleus schemes for Merino sheep

In Argentina open nucleus systems are common for Merino breeding communities. Nucleus flocks are established with best females and half of their replacements are selected from the base flocks. Males are selected on measured performance and visual inspection. Rams performing above average and that are visually acceptable get a special identification from a breeder's society. From these the best remain in the nucleus and the next best are used in the base flocks.

The rate of inbreeding can be reduced and genetic progress increased in the so called 'open nucleus' systems. In such systems the nucleus is 'open' to best animals detected in the base population. Typically very good females born in the base replace worst females in the nucleus. Typical designs have 5–15% of the total female population in the nucleus and have about half of the nucleus replacements come from the base. For example a community with a total of 700 breeding females would need about 70 breeding females in the nucleus. If 20 nucleus female replacements are needed each year, 10 should be selected from nucleus progeny and the other 10 from base progeny. The proportion of females in the nucleus and the proportion of base females going to the nucleus can be smaller if selection is more accurate in the nucleus or reproduction rate is high or the female to male ratio is high.

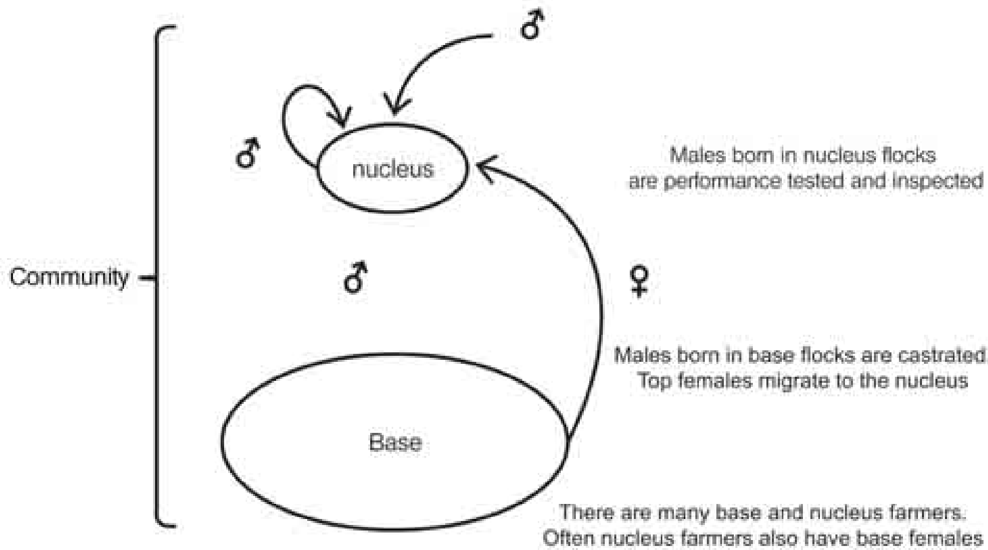


Fig. 4 Open nucleus scheme: nucleus and base flocks. Example, Merino Sheep Breeding Program, Argentina

We assumed that all animals of nucleus farmers breed males since all their females are supposed to be 'best'. This is not necessarily the case, as a nucleus farmer may also have inferior females. In that case the nucleus farmer may identify his 'best' females and mate only these with 'best' males, or he may mate all his females with 'best' males but consider for selection only the progeny of 'best' females. There will be several nucleus farmers with only some of their females qualifying as nucleus animals. Such a system requires controlled mating at the nucleus farm or early castration of male progeny from non-nucleus females.

For practical reasons, it is difficult for the individual farmer to raise male candidates from birth until final selection. Variations in level of husbandry between farms can create serious confounding, making clean separation between genetic and environmental superiority rather difficult. To get around such a problem, young candidate males, usually at weaning, are gathered and placed in one common station or farm; here their performances are jointly monitored under the same conditions for a fixed period of time. This process is known as 'performance testing' and the common station as the performance-testing station. Such a station may belong to the community itself or may be facilitated by an external organization (Figure 5).

