# Simulation of Alternative Plans for Community Based Goat Breeding Program in Arid, Semi-Arid and Mixed Production Systems in Ethiopia

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# Simulation of alternative plans for community based goat breeding program in Arid, Semi-Arid and Mixed production systems in Ethiopia

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**Key words**: Breeding scenario; Genetic gain; Genomic selection; Selection group; Simulation

## Abstract

On station small ruminant researches in Ethiopia were ineffective due to various factors. As alternative, community based breeding program (CBBP) has emerged. In the current CBBPs, sire side selection only (SN1) is practiced. The objective of the present work was to compare SN1 by simulating alternative breeding scenarios for Abergelle (AB), Centeral Highland (CH) and Woyto-Guji (WG) goat breeds in Ethiopia. Three scenarios including selection on dam side (SN2) in addition to SN1, application of genomic selection (SN3) onto SN1 and use of sires from SN1 for mating in additional flocks (SN4) were simulated and compared with SN1 based on the predicted annual genetic gain (PAGG) and discounted profits. The breeding objective traits or selection criteria were six month weight (6mw, kg) for all breeds, average daily milk yield (ADM, kg) and survival to six month of age (SURV) for AB, litter size at birth (LSB) for CH and WG, litter size at weaning (LSW) for CH and kidding interval (KI, days) for WG. ZPLAN+ software was used for the simulation. The PAGG for 6mw (kg) ranged from 0.087 (SN4) to 0.25 (SN3) for AB where it ranged from 0.47 (SN4) to 0.97 (SN3) for ADM (kg) for same breed. PAGG in 6mw (kg) ranging from 0.13 (SN4) to 0.47 (SN3) and from 0.20 (SN4) to 0.31 (SN3) for CH Gonder and Ambo sites, respectively were simulated whereas this parameter ranged from 0.10 (SN4) to 0.27 (SN3) for WG. The alternative breeding scenarios to SN1 resulted in better PAGGs, especially for 6mw in three of the goat breeds and for ADM in AB. Based on the PAGGs and profitability, we recommend SN2 over SN1. However, SN4 could also be applied, compared to SN1, in view of suitability of addressing emerging demands.

## Introduction

On station small ruminant researches in Ethiopia were ineffective due to various factors. Community based breeding program (CBBP), thought to be an alternative to the on station research, is design of breeding scheme that is deemed suitable for smallholder farming system (Gizaw et al. 2014). The CBBPs for small ruminants have been established in different parts of the world; for sheep and goats in Ethiopia (Duguma et al. 2011), for goats in Mexico (Wurzinger et al. 2013) and in Iran (Mueller et al. 2015).

In Ethiopia, indigenous goats make valuable contributions, especially to the poor in the rural areas. Ethiopia owns about 12 indigenous goat breeds where eight of them are reared for their milk production in addition to meat, manure and skin products (ESGPIP 2008). Where the recent goat population of Ethiopia was reported to be 30.20 million (CSA 2017), it was considerably smaller than the sheep population of the country. However, since very recently, the ratio of goat to sheep showed an increasing trend; 0.93 (CSA 2012), 0.99 (CSA 2015) and 0.98 (CSA 2017) which might be an indication that goats are becoming equally important as sheep in Ethiopia.

Implementation of CBBP of three indigenous goats in Ethiopia was executed by the leading role of Bioscience for eastern and central Africa and International livestock research Institute (BecA-ILRI) in six villages (CBBP sites). The breeds included Abergelle kept in arid pastoral, Central Highland inhabiting crop-livestock production system and Woyto-Guji within semi-arid agro-pastoral production systems (Tatek et al. 2016). In the current CBBPs, sire side selection only (SN1) was practiced. The objective of the present work was to compare SN1 by simulating alternative breeding scenarios for Abergelle (AB), Centeral Highland (CH) and Woyto-Guji (WG) goat breeds in Ethiopia.

## Methods and Study Site

### Description of the study sites

Optimization scenarios were based on the data collected from CBBP sites established in two villages per breed. From each of the two sites for Abergelle (AB) and Woyto-Guji (WG), averages number of breeding females were considered (the two villages per AB and WG were considered as one village taking the average number of breeding females) . Due to long distances between villages for Central Highland (CH), the two villages (Gonder (CH-Gonder) and Ambo (CH-Ambo)) were considered as separate villages bringing the total to four villages for the alternative scenarios.

