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Participatory definition of breeding objectives and implementation of community-based sheep breeding programs in Ethiopia

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Participatory definition of breeding objectives and implementation of community-based sheep breeding programs in Ethiopia

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DECLARATION

I hereby declare that this thesis is my own original work and that it has not as a whole or partially been submitted for a degree at any other university.

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DEDICATION

In memory of my late fathers, Alemu Jaleta and Duguma Jaleta, whom I lost while I was abroad for MSc and PhD studies, respectively, and unable to attend their funerals.

Abstract

The objectives of this study were participatory definition of sheep breeding traits of smallholder farmers/pastoralists and implementation of community-based sheep breeding programs in different production systems in Ethiopia. Four study areas: Afar (pastoral), Bonga and Horro (crop-livestock), and Menz (sheep-barley) were considered. Choice experiments were employed to define traits preferences in the different production systems. The approach was found to be important to value both tangible and intangible traits; the latter would have been concealed when one uses conventional valuation methods. Traits preferences of the communities were heterogeneous except for body size in rams and mothering ability in ewes. Three measureable traits that were most preferred by the respective communities were selected as objective traits and used for simulation of alternative breeding schemes. The alternative schemes were presented to communities and jointly discussed upon with scientists focusing on the advantages and disadvantages of the different scenarios. Equipped, with this information, the community members finally made a decision as to which scheme(s) they liked and therefore want to implement. Prior to implementation, baseline information was collected for benchmarking and evaluation of the changes that will be realized from the improvement intervention. A total of 1364 in Afar, 1074 in Bonga, 2248 in Horro and 2411 in Menz sheep were ear-tagged. Recording formats were developed and enumerators were employed for communities to assist households in the measurements and recording. Monitoring of the breeding activities was done fortnightly by a research team from respective research center. Two stages of selection were applied to select breeding rams: initial screening at 6- and final selection at 12 months of age. A committee composed of 5 members from each community was actively involved in the selection process. A total of 14, 21, 36, and 50 rams have been selected and distributed for use in Afar, Bonga, Horro and

Menz, respectively in two rounds of selection. Seed money was provided by the project to purchase the selected rams for the community and different ram-groups were formed based on number of breeding ewes, settlement and communal grazing areas.

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CHAPTER I

General Introduction

Ethiopia is a country of 1.1 million square kilometers and populated by an estimated 74 million people with an annual growth rate of 2.6%. About 84% of the Ethiopian populations live in rural areas with a majority directly or indirectly deriving their livelihood from agriculture (CSA, 2008). The contribution of livestock to the total agricultural GDP and the national foreign currency is about 30% and 16%, respectively (Institution of Biodiversity Conservation, 2004). Small ruminant population of Ethiopia is about 48 million of which 26 million is sheep. Small ruminants provide about 46% of the national meat consumption and 58% of the value of hide and skin production (Awigichew et al., 1991). They have many advantages over large ruminants for most smallholder farmers, including among others: less feed costs, quicker turnover, easy management and appropriate size at slaughter (Wilson, 1991; Abegaz, 2002; Donkin, 2005). They also suffer far less in mortality during periods of drought than large ruminants (Galal, 1983; Wilson, 1991). For instance, during early 1980's when drought hit Ethiopia, loss of small ruminants did not exceed 50% as opposed to cattle where about 80% or more were lost (Wilson, 1991). In addition, subsistence farmers prefer small ruminants as the risk of large ruminants dying and leaving them with nothing is too great (Sölkner et al., 1998).

In Ethiopia, sheep is the second most important species with diverse breeds and ecotypes distributed from cool alpine climate of the mountains to the arid pastoral areas of the lowlands. There are nine known breeds of sheep characterized through phenotypic and molecular methods in the country (Gizaw et al., 2007). About 99.6% of the total sheep population of Ethiopia is indigenous breeds (CSA, 2008) which are owned and managed by resource poor smallholder farmers and pastoralists under traditional and extensive production systems. The level of production and productivity of sheep in the country is generally extremely low. For instance, the average annual off-take rate and carcass weight per slaughtered animal for the years 2000 to 2007 were about 32.5% and 10kg, respectively (FAO, 2009); the lowest even among sub Saharan African countries. On the other hand, there is huge demand for sheep and goat meat in the Gulf countries. The demand and prices for sheep are also increasing locally due to increased urbanization and increased income in the cities. The demand is especially pressing given that the current population of the country is expected to rise to about 129 million by the year 2030 (Institution of Biodiversity Conservation, 2004). The present production conditions are unable to satisfy the increasing demand and supply the export abattoirs with adequate and quality live animals (Negasa and Jabar, 2008). The authors argue that the existing meat export abattoirs in Ethiopia operate at less than 50% of their operational capacities which has increased the fixed costs of operation thereby decreasing the abattoirs competitiveness in the domestic and export markets.

Institutionalized sheep genetic improvement efforts begun in 1944 when animals of the Merino breed from Italy were imported to be crossed with indigenous sheep breeds. Following this, Blue du Maine from France, Rambouillet from Spain, Romney and Corriedale from Kenya, Hampshire from UK, Awassi from Israel, and Dorper sheep from South Africa were imported at different times for genetic improvement through crossbreeding. Nevertheless, most crossbreds, except the Awassi from Israel, were later neglected because they were not accepted by farmers as they did not meet their phenotypic preferences (Tibbo, 2006; Gizaw and Getachew, 2009). The Ethiopian Institute of Agricultural Research (IAR) also initiated characterization and genetic improvement studies largely on indigenous sheep types in 1975 (Galal, 1983). This too failed to impact the traditional and extensive sheep production systems and the productivity still remains low. Main reasons for the failures were lack of involving or inadequate participation of sheep producers in the design and implementation of the breeding programs in addition to due considerations for infrastructural and institutional arrangements (Duguma et al., 2009; Tibbo et al., 2010). Success of breeding program is largely related to the level of involvement of the community in the design, implementation and operation of the program (Mueller, 2006). Consequently, community-based breeding program designed with the active involvement of the traditional breeders is appropriate for conservation of indigenous animal genetic resources. This is because smallholder livestock breeders have used different phenotypic features including adaptive attributes to identify and select their breeds, strains or landraces for centuries (Rege, 2001).

In 2007, the International Center for Agricultural Research in Dry Areas (ICARDA), the International Livestock Research Institute (ILRI) and the Austrian University of Natural Resources and Life Sciences (BOKU) in collaboration with the National and Regional Agricultural Research Systems in Ethiopia initiated a new approach where producers are involved in all steps of design and implementation of breeding programs and focus is given to indigenous sheep genetic resources. Final goals of the project were improved productivity and income of small-scale resource-poor sheep producers by providing access to improved animals that respond to improved feeding and management. This thesis is part of the project; and its main focuses were participatory definition of breeding objectives and practical implementation of community-based sheep breeding programs in different production systems in Ethiopia. The thesis is structured as follows: in Chapter II available tools used to identify breeding objectives of livestock keepers are reviewed. In Chapter III smallholder farmers and pastoralists preferences for sheep breeding traits are identified using choice experiments. Chapter IV presents practical implementation and operation of community-based breeding programs in different production systems. Major challenges in implementing the selected schemes in the different production systems are also described. In Chapter V some concluding remarks and recommendations are made.

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CHAPTER II

Participatory approaches to investigate breeding objectives of livestock keepers

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Abstract

There are distinct breeds suitable for diverse purposes in different production environments or ecological zones. Farmers in different production systems have different trait preferences and the strategies followed by them are also as diverse as the agro-environments within which they operate. In order to design a viable breeding plan, farmers' preferences for the different traits need to be investigated. In this paper available tools and methods for defining livestock breeding objective traits are described, discussed and comparisons among them are made. The reviewed tools were: participatory rural appraisal (PRA), choice experiments, ranking of animals from own flock/herd and ranking of others animals. Each methodology may be appropriate to specific situation; however, it is recommended that a combination of approaches be used to precisely capture the breeding objective traits of livestock producers. Elucidation of objective traits using the tools with active involvement of producers can result in appropriate livestock genetic improvement that is well grounded in practical reality and truly reflects owners' preferences.

Keywords: Choice experiments; phenotypic ranking; PRA; production systems

1. Introduction

In developing countries livestock production is still mostly subsistence oriented and fulfils multiple functions (Wurzinger et al., 2006; Roessler et al., 2008). In these countries, a considerable number of livestock breeding programs have failed (Roessler et al., 2008). Among others, reasons for the failures include limited involvement of farmers who are the final beneficiaries, in both planning and implementation, leading to ineffective breeding programs. Any development endeavor needs to be aligned to the specific goals of the target communities and production environments. Nevertheless, more often government policies still encourage and promote a small range of specialized ‘improved’ breeds (e.g. distribution of Holstein-Friesian heifers or their crosses to smallholders in Eastern Africa) where potential milk production or very limited production attributes are emphasized instead of due consideration of the broader livestock system functions (both tangible and intangible products) and environmental constraints (Drucker et al., 2001; Moll, 2005; Moll et al., 2007). These emanate from the perception that crossbreeding and/or replacement with exotic animals is the best option for improving productivity of indigenous livestock under smallholder conditions. Nevertheless, success has only been reported in the Kenyan highlands where the country’s successive governments instituted a number of changes in the provision of livestock production and marketing services that encouraged dairy production (Thorpe et al., 2000). Because, the breeding goals of livestock keepers are often comprehensive (Köhler-Rollefson, 2000; Bebe et al., 2003; Moll, 2005; Moll et al., 2007; Kosgey et al., 2006; Roessler et al., 2008) and are mainly driven by the underlying production systems (Wollny, 2003; Ouma et al., 2007). Smallholders also value the non-marketable by-products such as manure and appreciate the intangible benefits of livestock in insurance and display of status (Moll et al., 2007).

The ‘improved’ breeds often do not have the adaptive attributes required to fulfill the multiple roles (Drucker et al., 2001). Tibbo et al. (2008) compared indigenous Menz and their crosses with Awassi and found the indigenous Menz sheep to be as profitable as their crosses to the Awassi breed. The comparative study conducted by Ayalew et al. (2003) also indicated that within their local environments and resource-constrained production systems and broader market demands, local goat breeds can perform as good as exotic breeds. The authors further indicated that conventional productivity evaluation criteria are inadequate because they fail to capture non-marketable benefits of the livestock. Thus, as animal breeding programs which focus only on short-term market demands lead to unwanted side effects (Olesen et al., 2000), efforts to genetically improve local breeds should always take into consideration the multiple breeding goals of the communities and respect their cultural preferences (Kosgey and Okeyo, 2007; Ayantunde et al., 2007).

In conventional livestock breeding, where recording systems are in place, the following major steps are considered necessary in defining breeding objectives: a) determination of breeding objective traits, b) derivation of economic values for each objective trait, c) choice of selection criteria, d) estimation of phenotypic and genetic parameters for the breed under consideration, and e) simulation of the breeding program. Under smallholder production systems, however, conventional breeding methods are constrained by absence of records, low level of literacy, small flock sizes per household and uncontrolled breeding (Kosgey, 2004; Gizaw et al., 2009). To design viable genetic improvement schemes under smallholder production conditions, the prevailing production conditions and/or systems and production goals must be fully understood and views of the targeted communities duly taken into account. In this paper, available methodologies and tools applicable to characterization of production systems are reviewed within the context of livestock breeding objectives under smallholder situations in developing countries.

2. Description of production systems

In order to set up a breeding program, the target production system has to be well understood and characterized in the context of other farming or off-farm activities (Wollny, 2003; Mbuku et al., 2006; Kosgey and Okeyo, 2007). The description of the production environment should be detailed and distinction made of the target groups within the area for which the breeding program is derived, as different target groups may have various perceptions and priorities (Sölkner et al., 1998). Farmers usually have intimate knowledge of their respective local environments, conditions, problems, priorities and trait preferences and their relative rankings. However, "outsiders" who are sometimes investigating local communities with only partial system context knowledge, are often not familiar with this knowledge (Sumberg et al., 2003). Consequently inappropriate "improvement" schemes are introduced or adopted. For instance, the Horro Sheep Breeding and Improvement Ranch (1982-1999) located in Horro Guduru (Western Ethiopia) and established by the Ethiopian Ministry of Agriculture, failed causing huge financial and material loses (OADB, 2001) due to unsuitability of the area for sheep production. According to this report, the surrounding farmers were neither consulted initially regarding suitability of the area for sheep production nor their opinion heard until most animals died.

Production systems and production objectives are determined by agro-ecology and commonly differ in terms of stress factors, such as water shortages, disease and parasites as well as temperature extremes (Ouma et al., 2004; 2007). These conditions largely determine the breeding or production purposes, suitability of breeds/genotypes, and breeding methods particularly in small and large ruminants that depend strongly on their production environments. The strategies followed by resource-poor farmers and their trait preferences are as diverse as the highly variable agro-environments within which they practice (Reece and Sumberg, 2003; Roessler et al., 2008). Alternative tools/methods used for the description of the prevailing production system are outlined in the following section.

2.1. Collection and assessment of secondary information

Conroy (2005) emphasizes the importance of full use of any existing sources of information before starting participatory development activities. Secondary information on what breeds/genotypes have been tried out before, major crops being produced, varieties, availability and quality of feeds, the endemic diseases and levels of challenges, meteorological variables, etc. should be collected and synthesized to identify knowledge gap and have better insight.

