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EVALUATION OF COMMUNITY-BASED ABERGELLE GOAT BREEDING PROGRAM IN WAGHIMRA ZONE, AMHARA REGIONAL STATE, ETHIOPIA

MSc THESIS

BY

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Evaluation of Community-Based Abergelle Goat Breeding Program in Wag-himra Zone, Amhara Regional State, Ethiopia

MSc Thesis

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This is to certify that this thesis entitled "**EVALUATION OF COMMUNITY-BASED ABERGELLE GOAT BREEDING PROGRAM IN WAGHIMRA ZONE, AMHARA REGIONAL STATE, ETHIOPIA**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "**Animal Breeding and Genetics**" to the Graduate Program of College of Agriculture, Hawassa University by **Mr. Mulatu Gobeze Alamirew** (ID. No. GPAnBrR/0009/11) is an authentic work carried out under our guidance and supervision. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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LIST OF ABBREVIATIONS

ADG	Average daily gain
ADMY	Average daily milk yield
AFK	Age at first kidding
ANOVA	Analysis of variance
BLUP	Best linear unbiased prediction
BV	Breeding value
BWT	Birth weight
CBBP	Community-based breeding program
DMY	Daily milk yield
EBV	Estimated breeding value
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization of the United Nations
h^2	Heritability
HM	Hierarchical animal model
KI	Kidding interval
LL	Lactation length
LMY	Lactation milk yield
LWB	Litter weight at birth
LWW	Litter weight at weaning
MY90D	Ninety day milk yield
NGO	Nongovernmental organization
NMWt	Nine month weight
NRM	Numerator relationship matrix
PPR	Peste des petits ruminants
REML	Restricted maximum likelihood
SMWT	Six month weights
SNNPR	Southern Nation Nationalities and Peoples Region
TMWt	Three-month weight
YWt	Yearling weight

ABSTRACT

Evaluation of Community-Based Abergelle Goat Breeding Program in Wag-himra Zone, Amhara Regional State, Ethiopia

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Community-based breeding programs (CBBPs) are currently proved as one of the approaches used for small ruminants' genetic improvement in developing countries, particularly in Ethiopia. This study was conducted to evaluate the overall performance of the ongoing Abergelle goat community-based breeding program using technical and socio-economic criteria. On-farm biological performance data was collected from 2013-2019. Survey data was collected using semi-structured questionnaire interviews, focus group discussions and key informant interviews. Growth, reproduction and milk production performance data was analyzed using generalized linear model (GLM) procedure of the Statistical Analysis System (SAS, version 9.0) software. The genetic parameters for the breeding objective traits were estimated by the Restricted Maximum Likelihood method (REML) of WOMBAT software fitting different single-trait animal models. Six single-trait animal models for growth performance and two each for reproductive and milk production traits were fitted for genetic parameters estimation. Best model was selected using log likelihood ratio test. The genetic trend was estimated by the weighted regression of the average breeding value of the animals on the year of birth for each targeted trait. Random assignment of a single buck for the paternal pedigree line was used in the genetic evaluation process as the pedigree data structure in this study was obtained from multiple sires joining. Genetic and phenotypic correlations were estimated fitting multivariate animal models. Socio-economic data was analyzed using descriptive statistics in addition to direct narrations from formal and informal discussions. The overall least squares mean body weight at birth (BWt), three-month (TMWt), six-month (SMWt), nine-month (NMWt) and at yearling age (YWt) were 2.18±0.01, *7.27±0.03, 9.22±0.04, 12.16±0.04, and 15.56±0.10 kg, respectively. Location, sex of kid, birth type, season of birth, year of birth and parity of the dam were the important sources of variation for most of the growth performance traits ($P<0.05$). The average daily weight gain from birth to weaning (ADG1), weaning to six- month (ADG2), six to nine month (ADG3) and nine month to yearling age (ADG4) were 55.93±0.30, 21.59±0.29, 32.67±0.43, and 39.48±0.90 g/day, respectively. The overall least-squares mean of reproductive traits for litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB), litter weight at weaning (LWW), and kidding interval (KI) were 1.04±0.00 kids, 0.99±0.01 kid, 3.18±0.01kg, 11.24±0.04kg, and 356.05±1.68 days, respectively. In addition, the overall least-squares means of milk production traits found in this study for average daily milk yield (ADMY), lactation length (LL), and ninety day milk yield (MY90D) were 410 ±2.11 ml, 72.44±28 days, and 36.92±0.19 liter, respectively. Site, season of kidding, year of kidding and parity of the dam were the most important traits affecting most of the reproductive and milk production performance traits. The total heritability (h^2_t) estimates for weight at different ages were in the range of 0.28 to 0.40 at Bilaque site while 0.15 to 0.38 at Saziba site from selected models, respectively. Heritability estimates were in the rage of, 0.03±0.19 to 0.13±0.08 for reproductive traits and total heritability estimates for* *milk production traits were in the range of 0.05 to 0.20. The genetic correlations for growth traits ranged from 0.04 (BWt-NMWt) to 0.85 (TMWt-SMWt) but it was higher than the phenotypic correlation values. Genetic trend values were positive ($P<0.05$) for growth traits except BWt, no change ($P>0.05$) for reproductive traits and moderately higher ($P<0.05$) for milk production traits. The mean flock size of cooperative members was increased by more than 37% while reduced by 20% for non-members during the program implementation period. Even though the cooperatives build relatively strong institutional and financial capacity in the short run, they still require sustainable technical and financial support to run the breeding program. In the future, optimizing genetic evaluation methods like considering uncertain sire, economic selection index and improving mating ratio are suggested for maximizing overall benefit of the breeding program. Improving feeding and overall management assisted with strong reproductive biotechnology tools like estrus synchronization and artificial insemination are suggested for improving reproduction traits.*

