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Prediction of Genetic Gains for Breeding Objective Traits and Designing Selection Schemes for Washera and Gumuz Indigenous Sheep

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ABSTRACT

The aim of this study was to predict genetic gains of breeding objective traits and select the best sheep selection scheme for Gumuz and Washera sheep. Body size(six month weight and yearling weight) and litter size were breeding objective traits identified byown flock animal ranking experiment and personal interviews. Deterministic approach of ZPLAN computer program is used for modeling input parameters of Washera and Gumuz sheep and simulating breeding plans using gene flow methods and selection index procedures. One-tier cooperative sheep breeding scheme were proposed whereby ram exchange between and within villages is the main means of genetic dissemination. Genetic gains predicted for six month weight of Gumuz and Washera sheep were 0.43 and 0.55 kg, respectively. Genetic gains predicted for yearling weight of Gumuz and Washera sheep were 0.55 and 0.60 kg, respectively. Genetic responses predicted for litter size of Gumuz and Washera sheep were 0.08 and 0.09 lambs, respectively. The lower rate of inbreeding, the higher monetary genetic gain for aggregate genotype, higher return to investment and higher profit/ewe/year were quality measures of breeding programconsidered to prefer Scheme 4 for Gumuz and Washera sheep. Hence, for both Gumuz and Washera sheep populations' a sheep selection scheme designed with 15% selection proportion and one year ram use for breeding was recommended. Special emphasis need to be given to yearling weight with higher predicted genetic response and higher percentage of return to investment.

Key words: breeding program; six month weight; selection; yearling weight

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INTRODUCTION

Sheep production in Ethiopia is used as sources of cash income and provides social security in the bad crop years (Getachew et al., 2010). In Ethiopia, there are 32.85 million sheep, more than 99% of which are indigenous (Central Statistical Agency, 2020). However, the productivity of local sheep under traditional production system is low with high mortality of lambs. Because of this the increasing need for food of animal origin has largely been met with increasing number of sheep while productivity per sheep has remained low (Food and Agricultural organization, 2015). Indeed, there are two ways of improving the performance of sheep and goats, improving the environment and/or improving their genetic potential or genotype (Abegaz &Awgichew, 2008, pp. 81-102). Conventionally three main pathways have been considered for genetic improvement of sheep. These are selection between breeds (strains), cross breeding and selection within breeds (strains) (Food and Agricultural organization, 2010). Breed substitution and cross breeding programs involving temperate breeds are rarely successful due to incompatibility of the genotypes with the farmers breeding objectives and the production systems (Haile et al., 2011). On the other hand, selective breeding of the adapted indigenous breeds is the best possible option for genetic improvement of small ruminants in tropical countries (Gizaw et al.,2013). Because, indigenous breeds have special adaptive features such as tolerance to a wide range of diseases, water scarcity tolerance and ability to better utilize the limited and poo-quality feed resources (Kosgey and Okeyo, 2007). In order to efficiently utilize these special features of indigenous breeds, it is necessary to design a breeding scheme that fits well with the existing low input production system and breeding objectives of the farmers. Washera and Gumuz are among the valuable indigenous sheep breeds of Ethiopia demanding genetic improvement intervention. Washera is a populous indigenous breed in Ethiopia with wide area coverage. Gumuz sheep is considered as one of the most diversified indigenous breed type of Ethiopia (Gizaw et al., 2008).