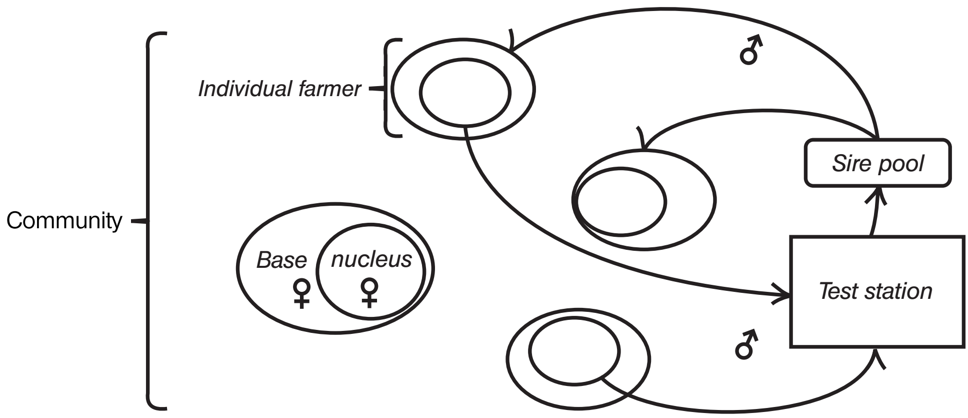


Fig. 5 Open nucleus scheme: dispersed nucleus. Example, Bonga and Afar Sheep Breeding Program, Ethiopia

In cases where nuclei are run and managed by several farmers, but all following similar management procedures and selection processes, then the nucleus is referred to as 'dispersed'. There are also programs with a single nucleus-farmer producing males for a group of farmers. Such systems are also called 'group breeding systems'. The principles of open nucleus systems apply; however, considering that 5–15% of the female population should be in the nucleus, group breeding schemes are appropriate for farmers with typically > 100 breeding females each or for a situation with a nucleus farmer is individually running a large flock.

For smallholders, large individual flocks are uncommon, but there are examples with community single-nucleus flocks or cooperative-nucleus flocks (Mueller et al. 2002). Sometimes a single 'central' nucleus is run by an external organization such as a university or a governmental body. In this case the design essentials regarding nucleus size and gene flow still apply but the control of the community over its breeding program may be low. Nevertheless there are also examples of community breeding systems which started with a 'centralized' nucleus and developed into a dispersed nucleus system. Such dispersed nuclei in turn may develop into reference sire schemes and eventually into population-wide evaluation schemes (Abad et al. 2002).

In conclusion, there are many alternative breeding structures and tools for its optimization. The tools are useful for a strategic optimization of a breeding program. In practice, however, many variables are fixed and a program can rarely start with an optimum structure in terms of layer size and gene flows. Thus, practical situations need tactical optimization, which means finding the best solution at each step of the program while having a target structure in mind.

3.5.2 Animal identification

Animal identification is crucial in genetic improvement programs. Animals should be uniquely identified, so as to accurately trace their respective pedigrees and link the performance of individual animals to her/his progeny and relatives through known genetic relationships. Combining performance and pedigree records enables more accurate computations of the genetic worth or breeding values of the animals to be estimated or predicted, and used for selection.

The identification methods employed can vary between regions and communities. Ear tags, collars, tattoo, branding and ear notches can be used. Ear tags are the most commonly used identification methods because they are relatively cheap, easy to apply, and are less stressful to animals. However, in some situations, where for some reasons ear tags are not acceptable or practical, for example because of cultural taboo or shape of the ear, other alternatives should be sought.

Unique numbering should be embraced, such that any two animals in the breeding program should never have the same identity, both in time and space. In our project we used a unique identification/ numbering system (five digits) per community. Plain plastic ear tags were procured, identification numbers were hand-written using indelible markers and all sheep belonging to community member households were ear-tagged.

The identification of the base population was done by the research team. Thereafter, identification of newly born lambs was undertaken by village enumerators. Ultimately, community members should be trained to handle animal identification by themselves.

Animal identification using ear tags

3.5.3 Data recording and management

Development and use of a simple, flexible, and cost-effective performance recording and evaluation system is essential for the breeding program. The recording formats should be kept as simple and as practical as possible for easy use and adoption.