## Breeding goals and selection criteria

Body size was identified as the breeding objective trait for all the three goat breeds. In addition, producers keeping CH indicated twinning and mothering abilities as the most targeted traits to be improved whereas twinning ability and short kidding interval were the most preferred traits by producers keeping WG. Increased milk yield and survivability were the additional targeted breeding objective traits in the case of AB. Selection criteria were six month weight (6mw), average daily milk yield (ADM), survival to six month of age (SURV), litter size at birth (LSB), litter size at weaning (LSW) and kidding interval (KI) for body size, milk yield, survivability, litter size, mothering ability and reproduction performance, respectively. Economic weights for the selection traits were derived according to the procedure illustrated by FAO (2010). The relative importance of selection traits, in an index form, for the goat producers were adopted from reports on productivity studies of same breeds (Tatek et al. 2016).

### Description of simulated alternative breeding scenarios

One tier community based breeding practice was taken as the base scenario (SN1) while three alternative scenarios were simulated in this study. The scenarios were; 1) inclusion of dam-side selection to SN1 (SN2), 2) inclusion of genomic selection to SN1 (SN3) and 3) systematic expansion of one tier to the two tier breeding (SN4). In the SN4 scenario, the numbers of additional breeding does targeted were assumed to be about three times the number of does in SN1. Details of the breeding scenarios and other methodologies were indicated in Jembere et al. (2019).

With regard to costs, only additional variable costs were considered (Nitter et al. 1994). The S1Bs that are assumed to be used for mating in additional breeding females in SN4 have been produced through SN1; there may be additional organizational costs but these could not be adequately estimated and thus were assumed to be negligible. On the other hand, additional US$ 125 per animal variable cost (1$ was about 1.0627 EUR on 15$^{th}$ April, 2015) was assumed for pre-genotyping and genotyping in SN3 on top of the variable costs in the SN1. The phenotypic standard deviations were obtained from the respective data generated on the breeds whereas genetic parameters were based on literature review. ZPLANPLUS, a web-based menu driven software (https://service.vit.de/zplanplus/) was used in the present study. The latest version that was used here allows modelling of genomic selection in contrast to the earlier versions.

## Results

### Predicted genetic gains in breeding objective traits

Predicted annual genetic gains (PAGG) in six month weights (6mw, kg) were highest in SN3 followed by SN2, SN1 and SN4. This was the same for all goat breeds, except for AB where the PAGG in 6mw from SN4 was higher than in SN1 (Table 1). The PAGGs in 6mw ranged from 0.31 to 0.47 for CH-Gonder site, 0.21 to 0.31 for CH-Ambo site, 0.19 to 0.27 for WG and 0.17 to 0.25 for AB. The highest PAGGs in 6mw were obtained for CH-Gonder site, followed by CH-Ambo site; the smallest values for the PAGG in 6mw were for Abergelle goat breed. The same sequence of superiority of PAGG in KI, for Woyto-Guji goat breeds from the scenarios (SN3>SN2>SN1>SN4) as in 6mw, was observed which ranged from 0.17 to 0.42.

While SN3 resulted in the highest PAGG in terms of average daily milk yield (ADM, ml) and in survival rates to six month of age for AB goats, the next highest values were achieved in SN4, followed by SN1 and then SN2. The PAGG estimated of ADM ranged between 0.62 and 0.97. The overall predicted annual genetic gain of survival rate (%) to three months for AB was generally low ranging from 0.008 to 0.013. Similarly, the predicted annual genetic gains of LSB for CH and WG and LSW for CH were generally small ranging from 0.001 to 0.004. The small predicted annual genetic gains in Survival rates to three months of age and the litter sizes at birth and weaning indicated that these traits could not be improved through genetic selection; rather general good husbandry practices could play to the betterment of these traits.