Community based breeding program (CBBP) is envisaged to increase the productivity and profitability of indigenous breeds without undermining their resilience and genetic integrity, and without expensive interventions (Haile et al., 2011; Karnuah et al., 2018). Breeding plans can be defined through personal interview, participatory own flocks live animal ranking experiment and by developing bio-economic models (Haile et al., 2011; Edea et al., 2012; Mirkena et al., 2012). Gizaw et al. (2010) simulated bio-economic models to identify breeding objectives and breeding plans for Washera sheep under subsistence and market-oriented production systems of Ethiopia. The current study aimed at predicting genetic gains for breeding objective traitsof Washera and Gumuz sheep populations intended for designing sheep selection schemes

MATERIALS AND METHODS

Description of sheep production

Setting up sheep breeding programs starteds with a description of sheep production system or the way we keep sheep and for certain purpose (Tibbo, 2006; Food and Agricultural organization, 2010; Haile et al., 2011). Washera is a short fat tail, large body size, short-haired, predominantly brown, both males and females are polled reared by Amhara and Agew communities. Washera is a good meat producer under good environment (Gizaw, 2009). Gumuz sheep is long thin tail, somewhat dwarf, convex face profile, long pendulous ear, commonly plain brown or with patch (39.4%), white with brown or black patch (21%), black (15.8%), white, black with white patch, brown with black patch, polled and reared by Gumuz and Amhara communities (Gizaw et al., 2008). Gumuz sheep is adapted to heat and have unique genetic make-up (Gizaw, 2009). The prevailing sheep production systems of Burie and Mandura districts were highland cereal-livestock system and lowland crop-livestock system, respectively (Gizaw et al., 2008). These systems are also characterized by inadequate health care, smaller land holding often less than two hectares and small sheep flock size (Institute of Biodiversity Conservation, 2004). Based on these criteria, Gizaw et al. (2008) described the scale of sheep production system as small scale, semi intensive, low input and traditionally managed.

Breeding objectives and selection criteria

Own flock animal ranking experiment and personal interviews were used to identify sheep breeding objectives and trait preference of smallholder farmers in northwestern Ethiopia. Personal interview was conducted from 72 households keeping Washera rams and 35 households keeping Gumuz rams to identify their trait preferences. Personal interviews and own-flock ranking experiment was undertaken considering 72 Washera and 54 Gumuz sheep keepers to identify their ewe trait preferences.

Respondents owning four or more ewes were selected purposely for own-flock animal ranking experiment. Open ended questionnaire was endorsed and sheep keepers were motivated to list all traits of sheep. Economically important traits were short listed by personal interview. Farmers were visited at their homesteads and were asked to select, their first best, second best, third best, and the most inferior ewes among their own flock based on each short listed economically important traits. They were also asked to give the reasons for their selection. Age, previous reproduction and production information of the identified animals was also obtained from farmers memory recall. Live body weight and some linear body measurements were measured and recorded. Estimates of heritability, phenotypic and genetic correlations were used from national and international literatures to assess the relationship between the selected traits. Two highly rated traits with genetically positive correlation were preferred for selection criteria of Gumuz and Washera ewe. Body size and litter size were first and second best traits of Washera ewe ranked by 226 and 124 weight score, respectively. Likewise, same selection criteria for Gumuz ewe were preferred with similar rank but different weight score. In that, body size and litter size were first and second best traits ranked by 197 and 166 weight score, respectively. The selected traits cover 350 (40 %) of 867 total weight score of Washera ewe. Similarly, the selected traits cover 363 (46 %) of 797 total weight score of Gumuz ewe.

Variance components and goal trait values

Estimates of genetic and phenotypic parameters for the traits (i.e. heritabilities and genetic and phenotypic correlations) were needed to establish a sound program to improve the breeding-goal traits. In many situations, these estimates will be unavailable or inaccurate at the initial stage (Food and Agricultural organization, 2010). Hence,the literature averages could be used as an input in optimization of alternative breeding schemes. Phenotypic standard deviations of six month weight and yearling weight were obtained from monitoring data of morphometric traits (by the author). Phenotypic standard deviations of litter size were obtained from national expertise (Gizaw, 2021, *personnel communication*) and were used to estimate phenotypic variance.Heritability values were also obtained from national and international literatures (Safari et al., 2005) and in the meantime were used to compute genotypic variance by multiplying it with phenotypic variance. Additive genetic standard deviation (σa) is estimated as the square root of the numerator of the heritability of each trait (Food and Agricultural organization, 2010). Goal trait values measure the increase in revenue associated with one unit increase in the trait in question. The calculation assumes that, when the trait is increased by one unit, other traits remain constant. Goal trait values can be estimated in one of two ways. The first method is simple subjective estimation, which is recommended at the beginning of the program when few socio-economic data may be available (Krupová