2.2. Diagnostic study

Diagnostic studies involve understanding of farming systems and planning for experiments to address farmers' problems (Franzel and Crawford, 1987; Doré et al., 1996). The objectives of such studies are to develop a basic understanding of how the farming system operates and use this information to identify problem areas or areas where potentials are but not being fully realized thus could benefit from intervention. These may differ for different farmers, therefore, initial steps focus on identification and clustering of the target groups on gender, occupation, wealth status, age, literacy level basis, etc (Besley and Case, 1993; Roberts, 1996; Sinn et al., 1999; Sumberg et al., 2003; Teratanavat, 2005). Diagnostic studies can be carried out with simple check-lists to facilitate discussion with key informants. In order to develop effective interventions, it is necessary to first understand what farmers are doing, why they are doing it in a given or particular way. Thus, information gathered during the diagnostic study is used to identify areas within the farming system where improvements can be made.

2.3. Formal survey

Formal surveys are based on administering structured questionnaires using the information collected from secondary sources and the diagnostic studies. Pre-testing of the questionnaires before final administration is crucial to ensure that the questions being asked are socially appropriate, and that the expected responses are within the expected bounds. Amendments are then made based on pre-test results. Selection of respondents is done by employing the correct sampling procedures and techniques to avoid biasness. Should enumerators/translators be used for interviewing, they must be properly trained about the subjects under consideration. It is also important to prepare a version of the questionnaire in the local language.

In livestock production systems study, questionnaire survey enables to investigate flock/herd size and structure, off-take rates, purpose of keeping different species and importance and use of livestock products. Breeding practices such as source and breed(s) of males used in the herd/flock, traits perceived important by owner, prevalent diseases that occur in the farm, treatment methods (both modern and traditional) and vaccination calendar etc., can be identified. The survey should also capture indigenous knowledge on the management of livestock and breeding practices. For socio-economic aspects, marketing channels and opportunities for animals and animal products, economic valuation of production (production costs, returns from sales), institutional settings that affect breeding and animal management including marketing and decision mechanisms at household level can be documented.

3. Defining breeding objectives

Definition of breeding objective should be the activity, after defining the production system in designing genetic improvement strategies. The concept and structure of a livestock breeding objective was initially formalized by Hazel (1943) and it defines the traits of importance and the direction of genetic improvement (Borg, 2004). Breeding objective is defined as the traits to be improved, the cost of production and the revenue from product sales related to a genetic change in each trait. Economic values are the relative importance of traits in a given system and can be derived only if breeding objectives are defined in economic terms (Kahi and Nitter, 2004; Rewe et al., 2006) that may vary from breed/genotype to breed /genotype or from region or production systems to region/production system for the same breed (Hazel, 1943).

Complete economic assessments of costs and revenues for low input systems in developing countries are difficult and are rarely available mainly due to illiteracy, lack of formal performance and pedigree record, small flock sizes, leading to too much noise and lack of precision. In addition, the many roles animals play in smallholder systems, makes it difficult to apportion the overall attributes against the many factors involved (Kosgey et al., 2003). In developing countries many important functions of livestock are embedded in traits that are not traded in the market, although valuable to the keepers (Scarpa et al., 2003b). When most of the environmental and public goods are not traded in the market, the value of the good shall be inferred through the application of the stated preference methods, which derive values from responses to hypothetical questions (Alpizar et al., 2001; Freeman, 2003; Birol et al., 2006). Prior to that one has to identify as to which traits are important for a given area based on community's preferences. However, only few priority attributes that would optimize the overall gain should be considered as objective traits in order to design simple but effective breeding plans for easy implementation under farmers' conditions. Involving livestock producers in objective traits identification and incorporating the identified traits in the design of breeding plans encourage them to actively participate in implementation activities. In the next section, methodologies and tools applicable to elicit objective traits under smallholder circumstances in developing countries are discussed.

3.1. Participatory rural appraisal (PRA)

Participatory rural appraisal (PRA) is an approach that involves local communities as active analysts of their own situations whereby they estimate, quantify, compare, rank/score and list priorities of resources, constraints and opportunities based on their circumstances (Chambers, 1994; Bhandari, 2003). Various alternative approaches can be used to rank/score the subject under investigation with PRA techniques such as asking the respondents to make drawings on the ground, using sticks of different sizes or known number of grains/pebbles, etc. For instance, Gizaw et al. (2010) working with two indigenous sheep breeds of Ethiopia provided producers with pebbles to rate trait categories. The process involves listing of pre-identified traits which is normally done with knowledgeable local villagers. Then producers are asked to rank/assign a score for each of the traits or trait categories.

3.2. Choice experiments

Methods for valuing non-market, public goods are categorized as revealed and stated preference methods (Alpizar et al., 2001; Birol et al., 2006). Revealed preference methods use actual choices made by consumers in related or surrogate markets, in which the non-market good is implicitly traded, to estimate the value of the non-market good. It has the advantage of being based on actual choices made by individuals. However, there are also a number of drawbacks; most notably that the valuation is conditioned on current and previous levels of the non-market good and the impossibility of measuring non-use values, i.e. the value of the non-market good not related to usage such as existence value, altruistic value and bequest value (Alpizar et al., 2001). As a result, stated preference methods have been developed to solve the problem of valuing those non-market goods that have no related or surrogate markets. In these approaches, consumer preferences are elicited directly based on hypothetical, rather than actual, scenarios (Alpizar et al., 2001; Birol et al., 2006). Stated preference methods can be used to cover a wider range of attribute levels in cases where revealed data do not encompass the range of proposed quality or quantity changes in the attributes of a public good (Birol et al., 2006).

There are three types of questionnaire that can be used in stated preference studies (Hensher, 1994). These are ranking experiment, choice experiment and rating experiment. In a ranking experiment, respondents must order the hypothetical situations in order of preference. The task becomes more complicated in a rating experiment, as respondents must be able to order their responses in order of preference and are asked to indicate how much they prefer one alternative over others. As a result a rating experiment is considered to be too demanding for respondents. According to Hensher (1994), limited relevant information could be provided below the 4th ranking of the respondent as at that stage it is too difficult for respondents to distinguish between choices.

A popular stated preference method used to elicit preferences for attributes of different goods based on utility theory is a choice experiment (McFaden, 1974). Though the method has been widely used in other fields like transport (McFaden, 2001; Train, 2009), its application for the valuation of livestock attributes is more recent and only few published studies are available in the literature (Scarpa et al., 2003a,b; Wurizinger et al., 2006; Ouma et al., 2007; Roessler et al., 2008; Omondi et al., 2008a,b; Kassie et al., 2009). These authors indicated that choice experiments are important tools to value both tangible and intangible traits. Wurizinger et al. (2006) reported that choice experiments are important for identifying selection criteria in traditional production systems where literacy level is low and recording practices are not in place. It provides robust information about what attributes and attributes levels producers want most and how much value they place on the different attributes. However, choice experiments have to be pre-tested thoroughly and number of attributes in the profile and number of levels for each attribute should be determined (Alpizar et al., 2001; William et al., 2004).

3.3. Ranking of animals from own herd/flock

Ranking of animals from own herd/flock implies grading of own animals based on reproduction and production performances and other attributes under own management. No literature report is found on ranking of animals from own flock/herd. The idea is that owners may have particular preferences for animals they raise based on some of the traits that can be observed on them. The procedure is, for example, to ask the owner to choose the 1st best, 2nd best, etc. dairy cows from her/his herd and to ask reasons for so ranking and record the reasons. A farmer may have her/his own 'ideal cow' in mind that fitted her/his farming system in terms of fertility, calf survival and growth, etc. Particular focus need be given how he/she makes decisions about ranking of the animals and what does he/she frequently referring to when making the decisions. According to Warui and Kaufmann (2005) the method helps to pin-point interrelationships between production aims, characteristics of livestock resources, environment and the respective prevailing management.

The most interesting aspect of ranking animals from own herd/flock is that most family members are partaking in the ranking activities as it is done at the owner's homestead or nearby. Family members involved in the ranking activities remind each other about reproduction history of their animals and other events as there are no written records kept by the smallholder farmers. They depend on recalled memory regarding the performance and pedigree of their animals. The other advantage is that the animals ranked are under similar management, though in some cases certain classes of animals get preferential treatments (eg. milking cows, working oxen, etc). In addition, ranking is based on a complex of traits not based only on the superiority/inferiority of a single trait. For instance, if ewe is a twin bearer but hardly rear her lambs or if their growth performance is poor or stunted, owners would not rank the ewe as good. Instead, they may go for a single bearer ewe which lambs' grow faster and viable at least to weaning (personal observation). Harvey and Baker (1989) also reported similar situation that farmers selected ewes that had superior subsequent performances (number of lambs weaned) to their culled group of ewes. After having detailed information from the owner and animals got ranked (eg. 1st best, 2nd best, etc.), measurements can be taken on each ranked animal focusing on attributes frequently mentioned. In case of female animals, additional information on reproductive performances can also be collected as recalled by owners. The approach may put some light on the association between smallholders' indigenous selection criteria and the modern knowledge of animal breeding.

Based on results obtained using the methods/tools described, alternative breeding plans involving different levels of recording can be simulated. After having the most preferred breeding traits identified, the basic principles of simulation of alternative breeding plans are the same with that of the conventional breeding program. Nevertheless, only few and easily recordable traits have to be considered in the breeding plans simulation for smallholders as most of them are illiterate. Finally, the simulated alternatives must be presented to the targeted groups to discuss on each alternative and decide which alternative they will implement.

3.4. Phenotypic ranking of group of live animals

In addition to hypothetical choice experiments, phenotypic ranking of animals has recently been employed to capture information about selection criteria of stock owners (Ndumu et al., 2008). For phenotypic ranking of live animals, identifying/marking and randomly assigning of animals of similar age, size and condition into different sub-groups for ranking are crucial. It would also be interesting if animals of different colors can be included to elicit their preferences for the different colors and attach value to each color type. Involving relevant stakeholders other than livestock owners, like local traders, can also help to attach values to animals of different age, color and size, etc. Randomly regrouping or reshuffling of animals at certain interval is necessary during the course of the ranking process to minimize biasness. Then each interviewee is asked by a well trained enumerator to rank animals of the different groups according to his/her own preferences and to provide reasons why s/he ranked the animals in that order. The ranking can be conducted first based on phenotype alone where after the interviewee is provided with additional information on each animal in the form of life history including production and/or reproduction performances; then to investigate decision changes to be made by the respondents.

If more decision change is made due to provision of life history, it may either indicate that attributes provided in the form of life history are very important to the respondents or respondents need informed decision to select animals under consideration for breeding. If significant decision changes are observed, the interviewee should be asked as to which of the provided attributes in the form of life history have influenced her/his decision, then to take measurements on those specific attributes. Production and reproduction performances of these particular animals may be evaluated in relation to the measurements taken to investigate their associations. Ndumu et al (2008) working with Ugandan Ankole cattle, reported that the methodology of preference ranking combining phenotype and a hypothetical life history provided better insight into stock owners' selection criteria than ranking animals based on phenotype alone. Evidently, providing life history allowed capturing information on relative importance of phenotype versus production and health traits.

3.5. Comparison of methods

The different methods described for defining breeding objective traits have advantages and shortfalls. One has to analyze the practical situation on the ground before deciding on the method to be used. However, Ndumu et al (2008) who compared three different methods (survey, phenotypic ranking of live animals and a hypothetical choice experiment) suggested a combination of at least two methods to be used in order to avoid overlooking of any important question for selection. The authors also indicated that these methods are applicable for situations where farmers have low levels of literacy and/or only a few years of formal education.

The different tools mentioned can be used to define livestock breeding objectives traits with active participation of producers to design livestock breeding plans. All methods may not be suitable for every situation. One method may work better than the other under some situations and at some stages. For instance, survey questionnaire enables to undertake the overall situation analysis of an area and to capture lists of objective traits to be considered important under a given system at early stage. However, the information captured at survey stage may be broad and need to be narrowed to focus only on few but very important traits. In addition, breeding program to be designed for the smallholders should be simple and may include one or two priority traits that can be easily measured on the candidates meant for selection. Traits preferred at this stage can be used for designing of choice experiments.

Choice experiment is important to value both tangible and intangible traits, where the later traits are valued using pictorial representation that otherwise could not be assessed. Ranking of animals from own herd/flock is important to capture information on production and reproduction performances. More detailed information may also be captured as owner judges her/his animals based on different traits including animals' behavior. Analysis of owner's views and the measurements taken on ranked animals may enable to blend indigenous knowledge with the sciences of animal breeding. This method also provides information (in the form of life history) to the phenotypic ranking of group of live animals, which focuses only on observable traits indicating that breeders may need informed decision to select animals for breeding. Thus, unless for cost and labor effects using multiple methods may give better insight in eliciting smallholders' livestock attributes preferences.

4. Conclusions

In this review, different tools and methods for defining production systems and livestock breeding objective traits are described, discussed and comparisons among them are made. Key issues identified were: a) understanding of production systems, b) identification and clustering of target groups on gender, occupation, wealth status, age, literacy level, etc. basis, c) elucidation of objective traits with active involvement of the target groups, and d) to use the most important identified traits for simulation of the genetic improvement program. Thus, an appropriate genetic improvement programs that truly reflect owners' preferences and well grounded in practical reality may be simulated.

Various methods were evaluated and compared in relation to efficiency in identifying breeding objective traits. Choice experiment is important to value both tangible and intangible traits, but attributes used to design the choice experiments have to be identified using other tools like production system studies. Ranking of animals from own herd/flock can reveal different traits based on individual breeder's preferences including production and reproduction performances and behavior. Ranking of group of live animals by others (not the stock owner) may not be efficient to reveal unobservable traits, indicating that producers may need informed decision to select animals for breeding. Thus, the use of a combination of methods gives better insights to explore the preferences of the owners than using a single method.