Key words: Abergelle goat, CBBP, growth traits, milk production, genetic parameters

1. INTRODUCTION

1.1. Background and Justification

Goats are distributed all over the world because of their great adaptability to varying environmental conditions and the different feeding regimes under which they were evolved and subsequently maintained (Aziz, 2010). Most importantly, the global goat production is characteristically distributed in the more difficult agricultural environments where resources are limited and feed availability varies in climates, the land is less suitable for crop production, and small ruminants especially goats provide the larger livelihood contribution to the producer in those areas. In developing countries, goats make a very valuable contribution, especially to the poor in rural areas. Aziz, (2010) reported that goats proved useful to humans throughout the ages due to their productivity, small size, and non-competition for food. They are amongst the commonest farm animal species, which sustain the livelihoods of smallholder farmers, pastoralists, and agro-pastoralists. They fulfill various functions such as generating cash income, serving as household security, accumulating capital, and fulfilling cultural obligations (Dhaba et al., 2012; Girum et al., 2012; Solomon et al., 2014).

The global goat population was increased by 18.6% in the last ten years (FAOSTAT, 2020) with larger genetic diversity of more than 579 local breeds from 50 regionally trans-boundary and non-specified internationally trans-boundary breeds (FAO, 2019). According to FAO (FAOSTAT, 2020), the Ethiopian goat population increased by 56.6% in the last decade with a total number of 52.46 million heads of goat in 2020 making the country the second most goat populous location in Africa next to Nigeria. In 2020, Ethiopia’s goat population accounts for 4.7% and 10.7% of the World and African goat populations, respectively. Though the population density of goats in mid- and low-altitude areas is high, they are produced across the country from the arid lowlands to the coolest highland areas. The higher number of live animals confirms the importance of goats as a potential source of meat, milk, skin, fiber, and other socio-cultural aspects of the rural people. In addition, goats have a higher multiplication rate, lower capital investment, and unique adaptation to harsh environments (Alade et al., 2010; Solomon et al., 2014). They are also important protein sources in the diets of the poor and help to provide extra income and support.

Despite its large number, genetic diversity, and significant contribution to the rural poor, the importance of this valuable genetic resource was underestimated and its extent of contribution to the livelihood of the poor was inadequately understood compared to other livestock species in the previous decades in developing countries (Aziz, 2010). Research and development projects to improve the relatively low level of goats' productivity do not match their potential importance, resulting in many goat breeds not being genetically explored, especially in developing countries. The information on breeding directions for goats is fragmented and not clearly known in terms of breeding objectives, breeding practices, and the state of the existing breeding program for sustainable genetic improvement strategies in Ethiopia. Different authors (Solomon Abegaz et al., 2010; Solomon Gizaw et al., 2010; Solomon Abegaz et al., 2014; Ahmed, 2017) reviewed and documented that the present production levels of indigenous goats with existing breeding strategies and practices are far below their potential. This resulted in the productivity per unit of animal and the contribution of this sector to the livelihoods of farmers in rural areas and the national economy being relatively low due to various technical and non-technical constraints.

