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Optimizing alternative schemes of community-based breeding programs for two Ethiopian goat breeds

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ABSTRACT

One tier community-based breeding schemes with four different scenarios for Western Lowland and Abergelle goat of Ethiopia were simulated using ZPLAN computer program to compare the genetic gain of the breeding objectives traits across the alternatives. The scenarios were different in terms of numbers of traits in selection criteria while keeping the breeding goals the same throughout the alternatives. Simulation study showed that there was little difference in annual genetic gain for individual breeding objectives traits and annual monitoring gain (aggregate gain) across the different alternatives. The range of 0.8702–0.8724 kg, 0.0001–0.0006 and 0.0184–0.0195% of six months weight, number of kids born and proportion of weaned kids were predicted for Western Lowland goat respectively. For Abergelle goat the range of 0.36–0.3675 kg of six months weight, 0.0066–0.0114 kg of daily milk yield and 0.0068–0.0085% proportion of weaned kids per does per year were simulated. The lowest aggregate genetic gains of 25.94 and 16.42 were obtained for Western Lowland and Abergelle goat respectively from the alternative where only one trait (growth) included in the selection criteria (index or record).
(Keywords: Breeding program, Ethiopia, Genetic gain, Goat, selection criteria)

INTRODUCTION

Almost all goats in Ethiopia are managed by resource poor smallholder farmers and pastoralists under traditional and extensive production systems. They provide multiple roles for their owners such as source of income, food (meat and milk) and manure (*Legesse et al*., 2008; *Abegaz et al*., 2013). 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 (*Negassa and Jabbar,* 2008). The growing demand of meat at the domestic as well as at the international markets also increases the importance of goat in the national economy of the country. However, goat production in Ethiopia is constrained by many biological, environmental and socio-economical factors. Among them, lack of systematic breeding programs is an important constraint.

There is no systematic goat breeding program in place and goat is the most neglect livestock species in research and development endeavors (*Tsegahun et al*., 2000). There have been a few attempts of genetic improvement program of goats through upgrading the exotic genetic blood levels. However it was reported that crossbred goats did not perform better than indigenous goats if both groups were kept atsimilar management levels (*Ayalew et al*., 2003). In general, many small ruminants cross breeding programs in tropical country were not successful because of the incompatibility of the genotype with the farmers breeding objectives, management methods and the prevailing environment of the tropical low input production systems (*Ayalew et al*., 2003; *Kosgey et al*., 2006). Pure breeding applying community based breeding program is believed to be a more appropriate breeding program for such type of production systems which are characterized as low-input system with poorly developed infrastructures (*Sölkner et al*., 1998; *Gizaw et al*., 2009). Optimization of the community based breeding programs by looking at different alternative schemes to predict the genetic gain and the economic return is very helpful during implementation. It gives the chance to adjust the technical, infrastructural and socio economic issues ahead of the implementation. The objective of this study is to evaluate different alternative schemes of community-based breeding programs for Abergelle and Western Lowland goat breeds of Ethiopia.

MATERIAL AND METHODS

Study areas

The study was conducted in two districts (Metema and Abergelle) of the Amhara Regional State of Ethiopia. Metema is located at about 860 km North West of the capital Addis Ababa. The district has an altitude of 550 to 1608 m and the latitude of $12^{o}40'$ N to $13^{o}14'$ N. It has uni-modal type of rainfall receiving the annual average of 850 to 1100 mm, which occurs from June to September. The production system is characterized as mixed crop-livestock system with crop dominance. Western Lowland (Gumuz) breed is the dominant goat breed of the area. Abergelle is located at about 780 km from Addis Ababa in the Northern part of the country. The area is characterized as dry/sub-moist highland agro-ecological zone. It has the altitude of 1150 to 2500 m with the latitude of $12^{o}18'$N to $13^{o}06'$N. The rain fall pattern of the area is very erratic and uneven. The area receives the mean annual rainfall ranges from 250 to 750 mm. The main rain season of the district is July to September. The production system of Abergelle district is mixed crop-livestock system with high priority of Abergelle goat production.

Breeding objectives and selection criteria

As the breeding program would be implemented at community level, for each breed, only three traits with high preference by farmers and easy to measure were considered (*Abegaz et al*., 2013; *Abegaz,* 2014). The breeding objectives identified for Abergelle goat owners were: Body size, milk yield and mothering ability (kids survival), while the breeding objectives for Western Lowland goat owners were body size, twinning rate and mothering ability (kids survival). Two selection indexes, one for each breed were constructed. Index 1, to reflect the breeding objective of Abergelle goat breeders, included six months weight (for body size), daily milk yield (for milk yield) and proportion of kids weaned (for kid survival). Index 2 to reflect the breeding objective of Western Lowland goat six months weight, number of kids born per does per year and proportion of kids weaned per does per year.

