Indigenous sheep genetic improvement schemes for Ethiopian smallholder farmers and pastoralists

M. Tadele[*†], G. Duguma[*†], A. Willam[*], A. Haile[†], L. Iñiguez[‡],
M. Wurzinger[*†], and J. Sölkner[*]

Introduction

With a total population estimated at 26.12 million (CSA, 2008) and with diverse breeds, sheep constitute the second most important livestock species in Ethiopia. They are owned and managed by resource poor smallholders under traditional and extensive production systems. There are no working breeding plans and binding breeding policy for any of the farm animal species in the country. Small animal populations per household, single-sire flocks, mobility (in pastoral areas), lack of systematic animal identification and recording, illiteracy, poor infrastructure, and ill-functioning public institutions are the major constraints limiting genetic improvement schemes. Yet, a technically and socially feasible option for designing breeding schemes where communal grazing and watering points are customary would be to consider the village population as one large flock or a breeding unit. Thus selection of animals based on phenotypes recorded within a village is appropriate. The aim of this study was to simulate different breeding plans for four different indigenous sheep breeds under different production systems with an objective of developing successful community-based sheep breeding schemes that suit the communities' conditions and needs.

Materials and methods

Study areas and communities. Simulated breeding plans target Afar, Bonga, Horro and Menz areas representing different production systems and agro-ecologies that are habitat to four indigenous sheep breeds. Major production systems are: pastoral/agro-pastoral in Afar, mixed crop-livestock in Bonga and Horro, and sheep-barley in Menz. Two communities per location consisting of 60 households each were organized based on sheep population (≥ 420 breeding ewes), presence of communal grazing land, accessibility, and willingness of the community. Households with at least four breeding ewes were considered as a community member.

Determination of breeding objective traits. Trait preferences were studied using production system studies, choice experiments, own-flock ranking, and group-animal ranking experiments approaches. A weighted rank was computed for each trait based on results of the independent studies. The selected measurable objective traits to be used in the simulation of alternative breeding plans for each breed were limited to three. These were

[*] BOKU University of Natural Resources and Applied Life Sciences, Vienna, Austria

[†] International Livestock Research Institute (ILRI) , Addis Ababa, Ethiopia

[‡] International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

milk yield, body size, and lamb survival in Afar; body size, lamb survival and twinning in Bonga and Horro; and body size, lamb survival and wool yield in Menz. Selection criterion to be used for each breeding objective trait is yearling weight (kg) for body size, milk yield (g) for milk yield, number of lambs born/year/ewe joined for twining, number of lambs weaned/ewe joined for lamb survival, and greasy fleece weight (kg) for wool yield.

Simulation methods. ZPLAN (Willam et al., 2008) that optimizes breeding strategies in livestock breeding by deterministic calculations was used to model alternative breeding programs. ZPLAN is based on comprehensive evaluation of both genetic and economic efficiencies of breeding strategies considering one cycle of selection. Output of ZPLAN includes annual monetary genetic gain for the aggregate genotype, annual genetic gain for each single trait, discounted return and discounted profit for a given investment period. The gene flow method (Hill, 1974; McClintock and Cunningham, 1974) and selection index procedure constitute the core of the program. For each breed, a breeding unit consisting of four selection groups (ram-ram, ram-ewe, ewe-ram, ewe-ewe) was defined. Essential input parameters for ZPLAN are given in Table 1.

Table 1. Input parameters for simulation of alternative breeding plans

Parameters	Afar	Bonga	Horro	Menz
Population parameters				
Population size (ewes)	670	650	650	650
Number of proven males/year	273	352	362	260
Biological parameters				
Breeding ewes in use (years)	5	5	5	5
Breeding rams in use (years)	2; 3	2; 3	2; 3	2; 3
Mean age of rams at birth of first offspring (years)	1.5	1.5	1.5	1.5
Mean age of ewes at birth of first offspring (years)	1.5	1.5	1.5	1.5
Mean time period between subsequent lambings (years)	0.75	0.71	0.61	0.71
Mean number of lambs per litter (litter size)	1.06	1.34	1.34	1.02
Mean number of lambs/ewe/year	1.34	1.41	1.45	1.40
Cost parameters†				
Animal identification and drugs (€)/ewe/year	2.80	2.89	2.93	2.87
Performance recording and monitoring (€)/ewe/year	0.63	0.65	0.65	0.65
Investment period (years)	15	15	15	15

†Interest rate return and costs (%) were 0.03 and 0.075

The average population size of breeding ewes and lamb survival to weaning were based on flock inventory taken from each community member household during the ‘own-flock ranking experiments’ while information on reproductive performance were mainly obtained from the production system studies. In addition, published reports based on on-station and on-farm studies (Galal, 1983; Gizaw, 2002; Gizaw et al. 2007) were consulted for the phenotypic and genetic parameter estimates. The breeding programs considered differed in selection intensity of selection of young rams (selection proportions of 10 or 15 %) and duration of use of rams for breeding (2 or 3 years).

Rates of inbreeding per generation (ΔF) were estimated using a formula $\Delta F=(1/(8Nm)+(1/(8Nf))$, where Nm and Nf refer to number of male and female breeding animals, respectively (Falconer and MacKay, 1996). Following Nitter et al. (1994), only costs that are additional to normal husbandry practices of smallholder farmers/pastoralists were assumed.