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et al., 2008; Food and Agricultural organization, 2010). The second method is objective derivation based on both concrete data on the socio-economic production environment and the use of advanced economic tools. With regard to this study, simple subjective estimation was employed to compute goal trait values by standardizing the indices/ratio calculated based on breeders' preferences, i.e. allocating 100 for six month weight, yearling weight and litter size and calculating index (ratio) for each selected goal traits. To standardize the units of measurement, these values must be inversely weighted by the additive genetic standard deviation σa (the square root of the numerator of the heritability) of each goal trait (Food and Agricultural organization, 2010). Thus, the goal trait values of each trait were calculated by dividing index (ratio) by additive genetic standarddeviation of the respective traits.The goal trait values for Washera sheep were 12.50 Ethiopian birr (ETB), 9.40 ETB and 300.00 ETB for six month weight, yearling weight and litter size, respectively. The goal trait values for Gumuz sheep were 14.89 ETB, 14.15 ETB and 300.00 ETB for six month weight, yearling weight and litter size, respectively.

Phenotypic and genetic parameters and their correlation

For both Washera and Gumuz sheep, weighted means of literature estimates for average heritability values of six month weight , yearling weight and litter size were 0.22, 0.29 and 0.10, respectively (Safari et al., 2005). The weighted meanphenotypic and genetic correlations, were also adopted from Safari et al. (2005).

Table 1 .Weighted meanphenotypic correlations (above diagonal), genotypic correlations (below diagonal) and heritability (along the diagonal)

Traits	SMW	YW	LS
SMW	**0.22**	0.74	0.01
YW	0.93	**0.29**	-0.02
LS	0.17	0.27	**0.10**

Source: Safari et al.(2005)
SMW = six month weight, YW = yearling weight, LS = litter size

Population structure and selection pathways

A survey data consisting of population, production, biological and cost parameters were collected as input parameters. Reproduction parameters and the survival rate of the lambs were biological parameters used to predict the number of confirmed (candidate) sheep per time unit (year). Table 2 shows input parameters of two indigenous sheep breeds(Washera and Gumuz) used for modeling ZPLAN and Fortran 90 computer program (William et al., 2008).The program is based on a pure deterministic approach. Its advantage is multi-trait modeling including return and costs over a given time horizon and the program is fast. For Washera and Gumuz indigenous breeds, similar one-tier cooperative village breeding scheme was proposed with a village populations serving as a breeding as well as production unit to generate and disseminate genetic gain. As suggested by Haile et al. (2011), six selection groups in one - tier cooperative scheme were used for simulation purpose using gene flow and selection index method. Rams to breed rams (RM>RM), ewes to breed rams (EW>RM), rams to breed ewes (RM>EW), ewes to breed ewes (EW>EW),rams to breed ewes in the production unit (RM> EP) andewes to breed ewes in the production unit (EW> EP).Genetic dissemination was predicted to be through ram exchange among members of cooperatives (villages) and between villages. Two villages consisting of 99 (50 and 49) households of Washera and two villages consisting of 90 (45 and 45) households of Gumuz sheep keepers each household owning a flock size of five ewes

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and above were considered. In this study, only the cost of routine activities and fixed costs of housing were regarded as a cost parameter.