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CHAPTER III

Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits: Choice model approach

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Abstract

Identification of breeding objective traits pertinent to specific production environments with the involvement of target beneficiaries is crucial to the success of breed improvement program. A choice experiment was conducted in four locations representing different production systems and agro-ecologies that are habitat to four indigenous sheep breeds (Afar, Bonga, Horro and Menz) of Ethiopia with the objective of identifying farmers'/pastoralists' preferences for sheep breeding traits. Following a synthesis of secondary information and diagnostic surveys, two communities per location consisting of 60 households each having at least four breeding ewes were identified. Producers' priority attributes used in the choice sets were identified through an in depth production system studies conducted from December 2007 to March 2008. Based on prior information, 4 to 7 attributes were used to design choice sets with different profiles in order to capture results that mimic real life of the different communities. The attributes and levels chosen for the sheep profile were: body size (big/small), coat color (brown/white/black), tail type (good/bad) for both rams and ewes; horn (polled/horned) and libido (active/poor) for rams; lambing interval (3 lambings in 2 years/2 lambings in 2 years time), mothering ability (good mother/bad mother), twinning rate (twin bearer/single bearer) and milk yield (2 cups per milking/1 cup per milking) for ewes. A fractional factorial design was implemented to construct the alternatives included in the choice sets. The design resulted in a randomized selection of 48 sheep profiles (24 sets) for both sexes that were grouped into four blocks with six choice sets each. An individual respondent was presented with one of the 4 blocks to make his/her choices. Results indicate that producers' traits preferences were heterogeneous except for body size in rams and mothering ability in ewes where nearly homogeneous preferences were investigated. In the pastoral production system, attention was given to coat color of both breeding rams and ewes, favoring brown and white colors over black. Ram libido influenced producers' decisions in

Bonga, Horro and Menz areas. The influence of milk yield and twinning on respondents' decision making was high in Afar and Horro, respectively. Breeders in all areas attempt to combine production and reproduction traits as good as they can in order to maximize benefits from their sheep. The elicited measurable objective traits were used to design alternative community-based sheep breeding plans for the four indigenous sheep breeds in their production environments that have been implemented since.

Key words: Sheep; breeding; choice experiment; community-based; Ethiopia

1. Introduction

Sheep is the second most important livestock species in Ethiopia estimated at 26 million (CSA, 2008). There are diverse breeds and ecotypes distributed from cool alpine climate of the mountains to the arid pastoral areas of the lowlands. To date, there are nine known breeds of sheep characterized through phenotypic and molecular methods (Gizaw et al., 2007). In Ethiopia, the livelihood of smallholder households depends to a great extent on livestock and sheep contribute substantial amounts to income, food (meat and milk), and non-food products like manure, skins and wool. They also serve as a means of risk mitigation during crop failures, property security, monetary saving and investment in addition to many other socioeconomic and cultural functions (Tibbo, 2006). However, sheep productivity is constrained by lack of technical capacity, scarce feed, diseases, insufficient infrastructure and market information resulting in inadequate utilization of the indigenous genetic resources. The average annual off-take rate and carcass weight per slaughtered animal for the years 2000-2007 are 32.5% and 10.1kg, respectively (FAO, 2009); the lowest even among sub Saharan African countries.

Institutionalized sheep genetic improvement efforts begun in 1944 when animals of the Merino breed from Italy were imported to be crossed with indigenous Arsi sheep at Agarfa, south central Ethiopian highland. Following this, Blue du Maine from France, Rambouillet from Spain, Romney and Corriedale from Kenya, Hampshire from UK, Awassi from Israel, and Dorper sheep from South Africa were imported at different times for genetic improvement through crossbreeding. In 1977, the national agricultural research system started on-station phenotypic characterization and genetic improvement of largely indigenous sheep types in various parts of the country. However, such efforts failed to impact the traditional and extensive sheep production systems that are owned and managed by resource poor smallholders. Among many reasons, the limited involvement of relevant stakeholders particularly smallholder farmers/pastoralists in the planning and implementation of sheep improvement endeavors contributed to such failures. This was particularly pronounced in the imported breeds as smallholders rejected most crossbreds except the Awassi crossbreds when distributed for further breeding purposes because of phenotypic unlikeness to the indigenous ones (Tibbo, 2006).

On the other hand, due to the country's strategic geographic location, market opportunities are promising as evidenced by increased volume of export trade. Moreover, urbanization and growing population resulted in increased domestic demand for sheep meat which also offers significant incentive for market oriented production.

There is a new thinking that local communities and institutions must be involved and focus has to be given to indigenous genetic resources in order to bring about the desired change. Sustainable strategy needs to be tailored to the specific goals of the targeted communities and production systems/environments as no single strategy fits all situations. The prevailing production conditions largely determine the breeding or production purposes, suitability of breeds and breeding methods. There are distinct breeds and breed groups suitable for diverse purposes in the different production environments/ecological zones. Furthermore, farmers in different production systems may have different trait preferences (Roessler et al., 2008) and they may also follow as diverse strategies as the agro-environments within which they perform (Reece and Sumberg, 2003). Understanding farmers' trait preferences provides insights into which traits are particularly important in their agro-ecosystem and how these can be incorporated in the design of sustainable breeding programs. Cognizant of this, ICARDA, ILRI and BOKU in partnership with national and regional agricultural research systems in Ethiopia are designing community-based sheep breeding programs for four breeds in four different regions of Ethiopia.

Hypothetical choice experiment (CE) is one of the numerous tools used to identify preferences of the subjects under consideration. The technique has been widely used in other disciplines especially in the transportation industry (McFadden, 1974, 2001; Train 2009). In agriculture particularly in the livestock sector, there is a recent boom in published reports (e.g., Tano et al., 2003 quantified farmers' preferences for cattle traits in West Africa; Scarpa et al., 2003a studied revealed and stated preferences of cattle traits in Kenya; Scarpa et al., 2003b investigated preferences of pig traits by Mexican backyard and smallholder farmers; Wurzinger et al., 2006 valued trait preferences in Ankole cattle of Uganda; Ouma et al., 2007 examined farmers' preferences of cattle traits in North Kenya and Central Ethiopia; Zander et al., 2008 estimated values of cattle breeds in South Ethiopia and North Kenya; Roessler et al., 2008 identified pig traits preferences in Vietnam; Omondi et al., 2008a,b analyzed goat and sheep traits preferences, respectively, of pastoralists in North Kenya; Kassie et al., 2009 evaluated cattle trait preferences of farmers in Central Ethiopia). However, to our best knowledge, there has not been any attempt to design breeding plans based on results of such studies. The objective of the current study was to identify breeding objective traits under different production environments to be used as an input in the design of alternative breeding plans targeting four Ethiopian indigenous sheep breeds.

2. Materials and Methods

2.1. Study area and sheep production systems

Four locations, Afar, Bonga, Horro and Menz, representing different production systems and agro-ecologies that are habitat to four indigenous sheep breeds were identified for the current study. Following a synthesis of information from respective bureau of agriculture and rural development and diagnostic surveys, two communities per location consisting of 60 households each were identified. The following criteria were used to select the communities: sheep population (≥ 420 breeding ewes), presence of communal grazing land, accessibility, and willingness of the community to participate in the sheep improvement project. Households with at least four breeding ewes were considered as a community member. The locations (Fig. 1) and sheep production systems are separately described below.

Afar is located in Afar National Regional State, northeastern part of Ethiopia sharing international borders with Eritrea and Djibouti. The project location is situated at about 250km east of Addis Ababa on the high way to Djibouti. Pastoral production system is practiced in most parts of the Afar region, except along the Awash River where cotton cultivation is practiced. The Afar sheep breed is fat-tailed with an unusual tail shape (shield shaped and descends to the hocks, with short S-shaped upturned tip) with no wool. It is a hardy breed adapted to arid and semi-arid areas of the middle Awash valley which includes the coastal strip of the Danakil depression and the associated Rift Valley in Ethiopia (Galal, 1983; Wilson, 1991). The breed is used for milk and meat. The annual precipitation of the area is about 600mm and mean daily temperature is about 28ºC with a maximum approaching 38ºC in June and a minimum of 15ºC in November (Getachew, 2008).

Bonga is situated in the South Western part of Ethiopia (7º 34´N latitude and 37º 6´E longitude), in the Southern Nations, Nationalities and Peoples Regional State at a distance of about 450km from Addis Ababa. The predominant production system of the area is mixed crop-livestock system. Bonga sheep, fat-long-tailed breed, is highly valued for its meat production. The area has one major rainy season that extends from May to October and the dry season lasts from October to April (Edea, 2008). The annual precipitation of the region is about 2300mm with mean maximum and minimum temperatures of about 24ºC and 12ºC, respectively (Denboba, 2005).

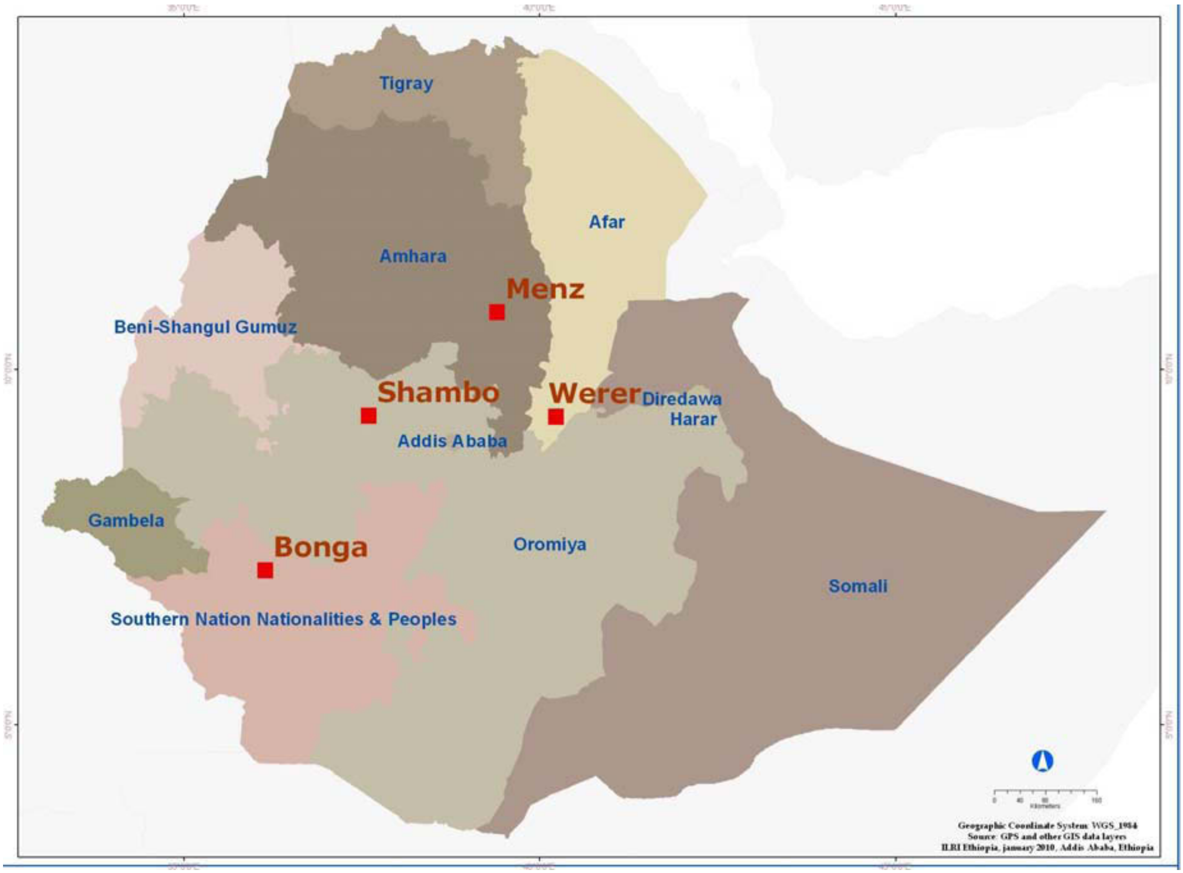

Figure 1. Study areas

Horro is located at about 315 km from Addis Ababa (9º 34´N latitude and 37º 6´longitude) in the Oromia National Regional State, West Ethiopia. Mixed crop-livestock agriculture is the main stay of the farming communities. The breed (and its ecotypes) is the most dominant sheep in the Southwestern areas of the country. Horro sheep have the following identifying features: a solid tan to dark brown color, short smooth hair, a triangular fat tail with relatively narrow base and with the pointed end hanging downward or with a slight twist. Often the rams have a mane between the head and the brisket and above the neck (Galal, 1983). The breed is mainly kept for meat. The area has one long rainy season extending from March to mid-October with mean annual precipitation of about 1800mm (Olana, 2006).

Menz is located in the Amhara National Regional State at about 280km North of Addis Ababa, Ethiopia. The area is characterized as a low-input sheep-barley production system. Menz sheep breed is fat-tailed, medium-sized (30–35kg), predominantly black, brown or white in plain and patchy coat color pattern. The breed is raised for its meat and coarse wool (used for weaving traditional blankets and carpets). The area is characterized by a bi-modal rainfall pattern where the main rainy season is from June to September and erratic and unreliable short rainy season in February and March (Getachew, 2008), with mean maximum and minimum temperatures of 18ºC and 7ºC, respectively.