Economic values

The economic weight and variance components of the traits are given in *Table 1*. The relative economic weight is derived based on the farmers' preference through participatory methods (*Abegaz,* 2014). The phenotypic standard deviations of the traits were estimated from the result of morphological characterization studies of the breeds (*Abegaz et al*., 2013). The genetic standard deviations of the traits were also estimated by multiplying the phenotypic standard deviation to the heritability of a trait.

Table 1

Economic weight and variance component of the selection criteria (traits)

Breeding objective traits	Selection criteria	Unit	REW	σ_a	σ_p
Abergelle					
Body size	Six month weight	kg	54%	1.45	2.74
Milk yield	Milk yield/ day	kg	30 %	0.13	0.23
Kid survival (mothering ability)	Proportion of kids weaned/does/year	%	16%	0.089	0.40
Western Lowland					
Body size	Six months weight	kg	55%	1.99	3.76
Twinning	Number of kid born /doe/year		31%	0.14	0.45
Kid survival (mothering ability)	Proportion of kids weaned /does/year	%	14%	0.13	0.60

REW: relative economic weight; σ_a: Additive genetic standard deviation; σ_p: phenotypic standard deviation

Population structure

The community based one tier selection scheme was considered for both breeds as the optimal breeding program for both of the study areas. The flocks from 30 households with the average of 26 breeding does per household were considered as one breeding unit for Abergelle goat, while the flocks from 60 households with the average of 5 breeding does per household was considered as one breeding unit for Western Lowland goats. The important input parameters of the two breeds for modeling (running ZPLAN) are shown in *Table 2*. The information for the input parameters were taken from the previous studies (*Derbie*, 2008; *Abegaz et al*., 2013, *Derbie and Taye*, 2013; *Abegaz*, 2014). The number of proven (candidate) animals in each time unit (year) were projected using the reproductive parameters and survival rate of the breeds. In this study, only the costs of additional activities to the normal management practices were considered as the cost parameters.

Alternatives breeding programs

Four different alternatives for each breed were proposed for evaluating optimal breeding program (*Table 3*). The alternatives were based on the variation of the number of the traits in the selection index (recording) while keeping all traits in aggregate breeding goal. The important considerations of the alternatives were to see the effect of the variation of the number of traits in the recording scheme (selection criteria) on the genetic gains of the individual traits as well as the aggregate response.

Table 2

Input parameters for modeling alternative breeding programs

Parameters	Abergelle	Western Lowland
Population parameters		
Population size (Does)	780	300
Number of proven males/years	300	255
Proportion of bucks selected	10%	10%
Biological parameters		
Breeding does in use (year)	5	5
Breeding bucks in use (year)	2	2
Mean age of bucks at birth of first offspring (years)	1.5	1.2
Mean age of does at birth of first offspring (years)	1.3	1.1
Kidding rate	0.85	0.85
Mean time period between subsequent kidding (years)	1	0.6
Mean number of kids per litter (litter size)	1.13	1.5
Number of kidding/doe/year	1	1.67
Kid survival to six months (%)	80%	80 %
Cost parameters		
Animal identification doe/year(€)	0.86	1.36
drug /doe/year(€)	0.86	1.36
Enumerator salary(€)	0.98	0.98
Stationary materials for recording(€)	0.20	0.20
Interest rate return (%)	0.05	0.05
Interest rate cost (%)	0.08	0.08
Investment period /year	15	15

Table 3

Alternative breeding schemes for Abergelle and Western Lowland goats

Alternatives	Breed	
	Abergelle	Western Lowland
1	All traits in the selection index (SMW+DMY+PKW)	All traits in the selection index (SMW+NKB+PKW)
2	SMW+DMY in the selection index	SMW+NKB in the selection index
3	SMW+PKW in the selection index	SMW+PKW in the selection index
4	Only SMW in the selection index	Only SMW in the selection index

Note: SMW=Six months weight, DMY=Daily milk yield, PKW=Proportion of kid weaned, NKB=Number of kids born

Genetic and phenotypic parameters

The genetic and phenotypic parameters are presented in *Table 4*. Due to the population parameters of the study breeds lacking, the weighted heritability estimates of the traits from published reports of other local and exotic goats were used. The genetic and phenotypic correlations of the traits were obtained from published reports on sheep.