Table 2. Input parameters of Washera and Gumuz sheep used for modeling ZPLAN

Parameters	Unit	Washera	Gumuz	Source
Population Parameters				
Population size (ewes)	No	495	450	
Number of proven males/year	No	240	218	
Proportion of rams selected	%	10 % ;15%	10 % ; 15 %	
Biological Parameters				
Breeding ewes in use	year	5	5	
Breeding rams in use	year	1; 2	1; 2	
Mean age of rams at birth of first offspring	year	1.27 (464 days)	1.14	Gizaw et al.,2007 ;Taye et al.,2011
Mean age of ewes at birth of first offspring	year	1.27 (464 days)	1.14	Gizaw et al.,2007 ;Taye et al.,2011
Lambing interval	year	0.83 (303 days)	0.55	Gizaw et al.,2007; Mekuriaw et al.,2013
Fertility (conception rate)	%	0.90	0.90	Mirkena et al., 2012
Lambing rate	%	0.85	0.85	Mirkena et al., 2012
Twining rate	%	1.06	1.06	Mirkena et al., 2012
Mean number of lambs per birth (litter size)	No	1.19	1.31	Gizaw ,2009; Taye et al.,2011
Mean number of lambs/ewe/year	No	1.8	1.9	3 lambing per 2 year=1.5 lambing / year*Litter size
Lambing survival to yearling	%	67	88	Gizaw , 2009; Mekuriaw et al.,2013
Sex ratio	%	50	50	
Estimated production costs				
Sources of costs				
Feed				
Hay	ETB	20	20	
Noug cake	ETB	29	20	
Veterinary and management cost				
De-worming	ETB	3.5	3.5	
Vaccinations	ETB	10	10	
Veterinary treatment and drugs	ETB	69.5	74	
Marketing	ETB	1.0	1.55	
Enumerator payment for performance recording and monitoring (ETB)/young males/year	ETB	24	26.66	
Interest rate costs (%)	%	0.08	0.08	
Fixed costs(Housing)	ETB	1.2	0.5	
Investment period	year	15	15	

Enumerator Washera: 1000 ETB/month = 12000 ETB/year; 12000 ETB/495 ewes » 24 ETB/ewe. Enumerator Gumuz: 1000 ETB/month = 12000 ETB/year; 12000 ETB/450 ewes » 26.66 ETB /ewe. Washera: veterinary treatment and drugs =25 ETB/ewe /year; 2.78 (an ewe+1.78 per TU(3 lambing in two years,1.5 laming per TU,1.5 lambing*1.19(LS)* 25 ETB = 69.5 ETB/ewe /year. Gumuz: veterinary treatment and drugs =25 ETB/ewe /year; 2.96 (an ewe+1.96 per TU (3 lambing in two years, 1.5 lambing per TU, 1.5 lambing*1.31(LS)* 25 ETB=69.5 ETB/ewe /year. Washera: vaccinations = 5 ETB/ewe/ vaccination = 10 ETB/ewe/year (2 vaccinations /year).

The average population size of breeding ewes were based on flock inventory taken from each community member households during the 'own-flock ranking experiment. Information on reproductive performance were mainly obtained from the national literatures (Gizaw et al.,2007; Gizaw, 2008 ; Gizaw, 2009; Taye et al.,2011 ; Mekuriaw et al.,2013). Further, four alternative selection schemes were proposed to be included to selection index and gene flow method with varying selection proportion and time unit of ram use. For indigenous sheep, ram replacement time is recommended to be annually (Abegaz & Awgichew, 2008,pp. 81-102). However, breeding rams of Menz sheep are commonly used for 2-3 years (Gizaw et al., 2014).

Based on these literature recommendations we plan two scenarios of ram use for breeding (for one year versus for two years). The proportion of selection commonly used is 10%. Thus, we plan optimization of the schemes by increasing proportion of selection to 15%. The schemes address genetic improvement activities at a village level covering the whole Washera and Gumuz sheep population in adjacent districts of West Gojjam administrative zone of Amhara regional state and Metekel zone administrative zone of Benishanguel regional state of Ethiopia. The following alternative selection schemes were proposedcandidates.

Scheme 1. 10 % selection proportion and 2 years of ram use for breeding
Scheme 2. 10 % selection proportion and 1 year of ram use for breeding
Scheme 3. 15% selection proportion and 2 years of ram use for breeding
Scheme 4. 15% selection proportion and 1 year of ram use for breeding.