In accordance with the agreed selection traits, three recording formats were developed for each location in our sheep project: two for ewes and one for lambs. The ewe format contained information such as lambing date, parity, and litter size. One of the ewe data formats had detailed information about the ewe (Annex 1) and was kept with the enumerator. The second ewe data format, however, had less information to be recorded by the household and was kept by each household. The lamb data format had information about lamb identity and performance. These formats were developed after a thorough discussion with the community.

Major traits considered for all breeds were weight (at birth, weaning, six months, and yearling) and number of lambs weaned. In addition, milk yield for Afar, number of lambs born (twinning) for Bonga and Horro, and wool yield for Menz were included.

Weighing of animals

In a community-based breeding set up, the ultimate goal should be to ensure that the community can handle and indeed does handle all activities required for the program to be functional at community level. At the initial stages, however, assistance is needed. In our project, an enumerator was employed for each community to assist households in measurement and record keeping and to continuously train them on how to do it. A recording book was prepared for each household for day to day follow up and one recording book, kept with enumerators, was provided per community. All necessary equipment (e.g. weighing scales, ear tags, and markers) should be made available for effective recording and follow up until the community masters the major activities.

Performance records used in the ICARDA–ILRI–BOKU sheep project

Appropriate training is crucial for success and should be organized for both enumerators and the community and offered in easily digestible components (i.e. not rushed and offered all at once). The type of data and frequency of collection need to be decided upon in close consultation with the community and must be based on the agreed breeding objectives and selection traits. The simpler it is the better and the higher is the probability of its sustainability. First, focus should be on the key few (3–4) traits only, with additional traits added to as and when necessary as the groups mature and become more sophisticated.

One should also discuss with the individual households to identify and agree which family member could be in charge of the data recording and handling. It is sometimes useful to engage school children, as adults might be illiterate. In this case, supervision by an adult person ensures that data are recorded on time and kept in a safe place. In our sheep project the type of data collected is summarized in (Table 3).

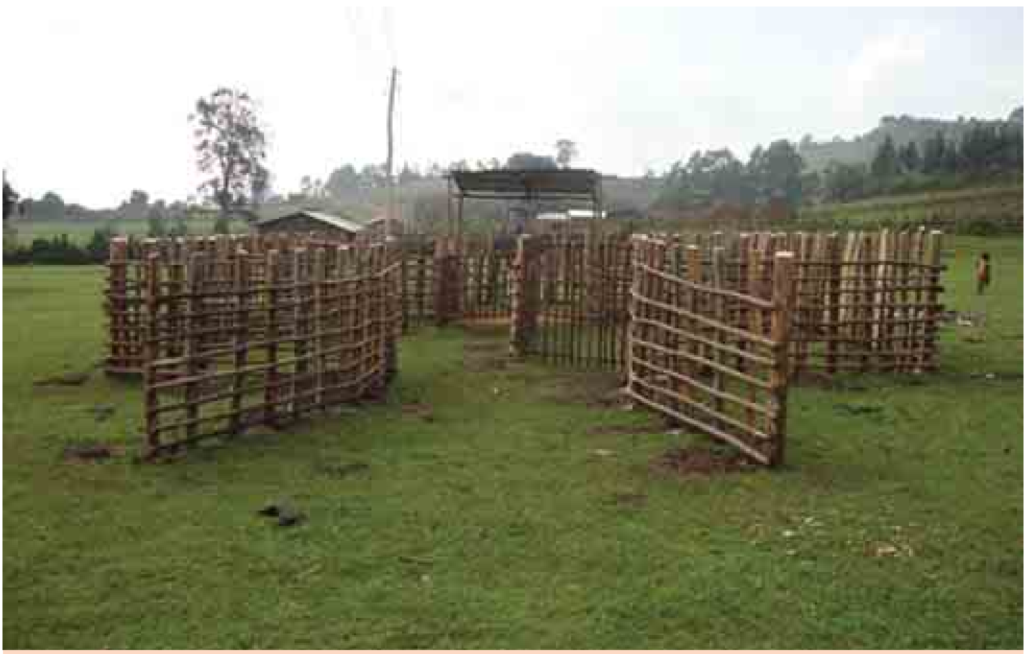
Table 3: Traits recorded in four sheep breed improvement communities in Ethiopia