Systematic breeding programs that can improve the genetic performance of indigenous small ruminant breeds especially goats were not in place in our country up to the most recent years except for a few attempts at crossbreeding and nucleus schemes in research centers (Solomon Abegaz et al., 2014) . To some extent, research and development initiatives for genetic improvement of goats in the country, which is believed to have started in the mid-1970s by different actors, were through the introduction of exotic genotypes targeting very few economically important traits (only milk). Since then, various exotic goat breeds were introduced from different countries in a fragmented and inconsistent manner including Saanen, Toggenburg, Anglo-Nubian, and most recently Boer goat breeds (Solomon Abegaz et al., 2014). All of these cross-breeding and nucleus scheme attempts were unsuccessful for all the breeds and the programs were closed without delivering expected results so far except for the Boer goat breed which is still being tested in research centers. Many small ruminant cross breeding programs in tropical countries were not effective due to incompatibility of genotypes to farmers breeding objectives, management methods, the prevailing environment of low input smallholding production system, and the absence of involvement of all stakeholders in the implementation of the program (Workneh Ayalew et al., 2003; Kosgey et al., 2006; Solomon Abegaz et al., 2014).

In the last ten years (since 2010), an innovative, holistic, simple and feasible genetic improvement program called "community-based breeding program (CBBP)" has been emerged as an option for small ruminants. This approach considers the farmers' needs, views, decisions, and active participation from inception through the implementation of breeding programs, and their success is based upon proper consideration of farmers' breeding objectives, infrastructure, participation, and ownership (Aynalem et al., 2011; Wurzinger et al., 2013). According to these authors, designing CBBP is much simpler and it is a matter of infrastructure, community development, and an opportunity for the improved livelihood of livestock owners through productive and adapted animals and markets for their products. Community-based breeding programs have been implemented in the country with selected breeds of sheep including Menz, Bonga, Horro, and Afar sheep breeds (Tadele Mirkena et al., 2012) and Woyto-Gugi, Abergelle, and Central highland goats in previous years (Alubel, 2015; Netsanet, 2016). Currently, the program has expanded to several populations in the country as well as in other African countries and has now become an investment opportunity in various regions (Aynalem et al., 2013; Zelalem et al., 2015; Mueller et al., 2015; Aynalem et al., 2019).

The overall performance of any breeding program needs to be evaluated in terms of genetic gain, monetary gain, and performance of breeding objective traits towards the breeding goal. An evaluation framework developed by Lamuno et al. (2018), suggested that the evaluation of CBBP guides the assessment of the performance, outputs, and associated impacts of CBBPs responding to the need of formalizing the evaluation procedures. It helps to monitor and evaluate the ongoing activities in CBBPs, to identify challenges and mistakes in the execution of the program, so that appropriate actions can be taken. This evaluation also serves as a guide for funding bodies to measure the socio-economic impact on the livelihoods of livestock farmers to decide if the program's goals have been met.

Community-based breeding programs targeting growth and milk production improvement are being implemented for the Abergelle goat breed in the lowlands of the Waghimra zone in the Amhara regional state since 2013. The program started with two villages but now is expanded to seven dispersed pilot villages and two production sites. The program has not yet been evaluated and needs to be assessed in terms of socioeconomic criteria like community participation, socio-economic benefits from the program, institutional arrangements for proper implementation and the attitude changes perceived by producers in the program, and technical criteria including genetic trend, the efficiency of the program towards breeding objective traits and operational procedures whether the program is running in the planned direction.

1.2. Statement of the problem

Abergelle goat breeding program under CBPP conditions was started in 2013 to improve the growth and milk production performance of the breed and improve the livelihood of the community. Evaluation of animal breeding programs at a certain stage is an important aspect to assess its socio-economic benefits and technical perceived impacts during the planning period. In addition, it helps for either wider scaling out of results or modifying operational procedures if the planned gains were not achieved. In this regard, the performance of this breeding program (Abergelle goat genetic improvement program under CBBP) has not been evaluated yet.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study was the evaluation of the overall performance of the ongoing community-based Abergelle goat-breeding program towards the breeding goal traits in terms of technical and socio-economic criteria.