Flock projection for each breed was done considering the population and biological parameters given in Table 6 using the formula used by Nitter et al.(1994) and Mirkena et al.,(2012). Likewise, in Burie for example, given a population of breeding ewes of 495 with 90% fertility, 85% lambing rate, 1.06 twinning rate, 1.5 lambing per year (3 lambing per 2 year)*LS, 67 % lamb survival to yearling and a sex ratio of 50%, the projection yields 240 yearling candidate rams (i.e., number of proven males/year = population size (ewes)* fertility rate* lambing rate* twinning rate* 1.5 lambing (3 lambing per 2 year*LS)* lamb survival to yearling *sex ratio = 495*0.9*0.85*1.06*1.5*1.19*0.67*0.5 = 240). As a quality measure of sheep breeding scheme, maintenance of genetic diversity measured by the rate of inbreeding is given a due attention. Based on population parameters obtained from survey data, the effective population size with different numbers of males and females was calculated following the formula used by Groeneveld (2009).

$$Ne = (4Nm*Nf) / Nm+Nf$$

Where:
Ne : Effective population size
Nm : Number of males
Nf : Number of females

The rate of inbreeding per generation was calculated following the formula used by Groeneveld (2009).

$$\Delta F=1/(2Ne)$$

Where:
Ne – effective population size
ΔF – rate of inbreeding

RESULT AND DISCUSION

Breeding structure and traits prediction

Evaluation of alternative designs of breeding schemes for Washera and Gumuz sheep was undertaken by assessing applicability of each structure on the ground and referring national and international literatures by giving emphasis for presence or absence of communal grazing systems, production systems, economic efficiency, operationally feasibility and setting up and maintaining a nucleus flock. Village based one tier cooperative scheme were proposed since it is believed to be suitable for smallholder mixed crop–livestock system with communal grazing systems and suits the existing breeding structures in most parts of Ethiopia, particularly in mixed crop–livestock production systems (Haile et al.,2011).

Based on the guideline (Haile et al.,2011), one-tier cooperative scheme was found to be ideal for sheep breeding scheme in highland perennial mixed crop–livestock and lowland mixed crop–livestock production systems of Burie and Mandura districts , respectively. Moreover, among village-based schemes, a one-tier cooperative village breeding scheme was economically more efficient and seems to be operationally more feasible since setting up and maintaining a nucleus flock within a cooperative breeding village is rather infeasible (Gizaw et al.,2014). The scheme involves cooperation among farmers. In a one tier structure, no nucleus flock is established. Breeding males are selected from among the young males born in the flocks of the cooperating farmers. Males can be evaluated within the cooperating flocks or maintained and evaluated in a separate place before being re-distributed among the farmers and all young males of the cooperating flocks are recorded. The shortcoming of the one-tier cooperative scheme is that it is organized within individual villages. This entails that cooperative breeding groups need to be set up in each village in order to scale up the breeding program. This is technically and logistically very challenging (Gizaw et al., 2014).

Selection strategies in sheep breeding can be optimized by ZPLAN computer program. Breeding programs and their parameters are defined and the program calculated the annual genetic gain for the breeding objective, genetic gain for single traits and return on investment adjusted for costs (profit) using the gene-flow method and selection index procedures (William et al., 2008). Four different alternative schemes of sheep breeding program were intended to be optimized for both Washera and Gumuz sheep with weight at six months of age, yearling weight and litter size as selection criteria included in the selection index. The predicted response to selection traits of Washera and Gumuz sheep was shown by Table 3. The highest percentage return from trait groups of Gumuz sheep was contributed by six month weight (SMW) accounting 39.89. The remaining percentage return from trait groups was contributed by trait combination of yearling weight (YW) and litter size (LS) accounting to 60.11. The highest percentage return from trait groups of Washera sheep was contributed by six month weight accounting 40%. The remaining percentage return from trait groups was contributed by trait combination of yearling weight and litter size accounting to 60%. The greater percentage return contributed by trait groups of yearling weight and litter size than six month weight was attributed to correlated response of yearling weight and litter size. The highest percentage return from selection groups of Gumuz sheep was contributed by rams selected to produce ram (RM>RM) and rams selected to produce ewe (RM>EW) accounting to 61.44-62.6. The highest percentage return from selection groups of Washera sheep was contributed by rams selected to produce ram and rams selected to produce ewe accounting 60.82-62.23. Accuracy of breeding value estimation was 0.54 and 0.55 for Gumuz and Washera sheep, respectively.