2.2. Choice experiment

Smallholder sheep owners priority attributes used in the choice sets were identified through an in depth production system studies conducted from December 2007 to March 2008 by Edea (2008) in Bonga and Horro and Getachew (2008) in Afar and Menz areas. As part of the survey, sheep owners were asked to select from an exhaustive list of traits those which they would use for ram and ewe selection for breeding and then rank them in order of importance. The proportion of respondents selecting a trait as first, second and third was used to calculate indices which represented a weighted average of all rankings of a particular attribute. The index for a particular attribute was derived as ((3*proportion of respondents that ranked a trait as first + 2*proportion of respondents that ranked a trait as second + 1*proportion of respondents that ranked a trait as third for a particular attribute)/sum of (3*proportion of respondents that ranked a trait as first + 2*proportion of respondents that ranked a trait as second + 1*proportion of respondents that ranked a trait as third for all variables in question)). Depending on the breeds and production systems, the highest 4 or 5 attributes for rams and 6 or 7 attributes for ewes were used to design choice sets with different profiles in order to capture results that mimic real life of the different communities. The attributes and levels chosen for the sheep profile are indicated below.

1. Body size: big/small
2. Coat color: brown/white/black
3. Tail type: good/bad (big, wide and straight tail that hangs to the hock is considered good whereas small, thin and twisted tail hanging far above the hock is bad tail)
4. Horn: polled/horned (rams) – not used for Horro rams
5. Libido: active/poor (rams)
6. Lambing interval: 3 lambings in 2 years/2 lambings in 2 years time (ewes)
7. Mothering ability: good mother/bad mother (ewes)
8. Twinning rate: twin bearer/single bearer (ewes)
9. Milk yield: 2 cups per milking/1 cup per milking (only in Afar ewes)

Considering the total number of attributes with either two or three levels, the design with the full factorial would result in combinations of 24 (2^3*3^1, i.e., three with two levels and one with three levels), 48 (2^4*3^1), 96 (2^5*3^1), and 192 (2^6*3^1) for the four, five, six and seven attributes used, respectively. Fractional factorial designs can be implemented to limit the total number of profiles in the analysis while still permitting the main effects and first order interaction effects to be estimated independently. SAS macro MktEx (Kuhfeld, 2005) was used to generate a fractional factorial design that resulted in a randomized selection of 48 sheep profiles (24 sets) for both sexes. The 24 choice sets for each sex were grouped into four blocks with six choice sets each. Attributes and attribute levels were represented using carefully designed sketches or words and sample cards are shown for ewes and rams in Figure 2.

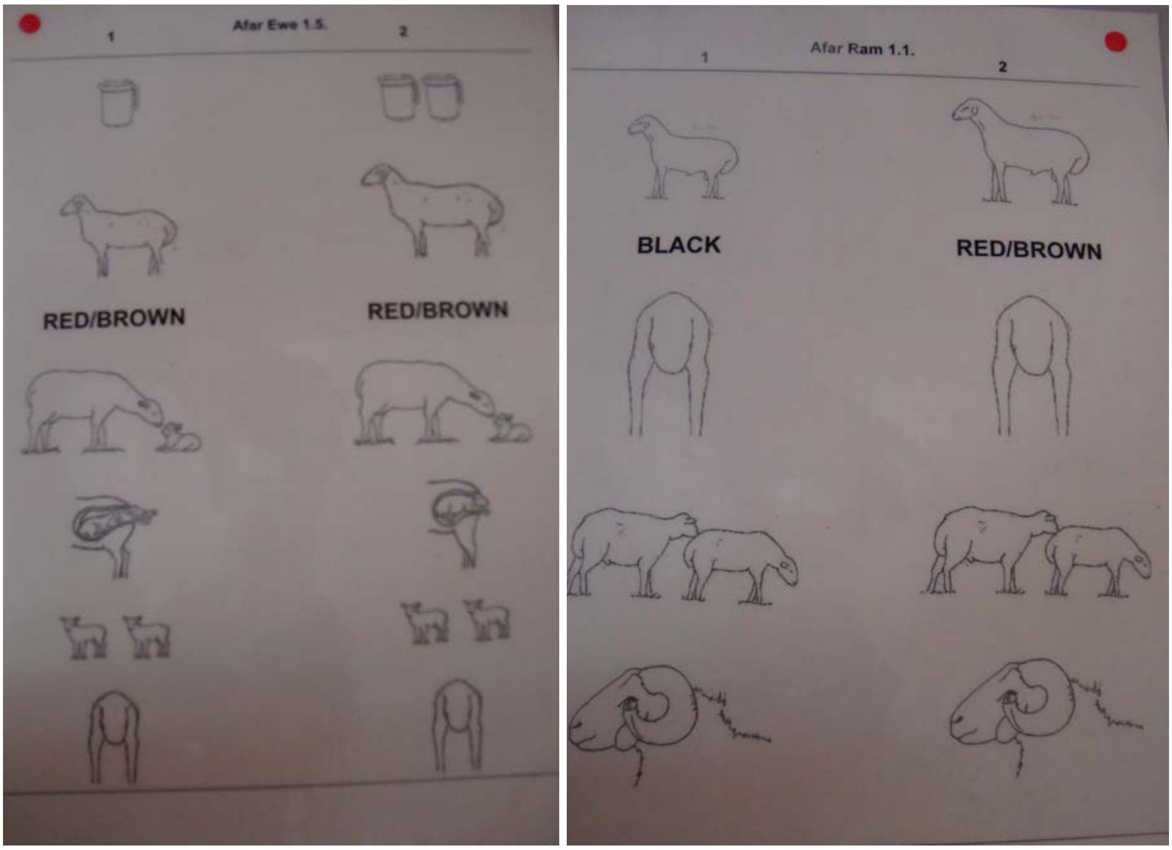

Figure 2. Sample choice cards

Surveys of the choice experiment were conducted from May to September, 2008. Data were collected from the 120 member households per location. The interviewee was briefed about the choice using test cards and the actual experimental cards. We investigated whether s/he understood the choice mechanisms through repeated choice task questions which also provided the respondent with some practice. Finally, a sequence of six choice sets for rams and ewes each were administered using a local language. There was also an option of not choosing any of the alternatives (an opt-out option) in order to avoid forced choice.

2.3. Analytical methods

The application of choice experiments has its roots in the crucial hypothesis of Lancaster (1966) that states goods possess or give rise to multiple characteristics in fixed proportions and it is these characteristics, not goods *per se*, on which the consumer's preferences are exercised. According to the random utility model, an individual n facing a choice among j alternatives would obtain a certain level of utility or profit from each alternative (McFadden, 1974, 2001). The utility that an individual n obtains from alternative j is U_{nj}, where $j = 1, \ldots,$ J. Utility can be decomposed into a part labeled V_{nj} that is known to the investigator up to some parameters (representing the deterministic portion that depends on the attributes of the alternatives) and an unknown part labeled ε_{nj} that is the stochastic or random term. Thus:

$$U_{nj} = V_{nj} + \varepsilon_{nj} \quad \forall j \tag{1}$$

The logit model is obtained by assuming that each ε_{nj} is independently, identically distributed (iid) extreme values. The density for each unobserved component of utility is:

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}} \tag{2}$$

In his Nobel lecture on micro-econometric analysis of choice behavior of consumers, McFadden (2001) indicated that consumers seek to maximize their self-interest. A logical extension of this idea entails that sheep breeders strive to maximize the productivity of their sheep by focusing on alternatives they perceive most important under the prevailing production circumstances. Thus, the probability that an individual n chooses alternative i over j can be expressed as:

$$P_{ni} = prob(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj} \quad \forall j \neq i$$

$$= prob(\varepsilon_{nj} < \varepsilon_{ni} + V_{ni} - V_{nj} \quad \forall j \neq i \tag{3}$$

Since ε_{nj} is unknown, the choice probability is the integral of $P_{ni}|\varepsilon_{nj}$ over all values of ε_{nj} weighted by its density $f(\varepsilon_{nj})$. Therefore,

$$P_{ni} = \int (\prod_{j \neq i} e^{-e^{-(\varepsilon_{ni}+V_{ni}-V_{nj})}}) e^{-\varepsilon_{ni}} e^{-e^{-\varepsilon_{ni}}} d\varepsilon_{ni} \tag{4}$$

Algebraic manipulation and rearrangement of this integral result in a closed form expression which is the logit choice probability.

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}} \tag{5}$$

Representative utility is usually specified to be linear-in-parameters: $V_{nj} = \beta' x_{nj}$ where x_{nj} is a vector of observed variables relating to alternative j. Then, the logit probabilities become:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} \tag{6}$$

A sample of N decision makers is used for estimation and since the logit probabilities take a closed form, the traditional maximum likelihood procedures can be applied (Train, 2009). The probability that an individual n choosing the alternative s/he was actually seen choosing can be expressed as $\prod_i (P_{ni})^{y_{ni}}$, where $y_{ni} = 1$ if n chooses i and 0 otherwise. Assuming that each individual's choice is independent of other individual's, the probability of each person in the sample choosing the alternative is:

$$L(\beta) = \prod_{n=1}^{N} \prod_i (P_{ni})^{y_{ni}}, \tag{7}$$

where β is a vector containing the parameters of the model. The log-likelihood function is then:

$$LL(\beta)=\sum_{n=1}^{N}\sum_{i} y_{ni}\ln P_{ni} \quad = \quad \sum_{n=1}^{N}\sum_{i} y_{ni}\ln(\frac{e^{\beta' x_{ni}}}{\sum_{j} e^{\beta' x_{nj}}})$$

$$=\sum_{n=1}^{N}\sum_{i} y_{ni}(\beta' x_{ni})-\sum_{n=1}^{N}\sum_{i} y_{ni}\ln(\sum_{j} e^{\beta' x_{nj}}) \quad (8)$$

The estimator is the value of β that maximizes this function.

PROC LOGISTIC regression in SAS (2002) was used to analyze the data. PROC LOGISTIC uses a cumulative logit function if it detects more than two levels of the dependent variable, which is appropriate for ordinal (ordered) dependent variables with three or more levels (Elkin 2004).

3. Results and Discussion

3.1. Stated trait preferences of smallholders

Analysis of the Maximum Likelihood Estimates (MLE), along with their standard errors, and associated statistics are summarized in Tables 1 and 2 for rams and ewes, respectively. The models' overall explanatory powers are good with a pseudo-R^2 ranging from 0.29 to 0.56 for rams and 0.40 to 0.62 for ewes.

The MLE of the parameters for rams exhibited the expected signs. The estimates were also significant ($p<0.001$) with the exception of horn in Bonga and tail type in Menz sheep breeds. Libido was the most preferred attribute for breeding ram selection in Horro and Menz sheep breeds and the second most preferred trait in Bonga next to tail. In Afar, ram attributes influencing breeding candidates selection were color, body size, tail type and libido in that order. Tail type and color were the least preferred traits in choosing breeding rams in Menz and Horro sheep breeds, respectively.

Table 1. Maximum Likelihood Estimates ± SE for ram traits

Parameter	DF	Estimates ± SE			
		Afar	Bonga	Horro	Menz
Size	1	1.09 ± 0.130***	1.35±0.163***	1.10±0.128***	0.92 ± 0.123***
Color	1	1.29 ± 0.085***	1.43±0.106***	0.50±0.076***	0.74 ± 0.076***
Tail	1	0.98 ± 0.129***	2.94±0.176***	1.53±0.130***	0.21 ± 0.121^{NS}
Horn	1	0.67 ± 0.128***	0.15±0.146^{NS}	-	0.64 ± 0.122***
Libido	1	0.77 ± 0.128***	2.30±0.173***	1.79±0.136***	1.70 ± 0.129***
Pseudo-R^2		0.38	0.56	0.34	0.29

*** = p<0.001; NS= p>0.05

Ram attributes preferences across the different production systems are heterogeneous as can be seen from Table 1. The first two attributes with higher utility values were coat color and body size in the pastoral/agro-pastoral community, tail and libido in the mixed crop-livestock system, and libido and body size in the sheep-barley system. The importance of body size, however, was evident across all systems with nearly comparable coefficients indicating homogeneous preferences. It is intuitive that rams with big body size are highly demanded on market for breeding as well as meat and hence command premium price. To our knowledge, similar studies are not so far available in sheep. However, high utility values for body size were reported from results of other discrete choice experiments conducted elsewhere (e.g., Kassie et al., 2009 in cows in central Ethiopia; Zander and Drucker, 2008 for bulls in southern Ethiopia and bulls and cows in southern Ethiopia and northern Kenya; Ouma et al., 2007 for bulls and cows in central Ethiopia and northern Kenya; Omondi et al., 2008a for bucks in Kenya; and Roessler et al., 2008 for pigs in Vietnam). Therefore, sheep breeders in the production systems studied would undoubtedly benefit from incorporation of this attribute in any sheep genetic improvement schemes.

The MLE of the parameters for ewes were significant ($p<0.001$) except lambing interval in Afar and twinning rate in Bonga. Attributes with unexpected signs were lambing interval in Afar; body size, and twinning in Bonga; and color in Bonga and Horro ewes. In all breeds, mothering ability was the most preferred trait. The second important attributes for breeding ewe selection were milk yield in Afar, tail type in Bonga, and lambing interval in Horro and Menz.