Results and discussion

The predicted annual genetic gain for each selection criterion used is presented in Table 2. The highest annual genetic gains in yearling weight were obtained from scheme 1 (0.44-0.94kg) whereas the lowest from scheme 4 (0.40-0.85kg) for all breeds. The responses from all schemes may be considered satisfactory and can result in appreciable genetic improvement of these sheep breeds under smallholder breeders' management practices. Gizaw et al. (2009) predicted an annual aggregate response of 0.492 to 0.704kg for yearling weights of Menz sheep under village-based breeding schemes applying selection proportions ranging from 5-20%. In another report on the same breed from on-station selection experiment conducted between 1998 and 2003, Gizaw et al. (2007) indicated average annual genetic response of 0.67kg in yearling weight for selected group.

The genetic gain in milk yield was in the range of 51g in scheme 3 to 56g in scheme 2 per generation for Afar breed. Afar breed has a lactation length of about 114 days, a milk yield of 224ml/day which translates to a lactation yield of 25.53kg (Galal, 1983). The predicted genetic gain, if realized, will result in 6.7 kg milk increase per lactation.

Table 3. Genetic gain year^{-1} for the breeding objective traits in different schemes
Scheme 1: 10% selection proportion and 2 years of ram use; Scheme 2: 10% selection proportion and 3 years of ram use; Scheme 3: 15% selection proportion and 2 years of ram use; Scheme 4: 15% selection proportion and 3 years of ram use
(A = Afar, B = Bonga, H=Horro, M=Menz)

Schemes and traits	A	B	H	M	Schemes and traits	A	B	H	M
Scheme 1 (rIH)	0.26	0.21	0.22	0.30	Scheme 3 (rIH)	0.26	0.22	0.22	0.29
YWt	0.44	0.89	0.94	0.70	YWt	0.41	0.87	0.88	0.64
MiY/NLB/GFW‡	0.02	0.01	0.01	0.01	MiY/NLB/GFW	0.02	0.01	0.01	0.01
NLW	0.01	0.01	0.01	0.01	NLW	0.01	0.01	0.01	0.01
Scheme 2 (rIH)	0.26	0.21	0.22	0.30	Scheme 4 (rIH)	0.26	0.21	0.22	0.29
YWt	0.42	0.85	0.90	0.67	YWt	0.40	0.81	0.85	0.62
MiY/NLB/GFW	0.02	0.01	0.01	0.01	MiY/NLB/GFW	0.02	0.01	0.01	0.01
NLW	0.01	0.01	0.01	0.01	NLW	0.01	0.01	0.01	0.01

‡MiY for Afar breed; NLB for Bonga and Horro breeds; GFW for Menz breed

The predicted responses year^{-1} and generation^{-1} for number of lambs born per ewe joined ranged from 0.9 to 1.0% and 2.34 to 2.90%, respectively, were of the same magnitude for Bonga and Horro breeds. These levels of improvements may be considered encouraging under farmers' management conditions in the tropics. Cloete et al. (2004) reported genetic changes that were in the order of 1 to 2% year^{-1} for selected Merino lines as substantial.

Regarding response in number of lambs weaned per ewe joined, it was similar in Menz, Bonga and Horro except in schemes 1 and 4 of Bonga. The gain was relatively low in Afar. The values were in the range of 0.9 –1.1% in the former three breeds and 0.8 – 0.9% in the latter. Gains in both numbers of lambs born and weaned per ewe joined may appear very

insignificant; however, the slightest improvements in these aggregate traits (number born and weaned) would mean sizable gain in terms of overall change.
Genetic gain per generation for greasy fleece weight (kg) was 0.024, 0.026, 0.016 and 0.017 in schemes 1–4, respectively. Comparable gains (0.016-0.022) were predicted for the same breed under village-based breeding schemes applying selection proportions ranging from 5-20% (Gizaw et al., 2009). A 0.017kg mean annual genetic response to selection was also reported by Gizaw et al. (2007) in an on-station study conducted over 5 years period.
The approximated rates of inbreeding, in percentage, at 10 and 15% selection proportions were 0.48 and 0.32 for Afar, 0.39 and 0.26 for Bonga, 0.37 and 0.25 for Horro and 0.50 and 0.33 for Menz. Gizaw et al. (2009) estimated an inbreeding rate of 1.35% under 10% proportion of selection for village-based sheep breeding scheme. Wurzinger et al. (2008) reported slightly lower values in a breeding program designed for Bolivian llama.
Results for monetary genetic gain and profit confirmed the superiority of scheme 1 over the others.

Conclusion

Among the ram selection and ram use scenarios considered in this simulation, strong selection and short use of rams provided the highest levels of expected genetic gain. The 8 communities involved in the ICARDA-ILRI-BOKU project on community-based sheep breeding were confronted with the results. Communities in Bonga, Horro and Menz opted for Scenario 1 (strong selection and ram use for 2 years) while the pastoralists in Afar opted for scenario 2 (strong selection and ram use for 3 years). The responses, especially in body weight, may be considered satisfactory and can result in reasonable genetic improvements of these sheep breeds under smallholder breeders' management practices. Realization of these predictions, however, largely relies on accurate recording and record keeping, estimation of reliable breeding values, monitoring and/or guidance, and motivation of the smallholder breeders. The first round of young ram selection was performed in February 2010, ram selection will done quarterly as the system is not seasonal.

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