Evaluation of alternative selection schemes

A breeding program should be evaluated by the genetic improvements obtained in all important traits and the effects on total output of products and outputs per unit of measurement, e.g. per animal and the economic impacts at both household and community levels (Haile et al.,2011). Choosing the best breeding scheme among a number of alternatives requires yardsticks to measure the quality of breeding schemes. Such yardsticks can be developed only when there is a well-defined breeding goal. Given that the breeding goal is clearly defined, there are criteria that summarize the quality of a breeding program (Table 4). These are selection response for the breeding goal traits, maintenance of genetic diversity as measured by the rate of inbreeding and costs of the breeding program.

Table 3. Out puts of alternative breeding schemes

Sheep breed /ecotype		Alternative selection schemes	Traits	Out put			
				Genetic gain per year for the single Traits (kg)	Return for economic traits (ETB)	Monetary genetic gain per year(ETB)	Discounted profit (ETB)
	1	10 % selection	SMW	0.43	0.68		
		proportion	YW	0.55	0.87	0.25	1.56
		2 years of ram use	LS	0.08	0.16		
	2	10 % selection	SMW	0.45	0.73	0.26	
		proportion	YW	0.58	0.93		1.68
		1 year of ram use	LS	0.08	0.17		
	3	15 % selection	SMW	0.43	0.67	0.25	1.54
Gumuz		proportion	LS				
		2 years of ram use	YW				
			LS				
			YW	0.54	0.86		
			LS	0.08	0.16		
	4	15 % selection	SMW	0.46	0.74	0.27	1.71
		proportion	YW	0.59	0.94		
		1 year of ram use	LS	0.09	0.17		
	1	10 % selection	SMW	0.55	0.86	0.3	2.1
		proportion	YW	0.6	10.9		
		2 years of ram use	LS	0.09	0.2		
	2	10 % selection	SMW	0.56	0.92	0.32	2.3
		proportion	YW	0.64	11.6		
Washera		1 year of ram use	LS	0.09	0.22		
	3	15 % selection	SMW	0.55	0.87	0.31	2.1
		proportion	YW	0.62	11		
		2 years of ram use	LS	0.09	0.2		
	4	15 % selection	SMW	0.60	0.96	.33	2.3
		proportion	YW	0.66	12.1		
		1 year of ram use	LS	0.09	0.22		

SMW = six month weight, YW = yearling weight, LS = litter, 1 ETB is approximately equal to 0.025 $ in 2021 G.C

The total population size (ewe) of Washera and Gumuz sheep was 495 and 450, respectively based on the inventory. These population sizes were projected to 240 and 218 effective population sizes of Washera and Gumuz sheep, respectively. Effective population size of Washera sheep was predicted to be 87 and 125 when proportion of selection is 10% and 15%, respectively. Effective population size of Gumuz sheep was predicted to be 80 and 114 when proportion of selection is 10%% and 15%, respectively. Effective population size of Washera and Gumuz sheep predicted by this study was in agreement with Rai (2003) suggesting that for persistence of a population, the minimum effective population size should not be smaller than 50 breeding individuals(ΔF=0.01). Predicted rate of inbreeding (%) of Washera and Gumuz is 0.6% with 10% proportion of selection. Predicted rate of inbreeding of Washera and Gumuz is 0.4 % with 15% proportion of selection. The rate of inbreeding coefficients predicted by the current study were within the acceptable threshold level, ΔF=0.5 % - 1% (Rai, 2003; FAO, 2010; Oldenbroek, K and van der Waaij, L., 2014, pp.141-144). Sheep selection scheme 4 with rate of inbreeding (ΔF=0.4%), 15% proportion of selection, with higher monetary genetic gain for aggregate genotype of 0.27 ETB, return to investment of 1.86 ETB and profit/ewe/year of 1.71 ETB was preferable for Gumuz sheep. Similarly, for Washera sheep selection scheme 4 with 0.4% rate of inbreeding,