A positive coefficient of MLE signifies that sheep keepers derive a positive utility from the attributes whereas a negative coefficient signifies that they derive a negative utility from those attributes (Zander and Drucker, 2008). In the current study, lambing interval in Afar, body size and twinning in Bonga and coat color in Bonga and Horro ewes had negative coefficients. Lambing is usually synchronized with season of feed availability in the Afar pastoral/agro-pastoral system and it is quite logical that short lambing interval is less favored in selecting ewes for breeding. In this region breeders manipulate timing of birth of lambs (e.g. Getachew, 2008) by tying the prepuce of breeding ram so as to divert the penis during mating. It is also reported in the literature (Balasse et al., 2003) that birth seasonality of animal is an important element of pastoralists' subsistence economies. Such controlled breeding normally results in longer lambing intervals than are found when breeding is allowed year round (Wilson, 1986). With regard to body size in Bonga ewes, though it might be difficult to provide concrete explanation, it may likely be that the respondents gave more weight to mothering ability. However, in the production systems study that preceded the current work, body size as a trait of ewes ranked first with a weighted index value of 0.28

(Edea, 2008). The other important attribute for Bonga ewes was tail type which they usually associate with beauty (physical attractiveness) and better body condition. For this purpose, farmers cut female lambs' tail tip a week or two after birth with a hot sharp knife. Though twinning rate in Bonga exhibits a negative sign, the figure is close to zero and statistically non-significant. Concerning coat color in Bonga and Horro, the results are inconsistent with our expectations that brown or white coat color types are preferred to black as usually the latter is undesired on market (Ayele et al., 2006) and as revealed by the production systems study (Edea, 2008). About 40% of the Bonga ewe population is of mixed coat colors (creamy white, white and black mixture, brown and white or brown and black or dark brown) and this might had undermined selection for solid coat color types. For Horro ewe population, about 85% was reported as uniform in coat color (brown, creamy white or tan) implying that coat color is not a constraint for the community. Respondents in both areas also argue that the attribute is largely inherited from the sire and not from the ewe.

Table 2. Maximum Likelihood Estimates ± SE for ewe traits

Parameter	DF	Estimates ± SE			
		Afar	Bonga	Horro	Menz
Milk	1	1.32 ± 0.141***	-	-	-
Size	1	0.79 ± 0.136***	-0.68±0.159***	0.92±0.154***	0.60 ± 0.132***
Color	1	0.99 ± 0.097***	-0.40±0.098***	-0.31±0.096***	0.23 ± 0.080**
Tail	1	0.62 ± 0.129***	1.80±0.182***	0.73±0.150***	0.85 ± 0.143***
LI†	1	-0.03 ± 0.136^{NS}	1.41±0.172***	1.04±0.150***	1.85 ± 0.145***
Twinning rate	1	0.51 ± 0.138***	-0.04±0.160^{NS}	0.97±0.149***	0.74 ± 0.135***
Mothering‡	1	2.32 ± 0.143***	3.98±0.188***	3.30±0.161***	2.39 ± 0.145***
Psuedo-R^2		0.40	0.62	0.54	0.42

†LI= Lambing interval; ‡Mothering ability; *** = p<0.001; ** = p<0.01; NS= p>0.05

In the current study, high utility value was attached to mothering ability of ewes as evidenced from the MLE values ranging from 2.32 to 3.98 (Table 2). Moreover, the attribute had a pseudo-R^2 of 23%, 52%, 45% and 26% for Afar, Bonga, Horro and Menz sheep breeds, respectively, when fitted into the model alone. Ewe mothering ability as a trait represents a wide aspects like maternal behavior that allows proper bonding to take place between mother and offspring, nursing behavior, responsiveness and attentiveness towards the lambs, and protectiveness of the lambs from predators.

3.2. Comparison of trait level preferences

Tables 3 and 4 present results of ram and ewe attribute level preferences of the communities. For both breeding rams and ewes, results are heterogeneous except for rams' libido in Horro and Menz. The odds of choosing big versus small sized rams ranged from 2.40 to 4.02. In the pastoral production system, due attention is given to coat colors of both breeding rams and ewes selection favoring brown and white colors over black. However, this attribute (with similar phenotype as that of Afar) was considered only in breeding rams selection in mixed crop-livestock and the sheep-barley systems giving less or no weight to color of breeding ewes. The attribute levels good tail type, brown/white color, and active libido of rams appear to be exceptionally important in Bonga compared to the rest.

Polled rams are preferred to horned ones in pastoral/agro-pastoral and the mixed crop-livestock production systems and vice versa in the sheep-barley system. In the latter system, presence, size and orientation of horns matter in the tradition of breeding ram selection. Big twisted horns that grow lateral, downwards and then slightly turned upwards are the most valued horn types. Rams with such horns are said to be graceful and have high market demand in Menz area.

Table 3. Odds ratio estimates against the reference category for ram traits

Effects	Point estimates (95% Wald CI)			
	Afar	Bonga	Horro	Menz
Size (1 vs. 2)	3.03 (2.34-3.91)	4.02 (2.89-5.59)	3.01 (2.34-3.87)	2.40 (1.88-3.07)
Color (1 vs. 3)	13.86 (9.86-19.49)	17.65 (11.59-26.87)	2.71 (2.01-3.65)	4.77 (3.50-6.50)
Color (2 vs. 3)	4.87 (3.44-6.65)	14.94 (10.01-22.30)	2.46 (1.83-3.32)	5.84 (4.24-8.05)
Tail (1 vs. 2)	2.68 (2.08-3.45)	25.55 (17.52-37.27)	4.61 (3.57-5.96)	1.17 (0.91-1.49)
Horn (1 vs. 2)*	2.17 (1.69-2.79)	1.04 (0.78-1.40)	-	2.16 (1.68-2.76)
Libido (1 vs. 2)	2.04 (1.58-2.64)	10.15 (7.13-14.45)	6.22 (4.75-8.13)	6.20 (4.76-8.06)

Size (1= big, 2=small); Color (1=brown, 2=white, 3=black for Afar, Bonga and Horro; 1= white, 2= brown, 3=black for Menz), Tail (1=good, 2=bad); Horn (1=Polled, 2=horned); Libido (1=active, 2=poor),
*2 vs 1 for Menz rams

Table 4. Odds ratio estimates against the reference category for ewe traits

Effects	Point estimates (95% Wald CI)			
	Afar	Bonga	Horro	Menz
Milk (1 vs. 2)	4.61 (3.43-6.19)	-	-	-
Size (1 vs. 2)	2.46 (1.88-3.23)	0.54 (0.39-0.73)	2.51 (1.86-3.40)	1.85 (1.42-2.39)
Color (1 vs. 3)	11.40 (7.44-17.47)	0.44 (0.30-0.65)	0.54 (0.37-0.79)	1.58 (1.15-2.17)
Color (2 vs. 3)	8.89 (5.83-13.57)	1.56 (1.05-2.31)	0.60 (0.43-0.85)	1.15 (0.83-1.59)
Tail (1 vs. 2)	1.82 (1.40-2.35)	5.06 (3.52-7.26)	2.06 (1.53-2.76)	2.33 (1.75-3.09)
Lambing interval (1 vs. 2)	1.11 (0.84-1.46)	3.67 (2.62-5.14)	2.71 (2.01-3.66)	6.33 (4.76-8.42)
Twinning rate (1 vs. 2)	1.91 (1.45-2.53)	0.95 (0.70-1.31)	2.61 (1.95-3.50)	2.07 (1.58-2.70)
Mothering ability (1 vs. 2)	12.71 (9.39-17.21)	58.36 (40.02-85.09)	26.55 (19.37-36.38)	10.90 (8.19-14.51)

Milk (1=2 cups/milking, 2=1 cup/ milking); Size (1= big, 2=small); Color (1=brown, 2=white, 3=black for Afar, Bonga and Horro; 1= white, 2= brown, 3=black for Menz), Tail (1=good, 2=bad); Lambing interval (1=3 lambing/2 year, 2=2 lambing/2 year); Twinning rate (1=twin bearer, 2=single bearer); Mothering ability (1=good mother, 2=bad mother)

Relatively good milker ewes had a chance of more than four folds of being preferred to poor milkers in Afar. The pastoral communities depend on livestock and livestock products, mainly milk, for their survival. Generally, goat and sheep milk is frequently used for immediate consumption especially for children and preparation of "*hoja*", a traditional beverage made of dried coffee leaves or coffee haulms boiled with milk. Normally, ewes which produce milk that is sufficient only for the lambs are not considered worthy.

Big sized ewes were more preferred than their counterparts in Afar, Horro and Menz sheep breeds but with less magnitude compared to rams. In Bonga, it appears that less emphasis was given to ewe body size as indicated by the odds of selecting big sized ewes versus small ones. In contrast, as mentioned above, big sized rams were highly favored than small ones (Table 4). Short lambing interval was given more weight in Bonga, Horro and Menz compared to long lambing interval whereas twinning was favored in Afar, Horro and Menz. These two traits are important for reproduction provided they are accompanied with good mothering and management. The odds of choosing good mothers as opposed to bad mothers were conspicuously high in all four locations. It is evident that breeders in these areas attempt to combine reproductive traits in as much optimum way as possible in order to maximize benefits from their sheep. However, in harsh environments like Afar (dry arid) and Menz (cool, tepid highland) where feed resources are scarce and highly variable both in quantity and quality among seasons and years, and where supplementing is not feasible, it is unlikely that genetic improvements in twinning rate would bring about benefits economically.

4. Conclusion

The identification of breeding objective traits pertinent to specific production environments with the involvement of target beneficiaries is crucial to the success of any genetic improvement endeavors. In the current study, a choice experiment was used as a follow-up of sheep production system study with the aim of eliciting objective traits of farmers/pastoralists in mixed crop-livestock, sheep-barley, and pastoral/agro-pastoral systems in four regions of Ethiopia. Generally, CE results agree with that of production system studies with the exception of few ewe traits in Bonga as discussed under *Section* 3. In all study areas, coat color, body size and tail type were the most preferred attributes in breeding ram selection, but with different magnitudes and orders, and mothering ability when selecting ewes for breeding. In general, there was a common perception among the communities of the different areas that size of lambs is determined more by the sire and hence the communities gave less emphasis for size of ewes during selection for breeding.

The study showed that traditional breeders value both tangible and intangible traits; the latter would have been concealed when one uses conventional valuation methods. Thus, hypothetical choice experiments are useful tools to identify objective traits that would be incorporated into breeding plans especially under traditional production systems where recording practices have not been in place. Nevertheless, one should bear in mind that breeding plans to be implemented by farmers or pastoralists in developing countries should be kept as simple as possible.

Using results of this and other studies, ICARDA, ILRI and BOKU in partnership with national and regional agricultural research systems in Ethiopia have designed alternative community-based sheep breeding plans for the four indigenous sheep breeds in their production environments that came into effect since May 2009 with the participation of eight communities in four different locations.

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CHAPTER IV

Implementation of community-based sheep breeding programs in different production systems in Ethiopia

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Abstract

This paper presents implementation process of community-based sheep breeding schemes selected by different communities among alternatives simulated following breeding objective traits identified through participatory approaches in Ethiopia. Four study areas: Afar (pastoral), Bonga and Horro (crop-livestock), and Menz (sheep-barley) were considered. Three measureable traits that were most preferred by the respective communities were selected as objective traits and used for simulation of alternative breeding schemes. The alternative schemes were presented to communities and jointly discussed upon with scientists focusing on the advantages and disadvantages of the different scenarios. Equipped, with this information, the project members finally made a decision as to which scheme(s) they liked and therefore want to implement. Prior to implementation, baseline information was collected for benchmarking and evaluation of the changes that will be realized from the improvement intervention. A total of 1364 in Afar, 1074 in Bonga, 2248 in Horro and 2411 in Menz sheep were ear-tagged. Recording formats were developed and enumerators were employed for communities to assist households in the measurements and recording. Monitoring of the breeding activities was done fortnightly by research team. Two stages of selection were applied to select breeding rams: initial screening at 6- and final selection at 12 months of age. A committee composed of 5 members from each community was actively involved in the selection process. A total of 14, 21, 36, and 50 rams have been selected and distributed for use in Afar, Bonga, Horro and Menz, respectively in two rounds of selection. Seed money was provided by the project to purchase the selected rams for the community and different ram-groups were formed based on number of breeding ewes, settlement and communal grazing areas.

Key words: Breeding programs; community-based; implementation; production systems; sheep; Ethiopia

1. Introduction

Genetic improvement programs of indigenous livestock in low- and medium-input production systems contribute significantly to improved livestock productivity (Olivier et al., 2002) as well as ensuring sustainable conservation strategies (Gizaw et al., 2008; Mirkena et al., 2010a). Livestock also contribute to the economy of the communities depending on them (Mueller, 2006). Research on production systems and local and indigenous knowledge systems during the last 10 to 15 years has yielded ample evidence that in many cases, indigenous breeds and their locally available derivatives would be the “best fit” in terms of adaptability to the physical and animal husbandry environments (FAO, 2010).

For production systems characterized by unfavorable environmental conditions, and poor infrastructure and weak organizational set up at farmers and national level, community-based breeding programs have been suggested as an alternative to governmental breeding programs (Valle Zárate and Markemann, 2010). However, for such programs to succeed, a careful analysis of information on all aspects of production systems should first be undertaken to elaborate a set of appropriate breeding objectives which normally varies from one production system to another so that the needs and aspirations of target groups are taken into account (FAO, 2010). A number of breeding programs have failed simply because preferences of target communities were not considered (e.g., some sheep crossbreeding programs in Ethiopia due to color and tail type deviation from the local breeds (Tibbo, 2006; Gizaw and Getachew, 2009; Rege et al., 2010); goat crossbreeding in Republic of Korea due to color difference of Boer from the local black goats (FAO, 2010)). Mueller (2006) summarized some examples of breeding programs in communities for sheep in Mexico and Peru, alpacas in Peru, llamas in Bolivia and goats in Argentina. Often only the outcomes of breeding programs are reported in literature; the specifics of the implementation process and lessons learnt from this process are not reported even though this information would be extremely important for repeating community-based breeding in other locations. A recent example of a comprehensive description of the concept, research results and implementation strategies taking as example pig breeding in Northern Vietnam is the paper by Valle Zárate and Markemann (2010). Thus, in this paper, we present the implementation process step by step for a community-based breeding program under smallholder conditions in four different production systems in Ethiopia.

