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Sustainable Sheep Breeding Programmes in the Tropics: a Framework for Ethiopia

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Abstract

Improvement programmes for small ruminants in the tropics face several constraints that have hampered the establishment and sustainability of such programmes. One major shortfall has been weak planning, particularly poor involvement of livestock owners and other stakeholders in the design and implementation of the programmes. In sub-Saharan Africa, low productivity, high density of animals in relation to grazing capacity, unreliable rainfall, increasing human population, small landholding, and declining land productivity are all major concerns. Studies in Ethiopia show substantial within and between breed variations, and hence genetic improvement is feasible among indigenous sheep breeds. Different breeding alternatives to maximise production (e.g. lamb growth and survival) per animal while culling less productive animals to reduce flock sizes, and re-allocating of resources (e.g. feed and health management) as a means of upgrading management levels for the genetically superior flocks are suggested. Breeding programmes are proposed to be based on open-nucleus flocks utilising government ranches at the top of a three-tier system of flocks. Selection schemes allow an in-flow of high potential breeding ewes from sub-nucleus herds for pure-breeding to nucleus flocks in the ranches. The selected superior rams from the ranches will be distributed to participating farmers in the sub-nucleus flocks for mating. Subsequently village flocks receive selected superior rams from the sub-nucleus herds. The programme is proposed to be managed by a nationally mandated Animal Genetic Resources Institution, which collaborates with research institutions and oversees all activities related to this programme. Such a participatory programme is believed to ensure not only long-term genetic improvement and livelihood improvement, but also conservation of the indigenous genetic diversity as well as eco-system health.

Keywords: Ethiopia, genetic improvement, indigenous sheep, open-nucleus breeding scheme

Introduction

Small ruminants (sheep and goats) have a unique niche in smallholder agriculture from the fact that they require small investments; have shorter production cycles, faster growth rates and greater environmental adaptability as compared to large ruminants. They are important protein sources in the diets of the poor and help to provide extra income and support survival for many farmers in the tropics and sub-tropics. Among livestock and livestock products it is projected by year 2015 that Africa would export only mutton and goat meat while she would import beef and continue importing milk and pig meat (FAO, 2002).

Small ruminants' improvement programmes in developing countries, however, have several constraints. One major shortfall has been weak planning, particularly poor involvement of livestock owners and stakeholders in the design and implementation of the programmes. In the sub-Saharan Africa countries, low productivity, high density of animals in relation to grazing capacity, unreliable and erratic rainfall, increasing human population, small landholding, and declining land productivity are all major concerns.

Despite huge (nearly 24 million) (CSA, 2004) and genetically diverse (DAGRIS, 2006) sheep population in Ethiopia, off-take is very low at 33% (EPA, 2002) with an average lamb carcass weight of 10 kg. Among many of the constraints to sheep production, scarcity of feed, slow growth rate and high mortality (Tibbo, 2006) has been the major limiting factors. This is partly because sheep breeding in Ethiopia is non-controlled, and health and nutrition management are very poor. Diminutive breeding efforts attempted as early as 1960s focused on crossbreeding of the indigenous breeds with exotic breeds (Bleu du Maine, Merino, Rambouillet, Romney, Hampshire, Corriedale, Awassi) to improve growth and wool yield (Tibbo, 2006). Currently, exotic and crossbreds sheep in Ethiopia constitute negligible proportion (<1%) of the total sheep population. The crossbreeding programme suffered from poor planning, not involving livestock owners and stakeholders in decision making and ownership of the initiatives on top of low regard to the potential of indigenous breeds. Studies made on indigenous sheep breeds revealed significant between and within breed variation for growth and indicated feasibility for productivity improvement of indigenous sheep breeds through genetic means (Abegaz, 2002; Ermias et al., 2002; Tibbo, 2006). In the light of failures and successes (if any) of those initiatives, and key factors that impact a breeding programme, a framework for sheep breeding in Ethiopia was seriously needed. This paper summarizes a framework of sheep breeding for Ethiopia, which could also be used for similar production systems in developing countries.

The proposed framework for sheep breeding

This framework was formulated using the limited information available on: (1) sheep genetic diversity and distribution; (2) productivity levels of indigenous breeds and crossbreds; (3) sheep production (farming) systems in relation to land use; (4) market opportunities (access) and/or demand for various sheep products; (5) lessons from past efforts; (6) community-based knowledge and practices; and (7) available capacity in terms of infrastructure and trained human resources.