Table 4

Phenotypic correlation (above the diagonal), genotypic correlation (below the diagonal) and heritability of the traits (along diagonal)

Traits	Abergelle			Western Lowland		
	SMW	**DMY**	**PKW**	**SMW**	**NKB**	**PKW**
SMW	0.28	0.1	0.1	0.28	0	0.1
DMY/NKB	0.2	0.32	0.14	0	0.10	0.15
PKW	0.3	0.53	.05	0.3	-0.20	0.05

Note: SMW=Six months weight, DMY=Daily milk yield, PKW=Proportion of Kids weaned, NKB=Number of kids born

Evaluation of alternative breeding programs

Alternative breeding schemes were evaluated using the computer program ZPLAN (*Willam et al*., 2008). Using the gene flow method and selection index procedures, the program enables to simulate different breeding plans by deterministic approach. The program calculates genetic gain for the aggregate breeding value, the annual response for each trait and discounted return and discounted profit for a given investment periods. Rate of inbreeding per generation (ΔF) were calculated using a formula relating effective population size to use number of male (N_m) and number of female (N_f) breeding animals (*Falconer and Mackay*, 1996); $\Delta F = (1/8\ N_m) + (1/8\ N_f)$

RESULTS AND DISCUSSION

Annual genetic gain in individual traits

The predicted annual genetic gains (ΔG) of individual breeding objectives traits from different alternative schemes of the two breeds are presented in *Table 5*. Those parameters were different among the different alternatives and breeds. For all traits considered, higher genetic gains were predicted for Western Lowland goats than the Abergelle goats. These variations were due to higher phenotypic variation of the traits, lower generation interval and better performance (such as high twinning rate) of Western Lowland goats. The highest genetic gain of 0.3676 kg per year for six month's weight was predicted for Abergelle goats in growth only scheme (alternative 4) while the lowest 0.3599 was obtained in the alternative 2. As expected the highest gain was simulated for six month weight from growth only alternative where only the information of growth was included in the selection index. The highest value 0.8724 kg annual genetic gain of the six months weight was simulated for Western Lowland goats from alternative 3 (growth and survival information in the selection index) whereas the lowest value of 0.8702 kg was simulated from alternative 2 (growth and twinning information in the selection index). The highest gain of six month weight from alternative 3 was due to relatively higher positive genetic and phenotypic correlation between the two traits. The lowest genetic gain of six months weight from growth and twinning alternative was associated with the lower phenotypic and the negative genetic correlation of the two traits attached in the model. The genetic gain of six months weight predicted in this study is in the range of the predicted annual genetic gain of six months weight in similar study of Kenyan cross breed goats (*Bett et al*., 2012).

Table 5

Genetic gain per year for the breeding objective traits in different alternatives

Breed	Alternativies	Traits			
		SMW(kg)	DMY(kg)	PKW (%)	NKB
Abergelle	1 SMW+DMY+PKW	0.3600	0.0114	0.0085	_
	2 SMW+DMY	0.3599	0.0110	0.0083	_
	3 SMW+PKW	0.3669	0.0069	0.0072	_
	4 SMW	0.3675	0.0066	0.0068	_
Western Lowland	1 SMW+NKB+PKW	0.8710	-	0.0192	0.0006
	2 SMW+NKB	0.8702	-	0.0184	0.0006
	3 SMW+PKW	0.8724	-	0.0195	-0.0001
	4 SMW	0.8718	-	0.0186	0

SMW: Six months weight, DMY: Daily milk yield, NKB: Number of kids born, PKW: Proportion of kids weaned

Relatively lower genetic gains of 6.60 g and 6.97 g milk yield were predicted from alternatives 4 and 3 for Abergelle goats, respectively. Higher values of 11.43 and 11.37 g of milk yield were predicted from alternatives 1 and 2, respectively. In these alternatives the information of milk yield was included in the selection index. Differently from this result higher genetic gain 0.261–0.809 kg milk yield were predicted in different alternatives of Kenyan dairy goat (*Bett et al*., 2012). However, a very close result with the range of 0.018–0.020 kg of genetic gain of milk yield was predicted for different alternatives in a study on Ethiopian Afar sheep (*Mirkena et al*., 2012). There was a difference of 4.77 g in genetic gain of milk yield between the alternative with highest gain and the alternative with the lowest gain in the present study. This result indicates that including milk record in the selection index would result the positive genetic gain but the profit will be minimal. Milk recording at village level is operationally difficult and routine milk recording even at monthly intervals is costly. It may be more appropriate to rely on indirect selection of milk yield through associated traits in this situation.