1.3.2. Specific objectives

The specific objectives include:

- To evaluate the phenotypic and genetic progress (growth, reproduction, and milk production trends) of the Abergelle goat CBBP over the years
- To estimate genetic parameters on growth, reproduction, and milk production traits for the Abergelle goat breed under CBBP
- To assess the socioeconomic benefits, income distribution, institutional arrangements, sustainability and operational performances of CBBPs
- To assess farmers’ attitude change towards genetic improvement under CBBP

1.4. Research questions

This study investigated the aforementioned situations described in the problem statement part using various data collection methods with the following important research questions;

- What are the characteristics of the population (heritability, genetic and phenotypic correlations for growth, and reproduction and milk production traits for the breed)?
- How much genetic gain was obtained with the intervention years for breeding objective traits?
- What were the operational procedures for the breeding program (buck selection, usage, selection intensity, mating ratio, and dissemination)? Were they followed in the right way?
- How much income was gained from the breeding program at the household level and how distributions of the benefits among members were done?
- What were the roles of respective stakeholders (institutions) in supporting the cooperatives?
- How farmers are knowledgeable and perceived about the program?

2. LITERATURE REVIEW

2.1. Goat breeds of Ethiopia and their geographical distribution

Comprehensive information on the physical description and management systems of goats have been compiled by Farm Africa (1996) which classified indigenous goats based on their geographic location and the ethnic communities who keep them. Based on the analysis of morphological characters and multivariate statistical analysis along with geographic distribution, fourteen distinct goat populations were identified across Ethiopia and Eritrea. These were categorized into four major families including the Nubian (Nubian, Barka), Rift valley (Worre, Afar, Abergelle, Arsi-Bale, Woyto-Guji), Somali (Hararghe highland, short-eared Somali, long-eared Somali), and the small East African (central highland, western Highland, western lowland, Keffa) goat families. After ten years of Farm Africa's characterization study, (Tesfaye Alemu, 2004) reported that almost all goat breeds are indigenous and have been classified phenotypically into 11 types. These are Abergelle, Arsi-Bale, Afar, Central Highland, Gumez, Hararghe Highland, Keffa, Long-eared Somali, North-West Highland, Short-eared Somali, and Woyto-Guji. These variations created other opportunities for molecular and genetic characterization of physically described breeds (Tesfaye Alemu, 2004; Halima Hassen et al., 2012). Based on a genetic characterization study by (Tesfaye Alemu, 2004) the Ethiopian goat population is currently classified into eight separate genetic entities following the analysis of 15 microsatellite loci. These include the Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergelle, Afar, Highland Goats (previously separated as Central and North West Highland), and the goats from the previously known Hararghe, Southeastern Bale, and Southern Sidamo provinces (Hararghe Highland, Short eared Somali and Long-eared Somali goats). He also reported their genetic differentiation analyzed by Weitzman formula indicated that about 75% of the total genetic diversity of the Ethiopian goats is present in four breeds: Afar, Abergelle, Gumez and Keffa with marginal loss of diversity of 24.32%, 19.22%, 16.59% and 12.99%, respectively.

With more than 40 years of research and development programs for goats including the nucleus and crossbreeding attempts in the country, the total population of both exotic and crossbred animals didn't show a significant increment which confirms the non-significant effect of crossbreeding activity in Ethiopia (CSA, 2018). The report indicated that, of the total goat population in the country in 2017, 99.97% were indigenous breeds with only 0.03% contribution from both the exotic and crossbred blood levels. The productivity of the population in terms of economically important traits is also not improved yet.

2.2. Goat genetic improvement and research initiatives in Ethiopia

Over the years, several approaches have been followed to improve livestock genetic resources with similar methodological procedures without considering potential capacities and infrastructure. Unlike in the developed world, small ruminant breeding programs in developing countries are generally characterized by smallholders/pastoralists initiatives, livestock is kept for multiple purposes (to produce food, skin and/or wool, manure, savings account, and increase social status), traditional and institutionally disarrayed (institutes do it independently). Furthermore, the program is characterized by a lack of clear and organized breeding policy, an absence of private sector participation (except in poultry), and is very complex in terms of execution (Philipsson et al., 2006; Solomon et al., 2014b; Aynalem, 2017). In general, the goal of goat production is to produce quality products with optimum efficiency. For this reason, several genetic improvements and research initiatives tested in the last four-plus decades in developing countries including Ethiopia.