Breeding objectives	**Traits recorded**	**Afar**	**Bonga**	**Horro**	**Menz**
Body size	• Birth weight • Three-months weight • Six-months weight • Yearling weight	√ √ √ √	√ √ √ √	√ √ √ √	√ √ √ √
Lamb survival	Proportion of lamb weaned/ewe	√	√	√	√
Twinning rate	Number of lambs born/ewe/lambing		√	√	
Wool yield	Greasy fleece weight (yearling)				√
Milk yield	Test day milk yield (once a month)	√			

Support in data entry and processing should be provided by the local/regional research centers. The local or partnering research institution can play this role, but once the database is developed and in place, the database can be updated on a near real-time basis through innovative use of aids such as cell phones, and verified via the same devices. Centralized data management tools would facilitate easy data capture, analysis, and reporting. Simple indices based on the set selection criteria for each breed should be developed and the overall merit values computed and shared with the communities and farmers as part of the feedback and for use to effect selection.

3.5.4 Selection of candidate rams

Young rams should be selected based on recorded data (own and maternal performance) for the set of agreed selection traits. Selection can be undertaken at different stages. For example, the first stage could involve culling of animals with undesirable phenotypic characteristics (e.g. tail type, coat color, horns, conformation, and general appearance) and clearly observable and genetic defects (e.g. testicle deformation and undershot or overshot palates). The retained individuals are then further judged based on morphometric and body weight. The stages at which the selection process takes place depend on both the existing traditional practices of ram selection and use, as well as on scientific requirements. If the selection decision can be made in line with the traditional practice, it will improve the probability of acceptance by the community.



Holding yard at Horro, Ethiopia

For good reasons, it is important to cull undesirable males before they reach puberty (i.e. before they can serve). Depending on the breeds, this can be as early as 6–8 months of age. Where communal grazing is practiced, synchrony and agreement on when to cull is important as flocks can meet in common pastureland or watering points, when the undesired entire males can breed, and hence reduce the selection impact. It is also important that the selected young males are effectively used for breeding before they are sold off in order to avoid negative selection.

Candidate rams for breeding in their holding yards at Horro, Ethiopia

When the breeding program is fully functional the best rams should be identified by their breeding value computed from recorded data and based on their pedigree. Animal models can be used to rank rams. If breeding values cannot be computed for whatever reason, rams can be selected based on simple index values that are computed from the available recorded data from the site population. The community has to be actively involved in the selection process so that the ram ranking closely match their (own valuations) goals and desires. This helps to build trust and confidence, buy-in, and a sense of belonging among the beneficiary community that increases both their confidence in the selected rams and ownership of the process (Box 4).

Box 4. Selection of rams

In the ICARDA–ILRI–BOKU project two stages of selection were applied: initial screening at the age when first sales of young rams occur (4–6 months) and final selection for admission for breeding at 12 months of age. All young rams are collected at one central place in each community on an agreed screening date. Selection is then carried out based on the data analyzed. A breeding ram selection committee composed of about 3–5 members elected by the community are involved in the selection. In here, if for example 15 rams were to be selected from a total 100 candidates, say 20 would be preselected based on their breeding value and the culling of the last five and the ranking of the selected rams would be made by the committee. The joint selection process strengthens the linkages between farmers and researchers.

Animal exhibitions or shows could be linked with the ram selection events. During such shows animals of different sexes and age categories could be ranked and the best ones awarded prices along with the best young rams. Animal shows are important as they can create awareness at the entire community of the higher relative worth of selected breeding animals compared to the unselected ones. Individual livestock keepers who manage their flocks and records better could also be awarded during such shows, thus creating healthy competition among the community members. This also has a social dimension in that winners are recognized in public and creates some level of social status, with pride to the winners and respect from the community. During selections and shows, judging should be done through a participatory process, and preferably by a panel of committee members, who are formed/nominated from among the local site farmers/pastoralist, by the community members. This creates some form of ownership and transparency.