The genetic gains of kid survival at different scenarios ranged between 0.006764% to 0.008517% for Abergelle goat, while it ranged from 0.018389% to 0.019227% for Western Lowland goats. In both breeds, the differences of annual genetic gain of kid survival between different alternatives were very small. This is because of the low heritability of the trait and low correlation with other traits. Comparable results with the range of 0.00–0.007% were predicted from different alternatives for Kenyan dairy goat breeds (*Bett et al*., 2012) and the range of 0.009–0.01% for Ethiopian Afar sheep breed (*Mirkena et al*., 2012).

Very low genetic gains of twining rate were predicted from all alternatives for Western Lowland goats. Even negative gain was predicted from the alternative 3 and 4 where the twinning information was not included in the recording scheme. This is due to the low heritability of the trait and low phenotypic and genetic correlation with other traits. In addition to this, selection intensity was mostly derived from the male path of selection thus the twinning rate performance information was obtained only from the dams of young bucks. Since recording of the twinning rate is very simple, it would be worthwhile to include the information of twinning rate in the recording and give more

weight in breeding goal to avoid the loss of genetic gain of twinning rates which was reported as the most preferred traits in Western Lowland goat keepers.

Evaluation criteria

Table 6 depicts the important evaluation criteria simulated by ZPLAN program. The selection accuracies of obtained from different alternatives for both breeds were in the acceptable range 0.481 to 0.512. Relatively higher accuracy of selection 0.504 and 0.512 were obtained from Alternative 1 (all traits in selection index) for Abergelle goats and Western Lowland goats, respectively. This reflects as the information source increased in the selection criteria the accuracy also increased. The annual monetary genetic gains ranged between 16.42 to 17.57 Euro/doe for Abergelle goats from the different alternatives whereas 25.96 to 26.06 Euro were predicted for western Lowland goats. As the difference between the schemes was only by varying the information source in the selection index, there was no difference between the different alternatives in selection intensity and generation interval within the same breed. The differences of those parameters between the two breeds were connected with the difference of population size of the breeding does and the difference in reproductive performance of the breeds in input parameters. A selection intensity of 1.99 and a generation interval of 2.88 years were predicted for Abergelle goats while the corresponding values for Western Lowland goats were 2.25 and 2.14 years. The discounted profit found in all alternatives and in both breeds was very high. It might not be appropriate to compare the alternatives in this study based on the discounted profit because the economic value attached to each trait is not in the real monitoring term and only additional cost to the normal practice were considered as the cost. The relative economic weights based on farmers' preference were assigned as the economic weight. The rate of inbreeding per generation 0.4% and 1.3% were calculated for Abergelle and Western Lowland goats respectively. The higher inbreeding rate for Western Lowland goats could be explained by the small flock size per household. During the implementation period, increasing the participant farmers within the village or implementing across village selection for Western Lowland goat breeds would be advisable to avoid the problem of inbreeding.

Table 6

Important evaluation criteria simulated from different alternative in Abergelle and Western Lowland goats

Alternative	Criteria	Abergelle	Western Lowland
1	Accuracy of selection	0.503	0.512
	AMGG	17.57	26.06
	Discounted profit/doe	138.85	213.29
2	Accuracy of selection	0.504	0.511
	AMGG	17.51	26.05
	Discounted profit/doe	138.48	212.83
3	Accuracy of selection	0.484	0.511
	AMGG	16.58	26.01
	Discounted profit/doe	133.24	212.99
4	Accuracy of selection	0.481	0.510
	AMGG	16.42	25.93
	Discounted profit/doe	132.32	212.41

AMGG: Annual Monitoring Genetic Gain

CONCLUSION

The community level alternative schemes were designed and predicted for smallholder goat farmer conditions. Community based breeding program is the breeding program implemented at the smallholder levels where the infrastructure is poor and low input production system prevails. Therefore, the organizational structure should be simple and the traits in the recording should also be small in number to avoid complexity during implementation (*Sölkner et al*., 1998; *Wurzinger et al*., 2008; *Gizaw et al*., 2009). This study was aimed to see how much genetic gain and economic return in aggregate breeding goals (breeding objectives traits) can change by varying the number of traits at selection criteria. Even though, relatively higher gain from the alternatives with more traits in the selection criteria, the magnitude of the loss in genetic gains and economic returns from the alternatives with single versus more traits in the selection index were very small. For instance, the difference in annual monitoring genetic gain between all traits and one trait alternative for Abergelle goats were 1.154%. This indicates that it is possible to start a feasible community based breeding with growth only or very few traits in selection criteria with little loss of genetic gain in breeding goal traits.