2. Study areas and community identification

Four study areas in different agro-ecological zones were targeted for the design and implementation of community-based indigenous sheep improvement schemes in Ethiopia. These were: Afar (pastoral/agro-pastoral), Bonga (mixed crop-livestock), Horro (mixed crop-livestock) and Menz (sheep-barley). In each area, a research center is mandated to monitor the day to day implementation activities. Descriptions of the study areas are given elsewhere (Edea, 2008; Getachew, 2008). Briefly, Afar is located at about 250km east of Addis Ababa on the highway to Djibouti. Livestock rearing is the main stay of the area, except along the Awash River where cotton cultivation is practiced. The Afar sheep, which is used for milk and meat, is a hardy breed adapted to arid and semi-arid areas of the middle Awash valley which includes the coastal strip of the Danakil depression and the associated Rift Valley in Ethiopia (Galal, 1983; Wilson, 1991). Bonga and Horro are situated in the South Western and Western parts of Ethiopia at about 450km and 315km from Addis Ababa, respectively. Mixed crop-livestock production is the predominant production system in both areas. Both breeds are fat-long-tailed sheep and are highly valued for meat production. The areas have one major rainy season that extends from March to mid October (Denboba, 2005; Olana, 2006; Edea, 2008). Menz is located at about 280km North of Addis Ababa. The area is characterized as a low-input sheep-barley production system. Menz is a fat-tailed breed raised for meat and coarse wool production. Menz area is characterized by a bi-modal rainfall pattern where the main rainy season is from June to September and erratic and unreliable short rainy season in February and March (Getachew, 2008).

Participating communities in each area were selected by a team composed of researchers, development agents and local government officials following syntheses of secondary information and diagnostic surveys conducted to determine major sheep producing areas. In total, eight communities each with 60 households were organized based on sheep population, presence of communal grazing land, accessibility, and willingness of the community members to get involved in the improvement program. For individual households, possession of at least four breeding ewes was the requirement to enroll as a member in the community-based breeding program.

3. Objective traits determination

Objective traits were determined for the different breeds through various approaches: production system studies (Edea, 2008; Getachew, 2008), choice experiments (Duguma et al., unpublished), own-flock and group-animal ranking experiments (Mirkena et al., unpublished). The various approaches were employed so as to cross-check the validity of preferences from independent sources and to ensure that all the important traits were captured. Results from the different studies were combined and weighted traits rank was computed.

In order to keep things simple, and for ease of implementation under smallholder farmers'/pastoralists' circumstances, only three measureable traits that were most preferred by communities were selected as objective traits. These were: body size and lamb survival for all production systems; twinning rate for the mixed crop-livestock system; milk yield for the pastoral/agro-pastoral system and wool yield for the sheep barley system (Mirkena et al., 2010b).

4. Simulation studies

Four alternative breeding schemes were simulated using a deterministic approach (Mirkena et al., 2010b). The schemes varied in the proportion of breeding rams selected and duration of ram use (in years). These were: 10% selection proportion and 2 years of ram use for breeding (Scheme 1), 10% selection proportion and 3 years of ram use for breeding (Scheme 2), 15% selection proportion and 2 years of ram use for breeding (Scheme 3) and 15% selection proportion and 3 years of ram use for breeding (Scheme 4). Details of simulation procedures, predicted genetic gains and economic returns achievable under the different scenarios were reported by Mirkena et al. (2010b).

5. Selection among alternative schemes

Simulation results of the alternative schemes were presented to communities and jointly discussed upon. The discussions between the scientists and the communities focused on the advantages and disadvantages (i.e. the consequences) of the different scenarios. Equipped, with this information, the community members finally made a decision as to which scheme(s) they liked and therefore want to implement. Communities in the mixed crop-livestock and the sheep-barley systems opted for strong selection pressure and use of rams for short durations (**Scheme 1**). However, the pastoral/agro-pastoral communities favored and opted for strong selection pressure and use of breeding rams for longer periods (**Scheme 2**). All the project communities favored strong selection intensities (10% best candidates) in view of possible superior genetic gains. Similar reasons were given by the communities in the mixed crop-livestock and the sheep-barley systems for choosing shorter duration of ram use. The reasons were: fear of increased risk of inbreeding and poor response of older rams to conditioning or fattening for sale. In the pastoral/agro-pastoral system, extended use of breeding rams was favored despite the communities' awareness of the associated inbreeding problems. Sato (1980) also reported that the Rendille pastoralists of Northern Kenya use breeding rams for 3 to 4 years. In the pastoral/agro-pastoral system, lambing is controlled to synchronize with seasons of feed availability making difficult frequent replacement of rams. This control results in longer lambing intervals than are found when breeding is allowed year round (Wilson, 1988). In addition, control leads to only one lamb crop per year while the uncontrolled breeding results in shorter lambing intervals enabling approximately three lamb crops to be obtained in two years. Thus, longer intervals coupled with litter size of about 1.06 for Afar flocks may lead to shortage of breeding rams for frequent replacement as compared to other sheep breeds found in the mixed crop-livestock system where lambing is year round and litter size is relatively high (1.34) and sheep-barley system where lambing is year round. Also, breeding males are generally considered as property of the clan where traditional laws inhibit individual owners the right to sale breeding rams once raised for breeding. Fattening is also not widely practiced in the pastoral areas.

6. Animal identification

Unique identification/numbering system (5-digit) per community was decided by the research team. Plain plastic ear tags were procured. Identification numbers were hand-written using indelible markers. All sheep belonging to project member households were ear-tagged. A total of 7097 animals (1364 in Afar, 1074 in Bonga, 2248 in Horro and 2411 in Menz) were covered. It was not possible to identify all animals in Afar due to reasons discussed below (*Section 4.7)*. Animal identification, performance and pedigree recording are the most essential management tools in genetic improvement and the development of sustainable selection decisions (Olivier et al., 2005; Bett et al., 2009). Based on practical experience of the sheep genetic improvement project in the Peruvian highlands, Mueller et al. (2002) reported that lack of performance recording prohibited accurate selection decisions.

7. Baseline information

Information on the current husbandry practices (i.e. baseline breeding, feeding, health, etc.) is essential for benchmarking and evaluation of the changes realizable from the improvement intervention. Separate workshops were held with the respective communities to document the current husbandry practices in addition to the in-depth production system studies undertaken by Edea (2008) and Getachew (2008). Complete census of flocks owned by project members was done along with ear tag application to determine flock size and flock structure (Annex A). Bodyweight measurement was also taken from each animal.

Selection of breeding rams in all areas is generally based on phenotypic appearance such as tail type, coat color, body size, conformation and libido. Within-flock selection is practiced but ewes may be bred by unwanted/unselected rams during grazing, given that village flocks share common grazing pastures and watering points. Ram borrowing is common among all the communities, but the extent varies from one community to another. In Afar, all breeding males are considered properties of a clan. Ewes are mainly culled for poor fertility and mothering ability. These two parameters were monitored for each ewe during the first 2 to 3 parities and the observations/ewe performance in these traits over such periods are assumed to be indicative of her performance in later life. Lee and Atkins (1996) also reported that early life fertility is an indicator of both fertility and the rearing ability of ewes in later life.

Availability of breeding rams in sufficient numbers differs among the production systems. In the pastoral/agro-pastoral system, though some male lambs are sold early, the communities indicated that adequate number of breeding rams is available. In the two mixed crop-livestock systems, male lambs are sold at as early as three to four months of age resulting in acute shortage of breeding rams in the flocks. Such early disposal of young animals culminates into unintentional negative selection because the fast growing animals with good genetic potential for growth are continuously eliminated before they pass their good genes to the subsequent generations, while the genetically inferior ones remain in the flocks and thus contribute the relatively less desirable genes to the next generation. In the sheep-barley system several rams are kept in the flock because marketing is mainly after fattening the castrated animals at about 2 to 3 years of age; castration is normally at about 1.7 years of age on average. Here too, genetically inferior males are left to stay intact and thus have chance to breed until such age that the owner considers appropriate for fattening and sale.

Feeding is entirely pasture based on private and/or communal grazing lands. In Horro and Menz, both communal and private grazing lands are available whereas there is only private grazing land in Bonga. Grazing lands are entirely communal properties among the Afar pastoralists and no exclusive rights are vested in individuals or groups and they can choose freely the pastures they wish to use.

Severe land degradation has occurred and continues to do so in the Menz area, while moisture stress is observed during significant parts of the year, during which forage availability and quality become severely limiting. The shrinkage of communal grazing lands due to human population pressure leading to crop land encroachment mainly by the younger and emerging farming households, and lack of responsibility regarding the management and development of communal grazing lands in Horro and Menz, frequent drought and invasion by *Prosopis juliflora* in Afar are the major obstacles that limit communal land utilization. Moreover, the communal grazing lands are usually located near marshy river banks that are infested by gastro-intestinal parasites leading to huge flock productivity losses due to high morbidity and mortality of sheep.

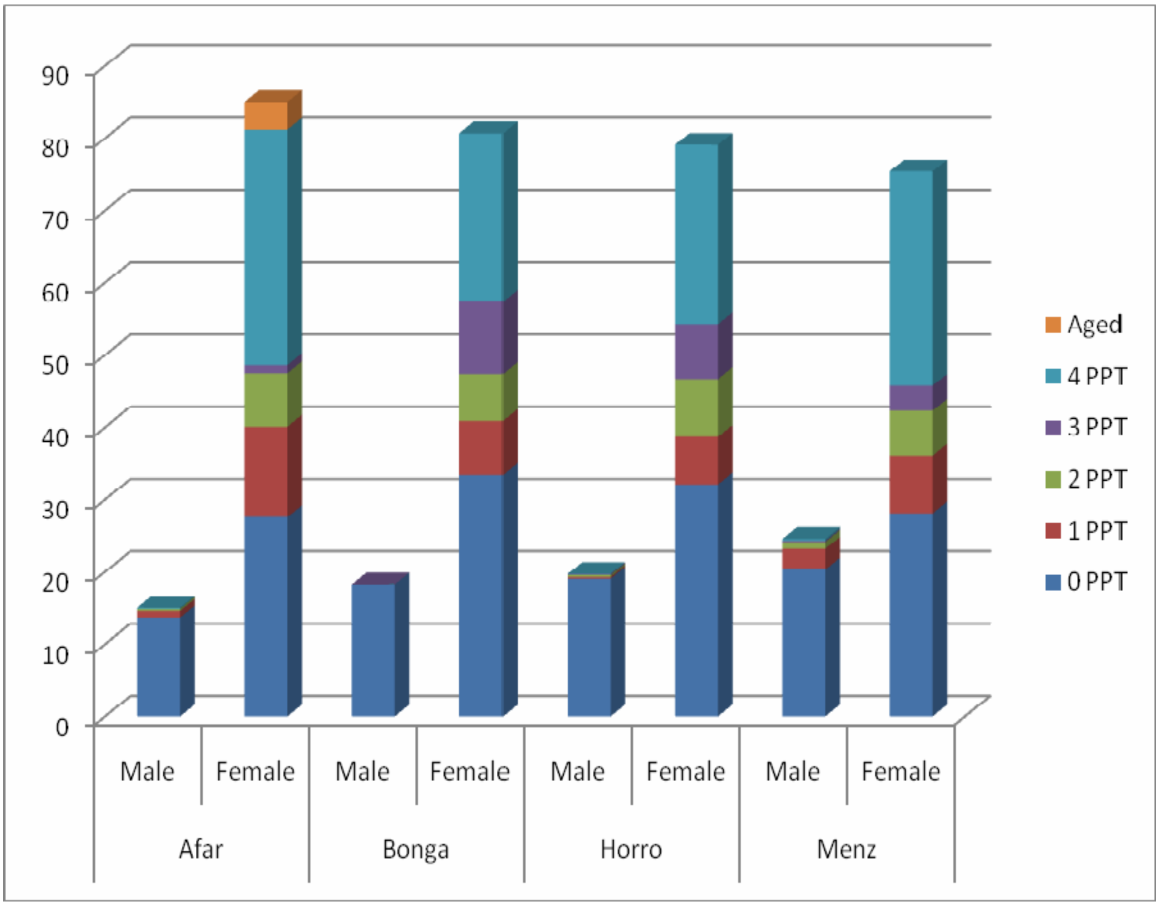
Mean flock size and flock structure by age and sex for the different breeds are presented in Table 1 and Figure 1, respectively. The largest flock size was 20 sheep (ranging from 4 to 64) and was recorded in Menz, while the smallest flock was 9 sheep (ranging from 4 to 23) and was in Bonga.