Philipsson et al. (2006) reported that many attempts to improve livestock in the tropics have been mainly by 'upgrading' with temperate breeds targeting crossbreeding. In Ethiopia, goat research was started in the mid-1970s as part of the small ruminant research program by the national agricultural system, Universities (Haramya and Hawassa since 1988), the Ministry of Agriculture, and other non-governmental organizations as described in (Aschalew et al., 2000; Solomon Abegaz K et al., 2014). In those years, goat research was mainly a secondary component of the small ruminant research program in the NARS. The goat research program, which includes management studies associated with breed evaluation and improvement programs for Afar, highland, and Saanen goats with their crosses, started at Holetta and Melka Werer research centers in the mid-1970s to early 1980s with the objective of growth performance and milk production evaluation with possible characterization. Even though these institutions provided limited data on the productive performance of targeted goat breeds, the program was discontinued due to the extremely cool highland environment at Holetta, which was not suitable for goat breeds adapted to the hotter climate. And in Werer, difficulties of half crossbreds at "on-farm" investigations with nomadic pastoralists, that limited the potential applications of research results under the surrounding pastoral system (Aschalew et al., 2000).

Another research initiative in the late1980s to the end of the 1990s was the dairy goat development project targeting Somali, Hararghe highland, Anglo- Nubian goats and their crosses by Farm Africa, Universities (Haramya and Hawassa), and the Ministry of Agriculture (MoA) for the production of crossbred goats and distribution to women in the surrounding areas (Workneh, 2000). This research project was also discontinued due to lack of efficient exit strategy reaching the targeted bodies. Later on, in the 1990s, somehow the longest-running project on goats in Ethiopia, running for more than 15 years from 1992 was the Arsi-Bale and Borana goat research that was conducted at Adami Tulu Research Center (Solomon Abegaz K et al., 2014). In addition, another project with the objective of food security and income generation through improved goat production and extension services involving women's groups was established in the late 1990s by the collaboration of domestic universities (Haramaya and Hawassa) with Langston University on Arsi-Bale, Somali, Toggenburg goats and their crosses (Girma, 2000). The recent goat genetic improvement initiative was crossbreeding of Boar with various indigenous goat breeds (Abergelle, Arsi-Bale, Central Highland, Short-eared Somali, Hararghe Highland, and Woyito-Guji) to improve growth performances. A detailed review by (Zeleke Tesema, 2019) described that in most of the Boer goat crossbreeding activities in Ethiopia, the performance of indigenous breeds and crossbreds were not evaluated under similar management. That created difficulties to evaluate the effectiveness of the crossbreeding program and to design other breeding alternatives. He also reported, most goat crossbreeding activities based on Boer goat were discontinued without any clear conclusion.

Most of the previous goat genetic improvement and research development initiatives in Ethiopia were almost not successful or discontinued so far without delivering the predefined breeding goals. The reasons for this failure include incompatibility of the genotype with the farmers breeding objectives, low-input systems, management methods, lack of capacity and infrastructure, institutional arrangements, lack of involvement or participation of livestock keepers, and lack of adaptation in "improved breeds" (Workneh et al., 2003; Kosgey et al., 2006; Markos et al., 2010).

2.3. Community-based goat genetic improvement programs

In the past, traditional breeders took special consideration about the adaptability of their livestock and in-consultation with all the relevant stakeholders in the process of developed livestock breeds. These methods relied on either replicating the developed world systems or centralized nucleus schemes with cross-breeding that were not successful due to lack of infrastructure and technical capacities in developing countries, top-down approaches that lack engagement of end-user smallholders, and incompatibility of exotic genotypes for the smallholder production system (Aynalem et al., 2013; Zelalem et al., 2015). For instance, with more than 30 years of goat genetic improvement program efforts in Ethiopia applying the described approaches, no success stories documented and reported up to the most recent years. During these long periods, the country lacked organized breeding goals, objectives, and strategies as a reliable genetic improvement tool for the small ruminant sector and especially for goats.