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higher monetary genetic gain for aggregate genotype (0.33 ETB), higher return to investment (1.91 ETB) and higher profit/ewe/year (1.54 ETB) was preferably proposed.

Table 4. Quality measures to compare alternative breeding schemes

Sheep population	Alternative selection indices		Quality measures			
			Monetary Genetic Gain for aggregate genotype (ETB)	Return to investment (ETB)	Profit/ewe/year (ETB)	Rate of Inbreeding (%)
Gumuz	1	10 % selection proportion and 2 years of ram use	0.25	1.71	1.56	0.6
	2	10 % selection proportion and 1 year of ram use	0.26	1.83	1.68	0.6
	3	15% selection proportion and 2 years of ram use	0.25	1.69	1.54	0.4
	4	15% selection proportion and 1 year of ram use	0.27	1.86	1.71	0.4
Washera	1	10 % selection proportion and 2 years of ram use	0.3	1.86	1.66	0.6
	2	10 % selection proportion and 1 year of ram use	0.32	1.88	1.48	0.6
	3	15% selection proportion and 2 years of ram use	0.31	1.84	1.44	0.4
	4	15% selection proportion and 1 year of ram use	0.33	1.91	1.54	0.4

1 ETB is approximately equal to 0.025 $ in 2021 G.C

We compared the two major sheep breeding programs based on applicability of each breeding structure and national and international literatures. Higher genetic gains could be achieved from selection programs that are organized with a central nucleus flock than from village-based breeding schemes without a central nucleus. This is to be expected as selection was on BLUP (best linear unbiased prediction) breeding values and both male and female selection pathways were modeled in the central nucleus scheme (Kosgey, 2004; Gizaw et al., 2014). However, by the current study one - tier structure of village or community based breeding program was proposed since setting up and maintaining a nucleus flock under village sheep breeding management condition was difficult (Haile et al., 2011; Gizaw et al., 2014). From sheep selection schemes perspective, we planned and evaluated four alternative sheep selection schemes and the best possible option was chosen. These alternative sheep selection schemes are the following. Scheme 1 is with 10 % selection proportion and 2 years of ram use for breeding, scheme is with 10 % selection proportion and 1 year of ram use for breeding, scheme 3 is with 15% selection proportion and 2 years of ram use for breeding and scheme 4 is with 15% selection proportion and 1 year of ram use for breeding. The selection of appropriate sheep selection scheme was undertaken by evaluating the selection response from basic and variation runs of ZPLAN computer program (William et al., 2008).

Genetic gain per year for the single traits in one-tier cooperative village breeding scheme was predicted. Genetic gain predicted for six month weight of Gumuz and Washera sheep were 0.43 and 0.55 kg, respectively. These genetic gains were greater than to 0.12 kg of Menz sheep flock (Gizaw et al., 2014) organized by similar one-tier cooperative village breeding scheme. Genetic gain predicted for yearling weight of Gumuz and Washera sheep were 0.55 and 0.60 kg, respectively.

The corresponding predicted values were 0.44 kg, 0.89 kg, 0.94 kg and 0.69 kg for Afar, Horro, Bonga and Menz sheep, respectively with 10 % selection intensity and 2 years of ram use for breeding (Mirkena et al., 2012). Genetic gain predicted by Mirkena et al.(2012) for yearling weight were 0.41 kg, 0.87 kg, 0.88 kg and 0.63 kg for Afar, Horro, Bonga and Menz sheep, respectively with 15 % selection intensity and 2 years of ram use for breeding. The predicted response for yearling weight of Washera and Gumuz sheep by this study were greater than that predicted for Afar sheep but less than from Horro, Bonga and Menz sheep (Mirkena et al., 2012).