Table 1. Number of households (HH) and mean flock size (SD) in the different locations

Location	Community	№ of HH	Average flock size (SD)	Range
Afar				
	Halaydegi	46	15.8 (9.22)	4 – 42
	Bonta	53	11.6 (10.29)	4 – 73
	Mean		13.5 (9.99)	4 – 73
Bonga				
	Boqa	63	9.4 (4.98)	4 – 23
	Shuta	64	7.5 (3.85)	4 – 21
	Mean		8.5 (4.53)	4 – 23
Horro				
	Kitlo	59	18.4 (14.24)	3 – 72
	Lakku-Iggu	63	16.5 (10.01)	4 – 50
	Mean		17.4 (12.23)	3 –72
Menz				
	Mehal-Meda	64	22.7 (12.95)	4 – 64
	Molale	58	16.5 (9.67)	4 – 41
	Mean		19.8 (11.87)	4 – 64

Getachew (2008) reported higher flock sizes per household for both Afar (23.0 ± 16.5 with range of 5 to 80) and Menz (31.5 ± 15.2 with range of 7 to 69). Edea (2008) also reported higher flock size for Bonga (11.3 ± 1.3 with range of 1 to 50) but smaller size for Horro (8.2 ± 2.1 with range of 2 to 50). The likely reasons for the disparity between these results and those obtained in the earlier studies may be attributed to the fact that the former studies covered wider areas and sampled respondents, while the current studies were based on complete census of flocks owned by target communities. The other likely reason for the observed differences was that some households in Afar and Bonga (one of the two communities) were not willing to disclose their respective correct flock sizes for cultural reasons as well as due to suspicions related to ear tag application.

Figure 1. Flock structure by age and sex of the different breeds



Aged=older sheep above 5 yr of age; 4PPT=full-mouthed sheep; 3PPT=sheep with 3 pairs of permanent incisors; 2PPT=sheep with 2 pairs of permanent incisors; 1PPT=sheep with 1 pair of permanent incisor; 0PPT=sheep with milk teeth

From the baseline data, about 85%, 81%, 79% and 75% of the flocks were females in Afar, Bonga, Horro and Menz, respectively. The flocks comprised of about 32.6 and 27.6% in Afar, 23.3 and 33.4% in Bonga, 24.8 and 32.1% in Horro and 29.4 and 28.1% in Menz adult ewes and ewe-lambs (milk teeth females), respectively. In Afar about 4% of the ewes were aged animals older than 5 years, with one or more pairs of erupted permanent incisors. Proportionally fewer younger males than females (< 1 year of age) of the same age were found in all flocks. They were lesser by 13.9% in Afar; 14.8% in Bonga; 12.9% in Horro and 7.8% in Menz. Such disparities may arise from early disposal of male lambs. Breeding rams with one or more pairs of permanent incisors (1 to 5 year old) were only about 1.3%, 0.28%, 0.68% and 4.3% of the respective total flocks in Afar, Bonga, Horro and Menz, respectively. This clearly indicates that there is critical shortage of breeding rams in Bonga and Horro flocks and confirms the findings of Edea (2008) who reported that there was critical shortage of breeding rams in both flocks. The absence of enough number of breeding rams in the flocks may negatively influence reproductive performances of breeding ewes.

Breeding ewes with one or more pairs of permanent incisors (1 to 5 year of age) constituted about 57.4% in Afar and 47.0% each in the other three breeds. Abegaz et al. (2005) also reported that breeding females of Horro sheep older than one year of age constituted about 47.0% of the total flock. Proportion of Menz ewes with at least one pair of permanent incisors (above 1 year old) reported in the current study is within the range (42 to 52.5%) of on-farm survey results reported by Agyemang et al. (1985), Mukasa-Mugerwa et al. (1986), Wilson (1991) and Mekoya et al. (2000) for same breed. Similar results are not available for Afar and Bonga breeds for comparisons. From Figure 1, it is clear that the proportion of older ewes (older than 5 year) which are generally past their most productive stage was higher in all the flocks than the more productive middle aged ewes. This warrants management decisions/interventions that favor the retention of large proportion of middle-aged ewes. It can also be observed from the proportions of ewe lambs (those younger than 1 year) and those of between 1 and 2 year of age, that a relatively high off-take rates are practiced for those younger than 1 year of age (i.e. only a small proportion of ewe lambs are retained for replacement and most of them are disposed before they reach breeding age).

Least squares means and standard errors of live weight of young ewe lambs and male lambs of about 1 year of age and adult ewes older than 4 to 5 years of age for the different breeds are presented in Table 2. The lack of an adequate number of breeding rams in the flocks of all breeds prevented the estimation of liveweight at older ages. Significant differences ($p < 0.001$) were observed in liveweight among adult ewes of the different breeds. Bonga ewes were the heaviest followed by the Horro ewes, with Menz ewes, especially at Molale being the lightest.

Table 2. Least Squares means (±SE) of live weight (LWt) of young animals of about yearling age and adult ewes of about 4 more years old of the different breeds

Breed	Category	Number	LWt (kg)	LWt range (kg)
Afar				
	Yearling male	12	21.8±0.86	16.8 – 26.0
	Yearling female	167	21.0±0.23	12.8 – 30.2
Bonga				
	Yearling male	5	38.2±1.20^{a}	36.0 – 40.0
	Yearling female	80	31.0±0.47^{b}	20.0 – 41.0
Horro				
	Yearling male	5	31.2±1.70^{a}	25.0 – 35.0
	Yearling female	148	26.5±0.31^{b}	20.0 – 39.0
Menz (Mehal Meda)	Yearling male	43	24.4±0.63^{a}	14.6 – 38.5
	Yearling female	105	20.8±0.42^{b}	12.8 – 32.4
Menz (Molale)	Yearling male	26	20.4±0.57^{a}	13.4 – 25.6
	Yearling female	87	18.1±0.31^{b}	11.8 – 29.0
Afar	Adult ewes	449	24.9±0.23^{a}	13.6 – 38.6
Bonga	Adult ewes	357	36.3±0.26^{b}	25.0 – 55.0
Horro	Adult ewes	727	33.4±0.18^{c}	21.0 – 56.0
Menz (Mehal Meda)	Adult ewes	497	23.6±0.16^{d}	15.0 – 35.0
Menz (Molale)	Adult ewes	298	21.3±0.20^{f}	13.6 – 29.0

Different super scripts indicate statistically significant differences ($p < 0.001$)

There were also significant differences between the two Menz flocks located at Mehal Meda and Molale. The likely reasons may be both genetic and environmental factors. Menz flocks in Mehal Meda are mixtures of crossbred animals having unknown blood levels of Awassi. Sex had significant influences ($p < 0.001$) on liveweight of younger animals of about one year of age (1 pairs of permanent incisors), except in Afar flocks. Yearling Bonga, Horro, Menz (Mehal Meda) and Menz (Molale) rams were heavier by about 7.2, 4.7, 3.6 and 2.3kg than their respective female counterparts, respectively (Table 2).

8. Record formats, recording and data management

Performance recording is an essential element in a breeding program. Development and use of simple, flexible and cost-effective performance recording and evaluation system is crucial. A performance recording systems or structure provides breeders with a uniform set of performance recording guidelines (Wilson and Morriecal, 1991) and allows for feedback from centrally managed and analyzed data to farmers on which areas/traits improvements should be made. Three record formats were developed for each location: two for ewe and a lamb record (Annexes B, C and D). Major traits considered were weight (birth, weaning, 6 months and yearling) and number of lambs weaned for all breeds. In addition, milk yield for Afar, number of lambs born (twinning) for Bonga and Horro and wool yield for Menz were included. Traits of economic importance that encompass reproduction, growth, milk, and wool production mainly focusing on objective traits were recorded in priori-discussed and agreed formats that were developed by the research team after a thorough discussion.

An enumerator was employed for each community to assist households in measurement and record keeping. A record book was prepared for each household for day to day follow up and one big record book for a community was given to the enumerator. Sample record formats were manually printed on each book. A weighing scale with 100kg capacity and accuracy of 200g, plain and printed ear tags, and permanent markers were also provided to the community. Focused trainings were given to enumerators and households on recording.

Monitoring of the breeding activities, record keeping by households and the enumerator was done on a fortnightly basis by a research team from respective research center. Data is normally entered in Excel at respective research centers and copies are sent to the International Livestock Research Institute (ILRI, Addis Ababa) where data is processed. It was initially planned to develop a centralized web-based database management tool that stakeholders could access and update online; and simple indexes based on the set selection criteria for each breed are calculated to effect selection. However, the database has not been finalized by the time this paper is prepared.

9. Candidate ram selection and animal exhibition

Thus far ram selection was done in two rounds in each area. Screening and selection procedures were mainly based on recorded information (own and maternal) and independent culling of animals for observable defects (tail type, coat color, horns, conformation and general appearance). Two stages of selection are applied: initial screening is done at 6 months and final selection for breeding at 12 months of age. A breeding ram selection committee composed of about five members from the community was actively involved in the selection of candidate rams. All young rams were collected at one central place in each community on the screening date. A total of 14, 21, 36, and 50 rams have been selected in Afar, Bonga, Horro and Menz, respectively during the two rounds of screening activities.

Animal exhibitions were organized simultaneously with breeding rams selection. Best animals from both sexes and the different age categories (6 month old males, year old males and those older than 2 years old; year old females, 2 to 4 years old ewes and mature ewes older than 4 years of age) were ranked from 1st to 3rd and awarded. Animal exhibitions were conducted to create awareness in communities that breeding animals have higher values than those raised for meat. It also strengthens the relationship between farmers and researchers so as to perform joint activities. A committee composed of 3 to 5 individuals from the community did the selection of the animals at each location. Members were pre-informed that best animals from each sex and age category will be identified and receive awards. All members of the community brought their animals at one central place in each community. Comparisons were made among animals in similar age category for both sexes. Committee members were asked to select and rank 10 best animals from each category of which those animals ranked from 1^{st} to 3^{rd} were awarded. Finally members of the committee, one at a time, were asked to give their views on why they selected and ranked an animal in that order when an animal was identified by its identity number and brought forth for award. Individuals who managed their flocks well were also selected by the community and received awards.

10. Management and use of breeding rams

Importance of sharing rams to avoid inbreeding was well agreed upon by the community members during the various stages of discussions and consultation workshops. From the crossbreeding experience at Mehal Meda (one of the communities at Menz where rams were provided by government), there was no problem in sharing and rotating the rams among the participating farmers. Some examples among good practices at Mehal Meda include preferential supplementation of breeding rams with locally available feeds (hay, residues from pulses, and weeds) and recording weight of rams regularly to monitor differences of individual farmers in handling of breeding rams. However, when it comes to sharing and rotating rams belonging to individual households, the communities in all locations except

Afar were reluctant. This was due to the fear that mismanagement of breeding rams by some members of the community may cause disappointment to the owners and subsequently may cause conflicts among them. In Afar, there is already a culture of ram sharing among the community and ram is considered as property of a given clan; denying others to use breeding rams is culturally prohibited. After repeated discussions with members, the following options that would enable smooth sharing of selected rams were suggested and discussed as alternatives:

- Sharing rams based on friendship and trust among members of the breeding group
- Exchanging rams based on written agreement
- Exchanging rams based on purchase between different breeding groups when the rams have fulfilled their services time in a given flock
- Obtain some seed money from the project or from members' contribution to purchase breeding rams in common.

The last alternative was finally implemented as seed money to create a revolving fund was provided by the project. This may serve as a remedy against early sale of fast growing young rams that was found to be a major threat for the implementation of the program. Ram-group formation was based on number of breeding ewes, settlement and communal grazing areas. Social network studies in all areas and resource mapping in two locations were also conducted to aid formation of ram-groups, though not properly used until now. A ram serves in flocks of a ram-group only for one year and then will be moved to another ram-group within the community. For proper handling and management of the selected breeding rams, individuals selected by members of each ram-group must sign an agreement with respective research centers.

11. Related interventions to support the breeding program

For genetic improvement programs to be successful and sustainable, an integrated systems approach is required (Olivier et al., 2002; Rege et al., 2010). The authors argue that increases in productivity in the short-term through management interventions assure farmer motivation well before the first positive breeding effects become visible. Health interventions that were made by the current project include strategic vaccinations against major endemic sheep diseases prevailing in each location, seasonal mass de-worming, and treatment of sick animals. Scarcity of feeds were addressed by distributing seeds of two to three types of recommended improved forage varieties in Horro and Menz areas. However, this was not done at Bonga as feed scarcity was not reported there; and in Afar due to the migratory nature of the Afar community. In all the locations, separate trainings on animal health and feeds management were conducted. Moreover, an in-depth training on animal health was organized for four community health workers in Afar who will assist the community in providing primary aids for non-serious animal health problems and castration of unwanted rams. In two of the communities, Horro and Menz, seedlings of high-value highland fruit were distributed to interested members.

12. Challenges

Implementation of a sustainable breeding program requires participation of local communities in activities such as flock recording. In this regard, low level of literacy and technical ability of local sheep breeders and the community members in general was a big constraint, especially in Afar region. In the absence of accurate records, objective selection decisions would not be possible. Rege et al. (2010) reported that animal recording, including the recording of inputs, animal performance and breeding activities, is critical to successful livestock management and genetic improvement. Despite the project attempts to equally communicate the new ideas to all the communities, adoption greatly varied among individual members and locations. For instance, it was very difficult to convince communities at Afar and Bonga (in one of the two communities) to use ear tags (in Afar application of ear tags without abandoning the traditional identification system) during the initial stage. Afar people have a traditional way of identifying their animals, which is through branding of unique pattern that are specific to each clan and households within a clan. It was very difficult for the community to accept use of ear tags for two main reasons: a) it was considered as violation of long standing traditional norms and b) for fear of theft in case animals stray from their usual flocks. Since the clan-based identification is known to every Afar person, animals which stray be easily recognized from the clan brands and brought back to their owners. This is an established norm within the Afar people that guarantees that animals that stray are never lost. But if animals are found ear-tagged (though the traditional branding are not abandoned it is not clearly visible at a distance), they may be considered as belonging to some outsiders and may never come back to the owners. In Bonga, there has been very limited interaction and intervention from research before, consequently, some community members were suspicious and did not want to disclose their animals for tagging.