**Predicted monetary genetic gain, discounted profits and Costs**

Highest mGGs, considering all the scenarios, were realized from Abergelle followed by Woyto-Guji, Central Highland Ambo site and Central Highland Gonder: the values ranged from 0.07 to 0.09 for Abergelle, from 0.07 to 0.09 for Woyto-Guji, 0.06 to 0.08 for Central Highland Ambo site and 0.05 to 0.08 for Central Highland Gonder site. Due to the relatively high costs, the discounted profit from SN3 was negative for all breeds in all sites. Positive profits were obtained from the three other scenarios except from SN1 for Woyto-Guji goat breed. SN4 resulted in the highest profits, followed by SN2 for three sites while the profit from SN2 was higher than from SN4 for Central Highland Ambo site. Breeding programs for Abergelle were more profitable than for the other goat breeds and sites, while the smallest profits were achieved with WG. The values (Euro) for profitable scenarios ranged from 0.13 to 0.35 for AB, from 0.05 to 0.1 for CH Ambo, from 0.04 to 0.16 for CH Gonder and from 0.01 to 0.17.

Table 1. Predicted annual genetic gains (PAGG) in selection traits, generation interval (GI) and intensity of selection (IS) from the four scenarios (SN) for Abergelle (AB), Central highland (CH) and Woyto-Guji (WG) goat breeds in Ethiopia

| | Abergelle site (AB) | | | | Gonder site (CH) | | | | Ambo site (CH) | | | | Konso site (WG) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trait* | SN1 | SN2 | SN3 | SN4 | SN1 | SN2 | SN3 | SN4 | SN1 | SN2 | SN3 | SN4 | SN1 | SN2 | SN3 | SN4 |
| 6mw | 0.17 | 0.18 | 0.25 | 0.18 | 0.34 | 0.36 | 0.47 | 0.31 | 0.23 | 0.24 | 0.31 | 0.21 | 0.20 | 0.21 | 0.27 | 0.19 |
| ADM | 0.74 | 0.62 | 0.97 | 0.87 | - | - | - | - | - | - | - | - | - | - | - | - |
| KI | - | - | - | - | - | - | - | - | - | - | - | - | 0.27 | 0.19 | 0.17 | 0.42 |
| Pro(€) | 0.13 | 0.26 | -8.6 | 0.35 | 0.04 | 0.08 | 12.8 | 0.16 | 0.05 | 0.10 | 13.4 | 0.06 | 0.02 | 0.01 | 16.8 | 0.17 |

6mw=PAGG in six month weight (kg); ADM= PAGG in average daily milk yield (ml); KI=PAGG in kidding interval (days); Pro(€) = profitability in EURO. * the Pro(€) in SN3s and SN1 of Konso site were negative.

**Discussion**

All the three scenarios simulated as alternatives to the current CBBP of goats in Ethiopia had advantages in terms of PAGG over the baseline CBBP in all the three breeds. Sizable PAGG, however, were obtained for 6mw weight only. The other breeding objective traits did not show substantial predicted annual genetic gain. This is probably because of generally low levels of variability for the traits within each of the populations. Heritability values of twining, mothering ability and survivability were smaller compared to the growth traits (Safari et al. 2005; Jembere et al. 2017). The unfavourable genetic correlations of these traits with growth traits could also be another possible reason for small genetic gain realized in the rest traits compared to growth. Abegaz et al. (2014) reported PAGG in 6mw (kg) of 0.8702 to 0.8724 and 0.360 to 0.365 for Western lowland part of Ethiopia and AB goat breads, respectively. These authors also reported PAGG in average daily milk yield (kg) for AB breed to be 0.0066 to 0.0114. These values were higher than the ranges of PAGG in 6mw in the three breeds and ADM in AB goat breed predicted from the current study. Except for Abegaz et al. (2014), reports for such comparisons were not available on indigenous goat breeds of Ethiopia.

However, similar reports are available on sheep breeds in Ethiopia and elsewhere. Gizaw et al. (2014) reported PAGG of 0.119 to 0.286 kg in 6mw of Menz sheep which is in agreement with this study from the various scenarios except for the higher value reported from the central highland Gonder site. However, simulations by Mirkena et al. (2012) resulted in much higher values of PAGG in yearling weights for Ethiopian sheep. The values in kg were in the range of 0.813 to 0.894 for Bonga, 0.850 to 0.940 for Horro and from 0.616 to 0.699 for Menz.

**Conclusion**

Based on the PAGGs and profitability we suggest SN2 over SN1. However, SN4 could also be applied, compared to SN1, in view of higher profitability and suitability of addressing emerging demands. The PAGGs in reproduction, mothering ability and survival were small implying that improvements of these traits are best achieved through improved management levels as part of the overall improvement program.

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