After a long period of fragmented genetic improvement efforts through crossbreeding in goats, a new, innovative, holistic, simple, and feasible genetic improvement program called "**community-based breeding**" has been initiated in 2009 and 2013 for selected indigenous sheep (Menz, Horo, Bonga, and Afar) and goat breeds (Abergelle, Central Highland and Woyto-Guji) goats, respectively. The project was the collaborative work of Biosciences for eastern and central Africa (BecA), ILRI, BOKU University, ICARDA, and local regional research institutes (ARARI, ORARI, SARI, and TARI) as described in (Markos et al., 2010; Aynalem et al., 2011; Solomon Abegaz, 2014; Tatek et al., 2016). Even though the program has been dated back longer years in some countries, it is at its younger stage in our country. This program has emerged as a viable option to bring genetic gains that improve small ruminant productivity and ultimately enhance smallholder farmers' livelihoods (Aynalem et al., 2011). Such programs could be described as a system of genetic resources and ecosystem management in which the livestock keepers are responsible for the decisions on identification, priority setting, and the implementation of activities in conservation and sustainable use of the livestock.

The main objective of the CBBP is to improve the productivity and income of the smallholder farmers and all those who were/are associated through the value chain and all the stakeholders in the process. CBBP increases the productivity and profitability of indigenous breeds or varieties without compromising their resilience and genetic integrity using easy-to-access interventions. This new thinking resulted in a promising result for genetic improvement of small ruminants in low input-output production systems of developing countries due to the involvement of local communities and institutions at the start. In addition, the program is suitable for smallholders to design with their participation, simple to implement/test the program with smallholders under on-farm conditions, and a possible way of taping into indigenous knowledge as it is designed using bottom-up participatory approach (Markos et al., 2010; Wurzinger et al., 2011; Aynalem et al., 2013; Zelalem et al., 2015).

The community-based breeding programs are an emerging way to improve livestock populations and the livelihoods of their owners in low-input smallholder production systems. It has been promoted as a tool for economic and livelihood development through genetic improvement of livestock and for conservation of local breeds in developing countries. Currently, the program stimulated global attention for wider implementation and rapidly expanding because of its promising results in pilot implementation communities in selected countries (Mueller et al., 2015). In **Error! Reference source not found.**, a list of some selected community-based goat-breeding programs having longer experiences, and published documented results with possible achievements in the global context are presented. In addition, the program is currently implemented in different countries including Sudan, Tunisia, Tanzania, South Africa, Iran, Mongolia, and other countries with the collaboration of the ICARDA project, which has not a documented result yet.

2.4. Components of community-based livestock breeding programs

In comparison to conventional breeding programs, CBBPs are exclusively implemented with the active participation of the producers starting from the inception throughout the implementation of the program (Aynalem et al., 2011). This phenomenon might have either positive or negative effects on the overall performance of the program for the targeted breed during the evaluation of the program. It simply means the participation of the community in the breeding program would have contributed to the utilization of the indigenous knowledge that could correlate with science or compromise their traditional perceptions of the real situation. In conventional breeding programs, there has been very little or no consideration of the needs of the farmers and pastoralists, their perceptions, and indigenous practices that make the program unsuccessful (Solomon et al., 2013).

CBBPs deviate from the conventional breeding program in terms of community participation, farmer's cooperative-based genetic improvement, and the use of integrated indigenous knowledge-science-based approaches for the overall procedures of the program. Due to this reason, selection criteria and selection intensity, the lifetime of selected males, mating structure (mating ratio), sire rotation, and other conditions decided with their agreement that may obey the scientific standards for these parameters. But, in terms of planning procedures, CBBPs follow the same basic steps and principles as conventional breeding programs (Mueller et al., 2015).

The effectiveness of selection in any of the breeding programs can be measured by the rate of genetic response and is influenced by four factors: selection intensity (*i*) or selection differential (S_d), heritability (h^2), phenotypic variation, and the generation interval (G_i). The rate of genetic change refers to the change of the mean breeding value of a population over time caused by selection with the unit of time usually being years ($\Delta_{BV/t}$) (Bourdon, 2014; Falconer, 1989).

The components (steps) of CBBP varies somehow from the conventional breeding program and the former includes consideration of enabling environments, understanding of the production system and defining the breeding objective, choice of selection criteria and recording, development of a genetic evaluation and breeding structure and its organization and evaluation of the proposed program (Philipsson et al., 2006; FAO, 2010; Mueller et al., 2015). The steps/components of CBBPs would affect the overall performance of the program towards genetic improvement in various ways.