A number of problems have been associated with the communal grazing land. It is the only feed resource utilized during cropping season (from June to September in Menz and Horro). In the communally grazed lands there are no pastures protection/conservation and development at all. Disease and parasites transmission, uncontrolled mating (breeding), overgrazing due to competition, and lack of responsibilities are some of the major problems to utilize the communal grazing lands wisely.

Recurrent droughts have become a phenomenon in Afar and Menz. For instance, there was a severe and prolonged drought in 2008/09 that caused forced mobility in Afar making it impossible to trace the project animals for monitoring. There were also communication gaps (language barrier) between the researchers and communities in some locations. Staff shortage and turnover were noticed deterring implementation activities as desired in some locations. Sluggish financial flow in the national and regional research systems was also another bottleneck to implement the project activities as planned.

13. Conclusions

It was possible to implement the breeding schemes selected by the different communities among alternatives simulated following breeding objective traits identification. This was done mainly because:

- breeding objectives and associated traits were developed using participatory approaches
- selection strategies were designed to suit the communities' practices
- different options for selection strategies were presented clearly to the communities, discussed and the communities decided which suited them best to implement

A genetic improvement is not possible unless the environment is improved to sustain it. So it should be born in mind that such genetic improvements must be accompanied by improved feed supply and health care. Generally, the on-going improvement programs can be sustainable provided the current technical backup from research centers continues.

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CHAPTER V

General Conclusions and Recommendations

Community-based breeding programs designed with active involvement of traditional breeders are appropriate for *in-situ* conservation of indigenous animal genetic resources. It is because smallholder livestock breeders have used different phenotypic features including adaptive attributes to identify and select their breeds, strains or landraces for centuries.

Available tools applicable to the identification of livestock breeding objectives under situations in developing countries are reviewed and their revealing powers of traits preferences of owners were assessed. The tools were: survey questionnaire, choice experiments, ranking of animals from own flock/herd and ranking of others (unknown) animals. Review results indicated that each tool is appropriate to specific situation and at some stage. For instance, survey questionnaire is important for overall situation analysis and for capturing exhaustive lists of objective traits in a given production system. Breeding traits identified in the survey study are used in modeling choice experiments, which have power to value intangible traits using pictorial representation that otherwise could not be assessed. Ranking of own animals mainly focuses on reproduction and production performances; and if supported with liveweight and linear measurements, which can be taken on the ranked animals, it may enable to blend indigenous knowledge with the sciences of animal breeding. In ranking of others animals, major focus is on observable attributes (e.g. coat color, tail type, body size, etc.) and respondents need informed decision to select animals for breeding purposes. Results revealed that: 1) choice experiments and ranking of own animals enable to capture both tangible and intangible objective traits, and 2) most of the different tools are complementing each other. Generally, it is recommended that a combination of approaches be used to accurately capture breeding objective traits of livestock producers. Elucidation of objective traits with active involvement of producers using two or more of the tools investigated can result in appropriate livestock genetic improvement that is well grounded in practical reality and truly reflect owners' preferences.

Identification of breeding objective traits pertinent to specific production environments with the involvement of target beneficiaries is crucial to the success of livestock improvement program. Choice experiments were carried out as a follow-up of sheep production system study with the aim of eliciting objective traits of farmers/pastoralists in mixed crop-livestock, sheep-barley, and pastoral/agro-pastoral systems in four regions of Ethiopia. The study showed that traditional breeders value both tangible and intangible traits; the latter would have been concealed when one uses conventional valuation methods. Thus, hypothetical choice experiments are useful tools to identify objective traits that would be incorporated into breeding plans especially under traditional production systems where recording practices have not been in place.

Despite the various challenges, particularly in the initial stage, it was possible to practically implement breeding scheme selected by the respective communities among simulated alternatives following breeding objective traits identified through participatory approaches. The current on-going genetic improvement can be sustainable provided that:

1. the current technical backup from research centers continues,

2. the improvement program is registered on the research agenda of the respective research centers and pass through the annual review processes as one of the on-going research activities,
3. problems related to shortage of skilled manpower and staff turnover received special attention of concerned authorities/institutions,
4. legally functioning breeding cooperatives are in place, and
5. those households left out (jumped) either due to less number of breeding ewes or other reasons are considered in the improvement program (i.e. all community members sharing the same grazing area have to be embraced in the breeding program).

Having legally functioning breeding cooperatives enables to coordinate and perform community-level collective actions: like exchange of breeding rams, culling of non-selected rams, joint procurement of medicaments, procurement of supplementary feeds to condition/fatten non-selected rams before marketing and marketing of such animals, etc. Scaling-up/scaling-out of the improvement program to wider areas does have its own influence on genetic improvement and marketing of more uniform animals at a time; of course the livelihood of producers can be improved through the benefits that come with it.

To be sustainable, genetic improvements must be accompanied by improved feeds supply and health care. For this to be effective, trainings in the areas of feeds management and health care have to be intensified. In the mixed crop-livestock system, where cereals and pulses productions are common, special attention has to be given to the conservation and use of crop residues. Rural communities are grounded in tradition and have deep roots and someone who is skilled and understands those traditions makes a huge difference. Thus, capacity building of local researchers and technicians with particular emphasis on feeds management, health care and data management are fundamental. In all locations, large proportion of older ewes (older than 5 year) which are generally past their most productive stage was higher in all the flocks than the more productive middle aged ewes. This warrants management decisions/interventions that favor the retention of large proportion of middle-aged ewes.

During extended drought season pastoralists move far away from their settlement areas in search of feeds and water for their animals which makes it difficult monitoring and selection of breeding rams. Under such circumstances it is essential to apply ear tags to newly born lambs, particularly to ram lambs, and let them to go; and do the monitoring and selection activities during when flocks are taken back to the settlement areas in the rainy season.

Summary

This study involves: review of available tools and methods used to identify breeding objectives of livestock keepers (**Chapter II**), identification of traditional sheep breeders' preferences for sheep breeding traits using hypothetical choice experiments (**Chapter III**) and implementation of community-based breeding program (**Chapter IV**) under smallholder conditions in different production systems in Ethiopia.

In the reviewed tools: survey questionnaire, participatory rural appraisal (PRA), choice experiments, ranking of animals from own flock/herd and ranking of others animals were covered. Results revealed that: 1) survey questionnaire is important in capturing exhaustive lists of objective traits that are used to modeling hypothetical choice experiments, 2) choice experiments and ranking of own animals enable to capture both tangible and intangible objective traits, and 3) ranking of others animals mainly values observable attributes (e.g. coat color, tail type, body size, etc.) and respondents need informed decision to select animals for breeding purposes. In general, most of the different tools are complementing each other, thus elucidation of objective traits using a combination of one or more of the tools with active involvement of producers can result in appropriate livestock genetic improvement that is well grounded in practical reality and truly reflect owners' preferences.

Identification of breeding objective traits pertinent to specific production environments with the involvement of target beneficiaries is crucial to the success of livestock improvement programs. Choice experiments were conducted in four locations representing different production systems in Ethiopia, that are habitat to four indigenous sheep breeds (Afar, Bonga, Horro and Menz) with the objective of identifying farmers'/pastoralists' preferences for sheep breeding traits. Following a synthesis of secondary information and diagnostic surveys, two communities per location consisting of 60 households each were identified. Based on prior information, 4 to 7 attributes were used to design choice sets. The attributes chosen were body size, coat color, tail type for both rams and ewes; horn and libido for rams; lambing interval, mothering ability, twinning rate and milk yield for ewes. Fractional factorial design resulted in a randomized selection of 48 sheep profiles (24 sets) for both sexes that were grouped into four blocks with six choice sets each. Respondents were presented with one of the 4 blocks to make their choices. Results indicate that trait preferences were heterogeneous except for body size in rams and mothering ability in ewes. Breeders in all areas attempt to combine production and reproduction traits. The elicited measurable objective traits were used to design community-based breeding plans that have been implemented since.

Chapter IV presents all steps followed to implement a community-based breeding program under smallholder conditions in four different production systems in Ethiopia. Information on the current husbandry practices (i.e. baseline breeding, feeding, health, etc.) and body weight of flocks of the project members were recorded for benchmarking and evaluation of the changes that will be realized from the improvement intervention. Complete census of flocks owned by project members was done along with ear tag application to determine flock size and flock structure (by age and sex). Recording formats were established focusing on the selection criteria defined for each breed. Enumerators were employed and trained to assist households in the measurements and recording. Monitoring of the breeding activities was done fortnightly by a research team from respective research centers. Two stages of selection were applied in selecting breeding rams (in addition to the independent culling of animals for observable defects): initial screening at 6- and final selection at 12 months of age. A

committee composed of 5 members from each community was actively involved in the selection process. Candidate rams were collected at one central place in each community on the screening date. A total of 14, 21, 36, and 50 rams have been selected and distributed for use in Afar, Bonga, Horro and Menz, respectively in two rounds of selection. Seed money was provided by the project to purchase the selected rams for the community. Different ram-groups were formed based on number of breeding ewes, settlement and communal grazing areas.

Annex A. Mean (SD) of live weight for different sex and age (dentition) groups

Breed	Sex	Dentition	n	Mean (SD)	Range
Afar	Male	0	182	12.2 (6.15)	2.3 – 29.8
		1	12	21.8 (2.57)	16.8 – 26.0
		2	4	26.5 (4.74)	20.4 – 31.8
		3	-	-	-
		4	2	32.6 (3.96)	29.8 – 35.4
	Female	0	368	13.9 (5.43)	2.3 – 28.0
		1	167	21.0 (2.99)	12.8 – 30.2
		2	98	23.0 (3.64)	16.8 – 33.8
		3	14	23.4 (4.57)	13.6 – 31.0
		4	435	25.0 (3.41)	17.8 – 38.6
		5	51	23.5 (2.96)	17.2 – 31.8
Bonga	Male	0	196	16.2 (7.64)	3.0 – 39.0
		1	1	38.2	-
		2	1	37.0	-
		3	1	32.0	-
		4	-	-	-
	Female	0	358	19.1 (8.20)	3.0 – 37.0
		1	80	31.0 (4.33)	20.0 – 41.0
		2	70	34.0 (6.49)	21.0 – 62.0
		3	107	35.2 (5.75)	25.0 – 52.0
		4	250	36.8 (5.79)	25.0 – 55.0
Horro	Male	0	428	15.5 (6.54)	3.0 – 35.0
		1	5	33.7 (5.10)	25.0 – 41.0
		2	6	34.1 (6.12)	27.0 – 50.0
		3	3	42.8 (4.35)	36.0 – 50.0
		4	1	40.7	-
	Female	0	720	17.6 (6.78)	3.0 – 35.0
		1	148	26.5 (3.79)	20.0 – 39.0
		2	180	28.8 (4.69)	19.0 – 47.0
		3	171	30.9 (5.31)	21.0 – 50.0
		4	556	34.1 (5.02)	24.0 – 56.0
Menz (MM; Mo)	Male	0	288;200	13.4 (5.36);12.6 (5.11)	1.6–27.8; 1.8–29.6
		1	43;26	24.4 (4.98);20.4 (3.58)	14.6– 38.5; 13.4–25.6
		2	12;11	27.5 (5.76);22.5 (4.56)	19.0–35.8; 15.0–31.4
		3	2;2	22.7 (3.82);23.3 (2.12)	20.0–25.4; 21.8–24.8
		4	3;3	41.3 (13.58);27.2 (4.01)	27.0–54.0; 22.6–30.0
	Female	0	409;266	13.7 (5.21);10.8 (4.21)	2.4–27.2; 1.8–27.2
		1	105;87	20.8 (3.97);18.1 (2.70)	12.8–32.4; 11.8–29.0
		2	89;60	21.3 (2.86);18.7 (2.37)	15.6–29.0; 13.6–25.8
		3	57;26	21.5 (3.30);20.1 (2.47)	15.0–30.0; 16.0–24.6
		4	440;272	23.9 (3.64);21.4 (2.85)	15.0–35.0; 13.6–29.0

MM=Mehal Meda; Mo= Molale

Community-based smallholder sheep breed improvement in Ethiopia
(ICARDA-ILRI-BOKU project in collaboration with NARS)

Annex B. Ewe Format

Farmer Name	Ewe ID	Special identifier	Coat-color	Dam ID	Sire ID	Mating Date	Breeding Ram ID	Lambing Date	Parity	Litter Size	Lamb ID			Litter Weight	PPWt	Number weaned	Weight weaned
											Lamb1	Lamb2	Lamb3				

PPWt=Post-partum weight of ewe

Community-based smallholder sheep breed improvement in Ethiopia
(ICARDA-ILRI-BOKU project in collaboration with NARS)

Annex C. Ewe Card (to be kept in each household)

Ewe ID №: ______________________________
Coat color: ______________________________
Birth Date: ______________________________
Dam's ID: ______________________________
Sire's ID: ______________________________
Owner's name: ______________________________

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

Community-based smallholder sheep breed improvement in Ethiopia
(ICARDA-ILRI-BOKU project in collaboration with NARS)

Annex D. Lamb Format

Farmer Name	Lamb ID	Dam ID	Sire ID	Birth type	Birth Date	Sex	Birth Weight	Coat-color	Weight at 3 months	Date	Weight at 6 months	Date	Yearling Weight	Date	Tail Type