Awarding of rosettes to the best breeding ram

3.5.5 Management and use of breeding rams

In cases where the individual flocks are quite small, the flocks should be treated as one flock. Selection would then be undertaken at community-flock level, with the selected best rams shared among the community members thereafter. This is often the case in smallholder mixed crop–livestock systems. In some communities such tradition of ram sharing may already exist; however, in other communities members may be reluctant to share rams outside their established social networks. Repeated consultations should be made with the community to arrive at an agreed modality as there is no single arrangement that applies to all situations. In our project, the modalities for ram exchange that were discussed with the communities included:

- Sharing rams based on friendship and trust among members of the breeding group
- Exchanging rams based on a written agreement
- Exchanging rams based on purchase between different breeding groups when rams complete the defined service period in a given flock
- Advancing some seed money from the project or from members' contributions to purchase the first round of breeding rams, use these, then sell them to generate a revolving fund to purchase the next and subsequent rounds of breeding rams.

It should be noted that one or a combination of the above arrangements may be adopted or used depending on the prevailing circumstances. In our project, the last option was chosen. It is expected that creating a revolving fund will sustain the program in the long term. This also helps to prevent the negative selection of rams that is a common phenomenon in the communities. Negative selection arises from faster growing males being sold off early before they are of breeding age, leaving the slower growing males as the breeding males in the community flocks. To avert negative selection, the best young rams are purchased by the project and are owned and used by the community. After two years of service (period to be agreed with the community), such rams are to be fattened and sold to support the purchase of the next group of selected rams for the community. Mechanisms of how to use the revolving funds and how benefits will be shared have to be agreed upon and the by-laws and an administrative procedure established.

The best way to use rams communally is by forming 'ram-user-groups' and this can be based on criteria such as number of breeding ewes, settlement pattern, and use of communal grazing areas.

Traditional ram use groups are often based on social networks and perhaps resource availability and thus these should be considered where and when applicable. In order to minimize inbreeding a strategy for ram rotation among the ram groups has to be established through a consultative process. Our project was planned such that a ram is used in flocks for one year after which it is rotated to another ram-group within the community. The ram rotation records must be diligently kept to avoid inbreeding. The management of selected breeding rams to be used by the community should be based on prior-agreed modalities. Some of the options include:

- Manage the ram in rotation
- Keep the ram in one agreed household and those who use the ram pay an agreed amount for the service
- Keep the ram in one agreed household and other community members contribute in kind (e.g. feed and veterinary drugs) to keeping the ram.

A critical issue that needs to be thought through is how to manage the unselected rams. It should be recognized that the unselected rams, especially those young rams that fulfilled the initial requirements but got lower ranks than the selected rams, are better than the rams in neighboring communities where no selection program exists. Therefore, mechanisms should be designed to sell these rams. Value addition in terms of fattening could be organized for the unselected rams and linked to markets. If the animals could be pooled together for targeted markets then their value would be much higher than when they are individually sold.

3.5.6 Institutional backup: organizational issues

Community-based breeding programs need to be initially supported by a committed team of researchers, extension personnel, the NGO community, and project staff. The institutional backup needed to implement such a project can vary depending on expertise and resource availability. For illustration, the structure that we used in our sheep project is presented (Table 4), but note that not all community-based breeding programs necessarily need to take such a form. A sufficient period (at least four years) is required for local communities and the national research institutions, before they can take over full responsibilities, ensures sustainability and success.

Table 4: Structure of community-based sheep breeding implementation team in the ICARDA–ILRI–BOKU sheep project

Level	**Team membership**	**Role/TOR**
Project level	Project Coordinator (PC) (plus quantitative geneticist for technical backstopping)	• Overall project leadership/admin • Liaison with project partners • Prepare progress reports
Site level	• Senior researcher (Team Leader) • Other scientists • District office of Agriculture	• Oversee activities on the site
Community level/Team	• Community leader • Community representatives (elected focal point) such as committee/council members, elders, women, youth, government representative	• Community-level leadership • Provide links between project team and the community • Reporting community-level developments • Assisting project logistics at community level • Feedback on progress of project activities
Graduate fellows		• Look at critical aspects of the project