REFERENCES

Abegaz, S. (2014). Design of community based breeding programs for two indigenous goat breeds of Ethiopia, PHD thesis, BOKU- University of Natural Resource and life Sciences, Vienna Austria, 115 pp.

Abegaz, S., Sölkner, J., Gizaw, S., Dessie, T., Haile, A., Wurzinger, M. (2013): Description of production systems and morphological characteristics of Abergelle and Western low-land goat breeds in Ethiopia: implications for community-based breeding programmes. Animal Genetic Resources Information, 53. 69-78.

Ayalew, W., Rischkowsky, B., King, J.M., Bruns, E., (2003). Crossbreds did not create more net benefits than indigenous goats in Ethiopian smallholdings. Agric. Sys., 76. 1137- 156.

Bett, R.C., Okeyo, A.M., Kosgey, I.S. Kahi, A.K., Peters, K.J. (2012). Evaluation of alternative selection objectives and schemes for optimisation of village goat improvement programs.Livestock Research for Rural Development, 24. 1.

Deribie, B., Taye, M. (2013). Evaluation of growth performance of Abergelle Goats under Traditional management systems in Sekota district, Ethiopia. Pakistan Journal of Biological Sciences, 16. 14. 692-696.

Deribie, B., (2008). Growth, Reproductive Performance and Carcass Characteristics of Abergelle and Central Highland Goat types under Traditional and Slightly Improved Management in Sekota Woreda. MSc, School of Graduate Studies of Haramaya University. 89 pp.

Falconer, D.S., MacKay, T.F.C. (1996). Introduction to Quantitative Genetics. Longman, Harlow, England

Gizaw, S., Komen, H., Van Arendonk, J.A.M., (2009). Optimal village breeding schemes under smallholder sheep farming systems. Livestock Sciences, 124. 82-88.

Kosgey, I.S., Baker, R.L., Udo, H.M.J. van Arendonk, J.A.M., (2006). Successes and failures of small ruminant breeding programs in the tropics: a review. Small Ruminant Research, 61. 13-28.

Legesse, G., Abebe, G., Siegmud-Schultze, M., Valle-Zárate, A. (2008). Small ruminant production in two mixed-farming system of southern Ethiopia: Status and prospects for improvement. Experimental Agriculture, 44. 399-412.

Mirkena,T., Duguma, G., Willam, A., Wurzinger, M., Haile, A., Rischkowsky, B., Okeyo, A.M., Tobbo, M., Sölkner, J. (2012). Community-based alternative breeding plans for indigenous sheep breeds in four agro-ecological zones of Ethiopia. J. Anim.Breed.Genet., 129. 244-253.

Negassa, A., Jabbar, M. (2008). Livestock ownership, commercial off-take rates and their determinants in Ethiopia. Research Report 9. ILRI (International Livestock Research Institute), Nairobi, Kenya. 52 pp.

Sölkner, J., Nakimbugwe, H., Valle-Zárate, A., (1998). Analyses of determinants for success and failure of village breeding programmes. In: Proceedings of sixth world congress on Genetics Applied to Livestock Production, Vol. 25 Armidale, NSW, 11-16 January 1998, Australia, 273-280.

Tsegahun, A., Lemma, S., Ameha, S., Abebe, M., Zinash, S. (2000). National goat research strategy in Ethiopia. In: Merkel, R .C., Abebe, G. & Goetsch, A. L. (eds) The Opportunities and Challenges of Enhancing Goat Production in East Africa. Proceedings of a conference held at Debub University, Awassa, Ethiopia, November 10-12, 2000. E (Kika) de la Garza Institute for Goat Research, Langston University, Langston, OK 1-5.

Willam, A., Nitter, G., Bartenchlager, H., Karras, K., Niebel, E., Graser, H.U. (2008). ZPLAN-mannual for a PC-program to optimize livestock selection schemes. Manual Version 2008 for Source Code "z10.for". Institute of Animal Production in the Tropics and Subtropics. Universität Hohenheim, Stuttgart, Germany.

Wurzinger, M., Willam, A., Delado, J., Nürnberg, M., Zárate, A.V., Stemmer, A., Ugarte, G., Sölkner, J. (2008). Design of a village breeding program for a llama population in the High Andes of Bolivia. J. Anim. Breed. Genet., 125. 311-319.

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