Strategies for genetic improvement

Strategies for genetic improvement could follow three pathways: (i) selection between breeds (or strains), (ii) selection within breeds (or strains), and (iii) crossbreeding or synthetic breed development. Due to large variation in performance among indigenous breeds and their unique

attributes (DAGRIS, 2006) the strategy for improvement should be different for different indigenous sheep breeds. Within breed improvement for growth could be relatively easier for large breeds (e.g. Horro, Bonga) as compared to small breeds (e.g. Tukur, Menz), which may require additional strategies such as crossbreeding, synthetic breed development or breed substitution. The later intervention, however, must consider the needs for these breeds to be adapted to tropical climate under low-input systems and to many stressors. Strategy for improving some unique breeds (e.g. Abergelle, Afar, Blackhead Ogaden/Somali) adapted to semi-arid to arid harsh climate (water and feed scarce areas) need to consider their unique attributes and focus on improving within breed with some level of crossbreeding with breeds that are adapted to such harsh climate.

Pathways for Ethiopia's sheep productivity improvement

The overall national sheep production to consumption goal for Ethiopia aims at improving production per sheep instead of keeping huge number of mediocre animals contributing to land degradation and feed scarcity. Eight hypothetical alternative (ALT) scenarios in comparison to the current sheep production situation are illustrated in Table 1. These alternatives are simulated by making changes towards reducing lamb mortality, improving ewe fertility and lamb growth, reducing marketing age and reducing number of ewes kept. This could be achieved through genetic means and modifying the environment (re-allocating feed resources to 'best' ewes and lambs by e.g. culling mediocre animals, shift to more favourable lambing season, and anthelmintic control management). This, in turn would improve ewe weight at mating and lamb weight at birth, thus improving survival in subsequent periods (Tibbo, 2006) and allowing more and heavier lambs in the flocks and being marketed much earlier in life time.

Although the scenarios and their assumptions presented in Table 1 are simplified, the results point at important areas for improvement as is shown in this thesis. Reduction of lamb mortality and increased growth rate by re-location of resources favouring pregnant and suckling ewes should lead to earlier marketing age of lambs. A doubled market output per sheep kept in the population is clearly achievable. As traditions are strong and the animals are kept for social security and other reasons an acceptable alternative might be based on an unchanged number of ewes but a higher turn-over rate of the lambs, allowing more resources to be used for priority groups of ewes and lambs. Both genetic and environmental interventions would be needed and supported by further research and extension services.

Within breed improvement

Within breed selection involves measuring and selecting on productivity such as growth, survival and litter size. In the tropics small flock sizes, single-sire flocks, lack of animal identification, lack of performance and pedigree recording, low level of literacy and organisational shortcomings (Kosgey et al., 2006) and flock mobility have been major problems. The situation is not exceptional in Ethiopia. Components of within breed improvement include defining the overall development objectives, characterising the production system, identifying breeds to be used and improved by selection, identifying a list of breeding goal traits and deriving goal values for each of the breeding goal traits. Breeding goal traits must have: (i) reasonably large genetic variability; (ii) easily and cheaply measurable; (iii) if not easily and cheaply measurable then, must have a high genetic correlation with a trait (indicator trait) that is easily measurable, has a higher heritability or can be measured earlier in life than the goal trait it represents; and (iv)

desirable economic value, either as a marketable commodity or as a means of reducing production costs.

The overall breeding goal for sheep production in Ethiopia would be improving growth to achieve a yearling weight of 30 kg, and survival of 90% at yearling. Since the stated yearling weight is demanded by importers* from Ethiopia (Aklilu et al., 2005), stakeholders which include exporters of sheep as live or mutton, should be involved at all phases. If a lamb could attain a high weight at 12 months of age, subsequent fattening for 3 months after castrating could fetch high market prices even in domestic markets. Measuring breeding goal traits with components of production and reproduction (e.g. number and weight of offspring per year) in smallholder farms, however, is not easy. The difficulty to measure and value the intangible benefits (Kosgey et al., 2006) derived from sheep presents more complications. Therefore, systems of utilizing government ranches and research flocks as nucleus breeding units, where proper livestock recording could be anticipated, should be looked for.