4. Creating an Enabling Environment

4.1 Community-implementers' relationship

It is crucial that the program provides the basis for farmers to effectively interact with researchers and extension staff and to openly discuss their fears, doubts, and ideas about the program. Workshops should be organized regularly to discuss every step of program design and implementation. Informal consultations with community elders would help to get information about the program. It is also vital to provide regular feedback to the farmers. Record sheets of individual flock productivity as deviations from population averages would help the community members to realize performance of their sheep compared to their contemporaries. Even preliminary results have to be presented and discussed with the farmers, thus giving them the chance to comment and share their opinion with the researchers. Such feedback also reduces the risk of misinterpretation of results, which could lead to wrong decisions. The relationships between researchers, extension agents, and farmers/ pastoralists should be based on trust, transparency, and respect, which is expected to evolve through working together closely. An important precondition is to consider and account for the cultural, religious, and ethical values of the community.

4.2 Complementary interventions, services and capacity development

Ideally a breeding program should be part of a broader livestock improvement program. Genetic improvement should therefore be complemented by other interventions, notably, access to improved and affordable health services, market information and market services, improved infrastructure, as well as supportive policies. Development of, and ensuring adequate quality, feed resources and supply all year round will ensure that improved genetics are expressed to their optimal genetic potential.

Legume and grass fields for livestock feeding

The benefits and effects of the complementary interventions are realized within a relatively short period of time, long before the real effects of genetic improvement become apparent or visible. Projects, research and extension departments, and NGOs can assist the program in various ways until the community understands the benefits and start to invest themselves.

The farmers may form cooperatives or farmers associations to ensure better access to markets and stronger negotiation power, and this also means that a larger number of animals and/or quantity of livestock products are regularly marketed. Cooperatives also have easier access to credit and can negotiate with service providers (feed industry and veterinarians) a better price for particular services or products, which can be ordered in larger amounts.

Local, regional, national, and international market-information – for breed, type, sex, body weight-for-age, and price – is key for market participation and market-orientation of farmers and pastoralists.

All in all, the interventions listed above should be accompanied by capacity development for the different actors involved in the program. The capacity development programs should start by mapping of the actors, assessing their respective strengths, and identifying the main gaps in knowledge, organization, and institutional weaknesses at the site level. This should then be followed by listing of priority topics that should be covered as part of capacity development. Tailor-made training programs would then be developed and offered to the different actors. Below are some of these possible actors and the possible areas that can be targeted for capacity development:

Livestock keepers: could get technical support in order to successfully implement the new technologies. Different forms of training should be envisaged, such as a few one-day workshops and trainings on improved husbandry, especially health care, animal housing, feeding, and the essentials of group dynamics, particularly on effective group management (e.g. meetings, recording, and conflict resolutions). Such training is best supported by practical demonstrations in the form of farmer field schools or reciprocal farm visits to neighboring communities to stimulate healthy competition among groups and farmers.

Staff members of extension services: also need to get refreshed and exposed to new related technologies, and nave their practical applications presented to them, as these persons are important key informants for farmers.

Researchers: may need specific training in participatory research methods or to have their knowledge refreshed on various aspects of a breeding program. They can also be trained on data recording, analysis, and effective reporting.

Private sector: this can be such people as drug vendors, veterinary service providers, feed suppliers, traders, brokers, butchers, and export abattoirs.

Financing and insurance institutions (government and private sector): these are essential bodies in accessing credit and also in establishing community-based insurance systems for livestock to deal with issues of death of animals.

It is important to note that more often than not, is the lack of soft skills among community members and the technical support staff that lead to failure of community-based livestock improvement programs. For success, focus on improving the soft skills of the actors, while simplifying the technical aspects is recommended.

4.3 Government support

For breeding programs to be sustainable, long-term commitment by the local and central government is essential. Initially the costs of performance recording and animal identification cannot be shouldered by the farmers, so the government should pick up such costs. In addition, supportive policies should be developed and their implementations facilitated by the government. Adequate funds should be allocated for technical personnel (researchers and extension staff) and infrastructure. Breeding programs require continuous technical and intellectual backstopping from well-trained technicians and researchers.