The predicted genetic gains per year for yearling weight of Gumuz and Washera sheep (Table 3) were greater than that predicted for six month weight and litter size because selection for six month weight enabled substantial genetic improvement on yearling weight. In addition, the greater genetic gain per year predicted for six month weight and yearling weight than litter size was attributed to the higher heritability values of six month weight and yearling weight (Safari et al., 2005). The slow genetic progress in litter size of this study for Gumuz and Washera sheep is in line with earlier report (Safari et al., 2005; Mirkena et al., 2012) for Afar, Horro, Bonga and Menz sheep. The slow genetic progress in litter size is attributed to low heritability and low genetic correlations with growth rate traits (Safari et al., 2005). Genetic gain predicted for litter size of Gumuz and Washera sheep was 0.08 and 0.09 lambs, respectively. This predicted genetic gain is greater than to response to selection of 0.0013 lambs of Menz sheep in a simulated village-based selection program (Gizaw et al., 2014). The predicted monetary genetic gain per year for aggregate genotype predicted for Gumuz and Washera sheep was 0.24 ETB and 1.05 ETB, respectively. The predicted monetary genetic gain of Gumuz sheep was less than 5.66 ETB for Menz sheep (Gizaw et al., 2014). The predicted monetary genetic gain of Washera sheep was greater than 5.66 ETB for Menz sheep (Gizaw et al., 2014).

The highest percentage returns on investment from trait groups of Gumuz sheep was contributed by six month weight (SMW) accounting 39.89. The remaining percentage return from trait groups was contributed by yearling weight (YW) and litter size (LS) accounting to 60.11. The highest percentage return from trait groups of Washera sheep was contributed by six month weight accounting 40. The remaining percentage return from trait groups was contributed by yearling weight and litter size accounting to 60. The returns on investment from trait groups of Washera and Gumuz sheep contributed by six month weight was in agreement with Gizaw et al.(2014). Gizaw et al.(2014) reported that among the component traits of the breeding objectives, genetic improvement of six month weight was virtually the sole contributor to returns on investment in all the six schemes. It accounted for 96.54% to 97.46% of the total returns.

Designing within and between village selection schemes involving two villages with the highest selection proportion (P=15 %) and ram use for one year was found appropriate. Selection proportion (P=15 %) and ram use for one year breeding has been proposed by Mirkena *et al*. (2012). Mirkena et al. (2012) suggested that rams should be used only for a single year in a given ram-group flocks and then exchanged with a distant ram-group. This will serve at least two major purposes. It minimizes inbreeding and creates genetic links across different flocks. In this study, for Gumuz sheep scheme 4 with 0.4% rate of inbreeding, the higher monetary genetic gain for aggregate genotype of 0.27 ETB, return to investment of 1.86 ETB and profit/ewe/year of 1.71 ETB were proposed. Similarly, for Washera sheep scheme 4 with 0.4% rate of inbreeding, higher monetary genetic gain for aggregate genotype of 0.33 ETB, return to investment of 1.91 ETB and profit/ewe/year of 1.54 ETB was preferably proposed.

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CONCLUSION

Designing a sheep selection scheme involving two villages with a ram exchange within and between villages with the highest selection proportion and ram use for one year was found appropriate for both Gumuz and Washera sheep populations. Hence, for both Gumuz and Washera sheep populations, a selection scheme need to be designed with 15% selection proportion, one year ram use for breeding and acceptable rate of inbreeding. Special emphasis need to be given to yearling weight with higher predicted genetic response and higher percentage of return to investment. One tier breeding scheme organized for each two villages from each respective districts is proposed whereby ram exchange between and within villages is the main means of genetic dissemination.

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