Open-nucleus breeding scheme

Open-nucleus breeding scheme (ONBS) is a scheme which allows an in-flow of high potential breeding animals (Philipsson et al., 2006) from lower-tier flocks for pure-breeding to nucleus flocks in the ranches as a strategy for genetic improvement of sheep in Ethiopia. The scheme could be utilised for conservation of genetic resources (including breeds, desirable genes, genotypes, etc) through improvement and proper utilisation (Yapi-Gnoaré, 2000; Philipsson et al., 2006). This scheme can serve for both pure-breeding and crossbreeding, and dissemination of improved genetic materials allowing conservation and improvement of the indigenous sheep breeds. Based on breeding values for the breeding goal traits, ewes born to superior rams would be selected and bought for transfer to nucleus flock. Nucleus flocks will be set-up in the governmental breeding ranches or similar settings (e.g. research stations). Subsequent genetic evaluations and selection for superior rams would be undertaken in the nucleus flocks where animals from different sources are evaluated in the same environment. Dissemination of superior rams to participating farmers will be made on cost-recovery basis.

Practical example of a structure for a possible open-nucleus breeding scheme for the indigenous Horro breed of Ethiopia consisting of 2 million ewes is illustrated in Figure 2. It is based on a three-tier system: nucleus, sub-nucleus and village flocks. There will be 10 nucleus flocks and each nucleus flock will consist of 4 000 breeding ewes and 160 fertile breeding rams. Thus, each ram will annually be used for 25 breeding ewes. Nucleus flocks will be established within the governmental ranches, research centres or any suitable settings and should be situated closer to animals' habitat and environment where they are finally be used. Litter size for Horro breed was 1.34 at Bako Research Centre (Abegaz, 2002). Survival at yearling was set to stand at 90% as a breeding goal and fertility rate of 85%, allowing each ewe to produce 1.03 lambs per year in well managed nucleus flocks. About 4% best rams each year should be selected at nucleus flocks for own use. From the remaining rams in the nucleus flocks, 30% of the second best rams will be used to cover the need of rams for the sub-nucleus flocks.

* Recent survey (Gebremedhin and Adugna, 2006) indicated that for Dubai and Bahrain export market 5-8 kg carcass weight (13-20 kg live weight) and for Saudi Arabia 9-12 kg carcass weight (20-30 kg live weight) is being marketed.

Table 1. Different hypothetical scenarios or alternatives (ALT) for sheep improvement in Ethiopia

Parameters	Current	ALT 1	ALT 2	ALT 3	ALT 4	ALT5	ALT 6	ALT 7	ALT 8
Marketing age (months)	18	18	18	12	12	18	18	12	12
Marketing live weight (kg)	25	25	25	25	25	35	35	30	30
Number of lambs born per ewe/year*	0.92	0.92	1.20	0.92	1.20	0.92	1.20	1.20	1.20
Lamb survival at marketing age	0.70	0.80	0.80	0.80	0.80	0.85	0.85	0.90	0.90
Number of ewes (million)**	10.00	8.75	6.71	8.75	6.71	8.75	6.71	7.39	9.47
Kg of lamb carcass weight/ewe/year***	6.44	7.36	9.60	7.36	9.60	10.95	14.28	12.96	12.96
Total kg of lamb carcass per year (million)	64.40	64.40	64.40	64.40	64.40	95.80	95.80	95.80	122.73
Number of growing lambs (million)	13.80	12.08	12.08	8.05	8.05	12.08	12.08	8.87	11.36
Ewes and lambs (million)	23.80	20.83	18.78	16.80	14.76	20.83	18.78	16.26	20.83
Output per sheep (%)	100.00	114.29	126.71	141.67	161.26	170.00	188.48	217.71	217.71

*Number of lambs born per ewe per year = litter size of 1.15 × fertility rate of 0.8 = 0.92; or litter size of 1.50 × fertility rate of 0.8 = 1.20.
** Current number of ewes represented 42.4% of the total population of 23.6 million, which is extrapolated using a study by Mekoya et al. (2000).
*** Lamb carcass weight per ewe per year = Marketing live weight × dressing percentage of 40% × number of lambs born per ewe/year × lamb survival
ALT 1 = reduced mortality by 10%
ALT 2 = reduced mortality by 10%, improved fertility to 1.2 lambs/ewe/year
ALT 3 = reduced mortality by 10%, reduced marketing age by 6 months
ALT 4 = reduced mortality by 10%, improved fertility to 1.2 lambs/ewe/year, reduced marketing age by 6 months
ALT 5 = reduced mortality by 15%, improved marketed live weight by 10 kg per lamb
ALT 6 = reduced mortality by 15%, improved fertility to 1.2 lambs/ewe/year, improved marketing weight by 10 kg per lamb
ALT 7 = reduced mortality by 20%, improved fertility to 1.2 lambs/ewe/year, improved marketing weight by 5 kg per lamb, reduced marketing age by 6 months
ALT 8 = reduced mortality by 20%, improved fertility to 1.2 lambs/ewe/year, improved marketing weight by 5 kg per lamb, reduced marketing age by 6 months

Opportunities

Considering the geographical proximity of Ethiopia to the Middle East and the emergence of large supermarkets in the Gulf States and the Middle East, market opportunities for mutton particularly in processed form are enormous. On top of breed improvement initiatives, to increase the competitiveness of Ethiopia's in mutton export improving the country's sanitary and phytosanitary (SPS) or food safety system which should include strengthening regional, national and international market interventions are important to raise rural household incomes and food security.