It is common to find that most of the smallholder and resource-poor livestock keepers have no access to affordable financial services, notably credit. In addition, national budgets for livestock development and research are always limited. Government should therefore facilitate access to credit, land, and other resources (e.g. watering points, rural access roads, livestock auction yards, and market information on livestock and livestock products). Therefore, there is need for better coordination among the various government departments and agencies, scientists, and other development agents involved in such schemes. Such close coordination and networking should be maintained sufficiently long to allow the breeding program to incubate and reach a sustainable stage.

4.4 Links with other projects/activities

The problems facing communities are complex and inter-twined. Piecemeal approaches to development interventions are undesirable and are usually more costly in the long run. Thus, it is of paramount importance to follow a holistic development approach for sustainable development of communities, necessitating integration and coordination.

As much as possible, it is recommended to try and link breeding programs to other ongoing development initiatives and activities in the local area. This will exploit the potential synergies, reduce on redundancies, and overall strengthen the projects. One example could be that a NGO wants to offer training courses to farmers. Members of the breeding program could participate in these courses. Such linkages would also help to get additional expertise and funding to support the breeding program.

5. Monitoring and Evaluation

An integral component of a functional community-based breeding program is monitoring technical and management issues related to the implementation of the breeding program; whether outputs, outcomes and impacts are achieved or achievable; and whether mechanisms to ensure sustainability of the breeding program are in place.

Ultimately, a breeding program should be evaluated by the genetic improvements obtained in all important traits and the effects on total output of products and outputs per unit of measurement, e.g. per animal and the economic impacts at both household and community levels. Ideally outputs should be related to inputs and the status of the natural resources utilized. These change with time and must be revised accordingly. By regularly monitoring the breeding program, corrective measures can be taken to improve the program. Showing the impact of the breeding program will be essential for ensuring continuous support of the program.

For effective monitoring and evaluation, the breeding program team should define key indicators to measure the progress in achieving the main outputs of the breeding program, as well as indicators to assess whether or not the program outputs are contributing or will eventually contribute to the desired outcomes and impacts at individual flock, household, and community levels. Appropriate tools and procedures for monitoring these indicators have to be devised, which should also include clearly defined timelines for each indicator. Although the details have to be specified individually for each breeding program, it is expected that the monitoring and evaluation system for the Ethiopian sheep breeding program proposed in (Table 5) is relevant and applicable for other small ruminant breeding programs.

Table 5: Monitoring and evaluation of community-based sheep breeding program

Parameters	**Indicators**	**How to monitor**	**When to monitor**
Technical issues related to implementation of the breeding program:			
• Proper animal identification	• Percentage of ear-tagged animals in participating households	• Follow-up/control in each participating household through enumerators	Continuous
• Proper data collection, analysis and use	• Number of farmers involved/ dropped out in recording • Estimated breeding values of rams available at time of selection	• Follow-up/control in each participating household through enumerators	Continuous At each selection event
• Selection and management of rams	• Accurate selection of best rams with the community at agreed intervals • Number of active rams included/culled • Community uses revolving funds to buy rams	• Organization and documentation of selection events through NARS • Detailed accounts kept by community of how revolving funds are being managed and used	At each selection event
• Ram sharing	• Selected rams shared and used as planned • By-laws for ram purchase and ram sharing developed and implemented	• Follow-up and documentation by community committee • Documentation by NARS of whether agreed modality is followed or, if there are changes occurring, the reasons for the changes	Regular intervals
• Establishing breeders associations	• Number and participants of formal or informal breeders associations	• Documentation by NARS	After three years
• Complementary interventions: › Value addition for unselected rams › Feed supply › Disease prevention and treatment measures › Proper market linkages	• Number of fattened rams sold and cost–benefit of fattening • Increased quality feed supply • Productivity losses and mortality reduced • Market prices achieved for animals sold by participating households	• Monitoring of quality and continuous supply of feed for flocks and for fattening by enumerators and NARS • Flock records and follow-up of health of flocks and shared rams by animal health workers and vets • Recording of animal sales by households and additional rapid surveys with traders	Regular intervals

Table 5: (Continued)

Parameters	Indicators	How to monitor	When to monitor
Program outputs			
• Level of engagement of the actors in program activities	• Active community breeder committees at each site • Attitudinal change among different actors in the livestock development	• Detailed studies on the behavior of different actors (comparison against the base year when the program started)	After 2–3 years and repeated in subsequent years
• Superiority of breeding animals	• Appearance and performance of the selected animals is better than their contemporaries • Demand from neighbors, etc. for breeding stock produced by the breeding program • Higher price paid for breeding animals originating from the program	• Evaluation of visual observation and performance of the selected versus non-selected rams by community and NARS • Recording of sales and market prices for selected rams by owners	At each ram selection
• Breeding progress	• Genetic and economic gain achieved by the program	• Detailed analysis of genetic and economic gain • Estimation of breeding values and breeding progress by NARS	Annually
Outcomes and impacts			
• Involvement of the community and acceptability of the scheme	• Regular feedback from beneficiaries received and documented • Dropouts of participants	• Meetings with individuals and the community • Documentation by community committee and NARS	Regular intervals Continuous
• Livelihood improvement	• Productivity gain at animal and flock level • Changes in the livelihoods (income, food availability, and work sharing) of participating households	• Analysis of flock records • Analysis of incomes as well as consumption patterns of households against baseline information collected at program initiation	After 3–4 years After five years
• Sustainability of the breeding program	• Economic gains from the breeding programs need to be evaluated • Program being implemented with little 'external' support over long period of time • Feasibility of the program in terms of economic, social, and natural resources dimensions	• Project-related financial expenditures need to be monitored and reports prepared according to plans • Assessment of whether there is any external support to the program • Survey • Impact modeling	Every 3–5 years

6. Concluding Remarks

Community based breeding programs are proposed as an option for genetic improvement of livestock in developing countries. This new approach has been tested with promissing results in few places (e.g. with dairy goats in Mexico and with llamas and alpacas in Bolivia and Peru).

In Ethiopia, we designed and implemented community-based breeding programs for four sheep breeds representing different agro-ecologies and production systems. Although it will take more time until changes in genetic gains can be fully evaluated, the breeding programs have already achieved important ouputs:

- Negative selection has been reverted as fast growing lambs are now being retained for breeding instead of ending up in markets
- The acute shortage of breeding rams observed previously in flocks of participating communities has also been rectified as farmers are now fully aware of the importance of breeding males
- Preliminary data analysis indicates that the market outlet has increased through more births of lambs, bigger lambs at birth and weaning and reduced mortality due to the combination of breeding with improved health care and feeding.

These guidelines aim to address the lack of generic guidance on designing and implementing community-based breeding programs. Though based on Ethiopian experience, the modalities highlighted in the guidelines are largely applicable to similar situations where community-based breeding is an option. As community-based breeding program is a novel approach, the present guidelines will have to be refined and updated as experience in community based breeding accumulates and our tools improve.

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8. Further readings

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Annex 1. Community-based small holder sheep breed improvement in Ethiopia – data recording format

Lamb Format

Farmer	Lamb ID	Dam ID	Sire ID	Litter size	Birth date	Sex	Birth weight	Coat Color	Weight at 3 months	Date	Weight at 6 months	Date	Yearling weight	Date	GFW	Tail

Ewe Format

Farmer	Ewe ID	Name/ Special identifier	Coat Color	Dam ID	Sire ID	Mating date	Ram ID	Lambing date	Parity	Litter size	Lamb ID	Lamb ID	Litter weight	PP Wt	WWt

Ewe Card (to be kept in each household)

Ewe ID Nº/Name:
Coat color:
Birth Date:

Dam's ID/Name:
Sire's ID/Name:
Owner's name:

	Parity Number								
	1	2	3	4	5	6	7	8	9
Mating date									
Sire's ID №/Name									
Lambing date									
Litter size									
Lamb's ID & sex (Lamb 1)									
Lamb's ID & sex (Lamb 2)									
Litter weight at birth									
Ewe post-partum weight									
Litter weight at weaning									
Ewe weight at weaning of lambs									
Number of lambs weaned									

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ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

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