The sub-nucleus flocks are those owned by participating sheep owners. Sheep owners in this tier will be selected based on ease of access to farm, availability of enough grazing and water, size of flock, ability to follow prophylactic programmes, supplement their animals during critical periods, and willingness to use controlled breeding (use selected rams from nucleus flocks and castrate mediocre unselected rams of their farms). In these tier flocks, a litter size of 1.2, survival rate of 85% at one year of age, and fertility of 80% would mean that a 0.82 lamb is produced per ewe/year. About 11% best rams each year will be selected at sub-nucleus flocks to be distributed (sold) to village flocks.

Village flocks here are flocks owned by people who are hardly accessed for monitoring and detailed evaluations. At this level evaluation methods to select best animals should be kept very simple. Best ewes would move upwards from sub-nucleus flocks to nucleus flocks, as it may be possible to keep some basic records on pedigrees and production at the sub-nucleus level.

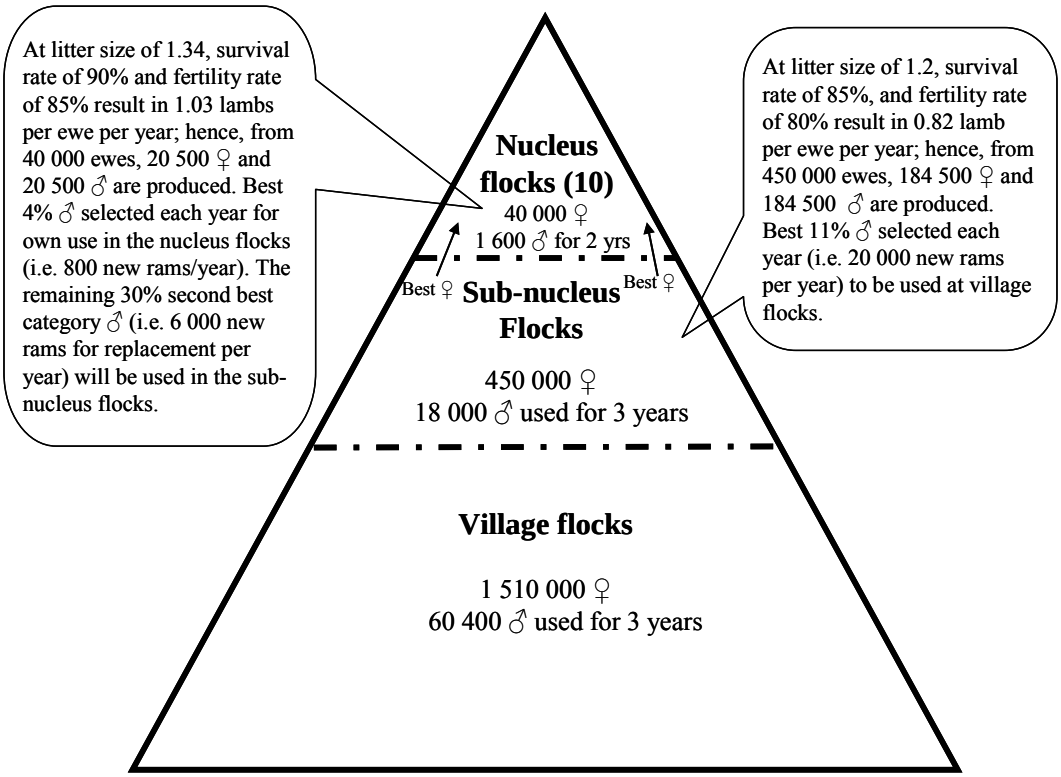

Figure 11. Example of a possible open-nucleus breeding scheme for the Horro sheep breed consisting of 2 million ewes

Improvement programmes for sheep through breeding in Ethiopia will be focusing on between and within breed selection for traits such as growth, survival and fertility. Some other traits (e.g. skin quality) which are "not easy" to measure in the field will be considered when facility and finance allows. Since crossbreeding of indigenous with exotic breeds from temperate regions failed due to incompatibility of the genotypes with the environment (under low-input production systems) in Ethiopia, crossbreeding or synthetic breed development should be used with limited scope where farmers' resources and market allow. Furthermore, molecular and reproductive techniques such as identifying markers, artificial insemination (AI), multiple-ovulation-embryo-transfer (MOET) and in vitro ova collection and maturation techniques could at first only be attempted in experimental stations for selection and dissemination of improved stock in targeted areas when the basic framework for selection and distribution of rams to farmers is in place.

Implementation of the programme

One of the most important limiting factors in setting up of breeding programmes has been lack of an institution who oversees these activities. Therefore, there is an urgent need to establish an institute (national Animal Genetic Resources Institute, AnGRI) with clear organisational structure, implementation procedures, and responsibilities of each key player (Tibbo, 2006). This has to be enacted bylaws stating the roles and responsibilities of all stakeholders for activities related to AnGR management, improvement and utilisation. AnGRI is suggested to be responsible for developing the breeding programme and estimation of breeding values and economic weights for indexes to be used. Furthermore, it could oversee the monitoring of the breeding programme (including quantifying extent of genetic progress) and electronic data processing. AnGRI also designs a system of mating and exchange of breeding animals between locations and flocks at different tiers, and delivers breeding advice, training of staff to work in the breeding programme, and ensures participation and co-operation through extension and education. Details of the linkages and the need to establishing community-based AnGR nodes with community participation are described by Tibbo (2006).

Some important principles and activities in the implementation of the programme:

- breeding programme will be first launched in very strategic and realistic areas where impact can be demonstrated to build confidence
- participating farmers should agree to practice controlled breeding; their capacity should be raised through community trainings, enabling them in recording and allowing them to make informed decisions
- simple performance recording could be done at this level with major involvement and facilitation by extension services
- sophisticated recording and genetic evaluations at nucleus flocks levels in the ranches or research centres
- data entry, cleaning and preliminary analysis could be done at district level with assistance from nearby research or training institutions as appropriate
- final data analysis at national level by AnGRI using BLUP animal models, survival analysis
- consistent capacity building at all levels
- participating farmers need to share the cost and should agree to a minimum level of management not only to realise the benefits of genetic improvement, but also to make genetic evaluation possible
- financial assistance through subsidy is important at the start but should be kept to the minimum to ensure sustainability
- A Trust Fund in any suitable form could be established: local social organisations (e.g. *Ekub, Edir*) could be viable means to lay ground for such initiatives
- participating farmers may need to pay for the services they receive (e.g. cost per improved ram distributed)
- fund raising activities

Possible constraints and risk assumptions:

- the success of the programme is dependent on careful monitoring, i.e. measuring the performance of the progeny of distributed rams
- extension staffs at district level are responsible for this monitoring - failure of the project would have far-reaching effects
- lack of grazing area might also be a problem due to possible conflict among participating and non-participating farmers for common resources. Related to this, a problem may arise because non-participating farmers leave their inferior non-castrated rams in the communal grazing land which unduly affects the programme. If there are members unwilling to castrate their rams, the programme should ensure physical separation once improved rams are introduced by relocating them to either their distant relatives or close friends
- With regard to land tenure, there is no clear policy that protects grazing areas and the land belongs to the government and individual farmers have no right to apply any progressive farming methods resulting in land degradation
- Assumptions are that the quality of the sheep produced would lend itself to effective marketing; resources (land, water, genetics and general infrastructure) will be adequate to effect change; extension staff can be sufficiently trained in the process; there will not be a major disaster (e.g. severe

drought, disease outbreak); communal farmers will accept some drastic changes to their current way of producing animals (e.g. using identification tags for their animals).

Conclusions and recommendations

- Indigenous sheep breeds are highly adapted to low-input systems or are naturally selected for survival under sub-optimal and disease ridden environments
- The low off-take per ewe is partly a result of keeping too many unproductive animals thereby limiting feed supply and contributing to land degradation.
- Ethiopia's vision in sheep breeding shall be improving production per animal and re-locate resources (e.g. feed & water) to selected ewes that produce more and better growing lambs through combined efforts in planning, management and selection with careful consideration of breed (genotype) × environment interaction.
- The best alternative (ALT 8) for sheep production in Ethiopia revealed that the output per sheep could be doubled with 15% less number of sheep through environmental and genetic means that reduce mortality and increase fertility, growth and yearling weight allowing lambs to be marketed at yearling age.
- Breeding programmes based on open nucleus flocks utilizing government ranches (and research centres) at the top of a three tier system of flocks will be used for conservation and improvement of indigenous breeds as well as for crossbreeding.

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