Recording system: Record keeping is the primary component of livestock breeding programs that help to maintain pedigree details of animals, implement their genetic improvement programs, assist farmers in the management of their animals, and follow up and control diseased animals in advanced breeding systems (FAO, 2016). Recording systems developed in advanced breeding systems are not directly replicable in low-input systems due to differences in socio-economic conditions, production environments, livestock service providers, veterinary institutions, resource availability, and farmers' capabilities. This situation resulted in inadequate data provision for genetic evaluation in low-input systems. In CBBPs, data recordings are believed to lack scientific qualities due to the complexity of the collected traits, quality of data collectors, as they are not skilled, a very traditional method of recording, the difficulty of data collection as the animals owned by different households. The magnitude of data quality in CBBP needs assessment in the evaluation step of the breeding program.

Buck selection and management: In conventional breeding programs, the selection of males is undertaken during the actual period of evaluation because of their proper management in the herd. In the case of CBBPs, farmers' needs are diverse and they want to sell those superior males to market before the selection time which needs precise scheduling. The duration selected bucks stay in the population is also not uniform in different CBBPs. A result reported by (Solomon et al., 2014) indicated that a breeding service period of 2-3 years was practiced in CBBP villages of Menz sheep cooperatives. The case is not similar to other species that need a comprehensive evaluation of whether it is correct or needs some sort of modifications in CBBPs.

Selection intensity and mating ratio: In comparison to conventional breeding systems selection intensities are loosened in CBBPs due to various reasons that could result in retarded selection responses. Mating ratios are also the other important factor affecting selection intensity in the case of CBBPs. The extent of the effect of selection intensity and mating ratio on genetic progress needs to be evaluated for the success of breeding programs.

Rotation modalities for selected sires: Rotation of selected males among members of the breeding cooperatives considering previous mating history is an important step to reduce inbreeding rates in communal mating systems. In the case of CBBPs, sire rotation procedures are challenging due to variations in the management, considering the male as fixed property for individuals, and other perception-related constraints. In some circumstances, some of the members are not respecting the drafted bylaw which governs the overall management of selected bucks with scientific standards. The extent and magnitude of this situation need precise investigation during the evaluation phase of the program. All the procedures of the breeding program including the selection intensity, sire rotation, and management need to be implemented based on the guidelines described in (Aynalem et al, 2019) for quicker improvements.

Dissemination of improved genetics to production unit: The final target for any breeding program should be on improving the performance of the whole population for a targeted breed not to be limited to improving only small individuals enclosed in elite villages. In this regard, CBBPs are targeting genetic improvement at only small population levels, and dissemination of improved genotypes to the production unit is scarcely practiced up to date due to a lack of cooperation from the research and development sides. Currently, some initiatives by ICARDA and regional livestock agencies are made to upscale the genetic improvement results found at elite CBBP sites either by replicating the number of CBBPs or disseminating surplus sires to base population. It requires a multi-stakeholder implementation to reach wider small ruminant breeds in the country and it needs public and private investments as documented by (Aynalem et al, 2019). According to (Wilson et al., 2020), multi-stakeholder collaboration in the implementation of community-based breeding programs offers an opportunity for different actors to work together by pooling financial resources and technical expertise for the establishment and sustainability. The authors noted that scaling up strategies should be an integral part of the pilot design hence dissemination partners need to be engaged during the design and inception stages of the pilot CBBPs.

Table2.1 Selected goat CBB programs with their target traits and country

Country	Year started	Target trait	CBBP size	Population (goat)	Achievements	References
Ethiopia	2013	Meat, Milk	>10	>10000	More birth, better growth, increased income	(Solomon , 2014: Mulatu et al., 2018)
Kenya	1997	Milk	160	>1000	Farmer income improvement, increased milk consumption	(Ojango et al., 2010)
Malawi	2014	Meat, survival	6	2556	Higher off-take rate	(Wilson et al., 2016)
Liberia	2016	Meat	6	229	Increased productivity and greater genetic diversity	(Arthur et al., 2018)
Uganda	2014	Meat	4		Increased live animal sale	(Onzima et al., 2017)
Mexico	2007	Milk, meat	7	276	Increased income from the sale of milk	(Wurzinger et al., 2013)
Argentina	1987	Mohair	>21	62000	Increased income from the sale of mohair	Described in (Mueller et al., 2015)
Iran	2009	Cashmere	8	2500	The improved livelihood of rural poor and women	(Mueller et al., 2015)
Bangladesh	2004	Meat	Few		Improved production and reproduction performances	(Mohammad et al., 2017)

Due to its wider application of the program at the global level with different production systems, CBBP's are complex in terms of their local contexts and linked to particular socio-economic and cultural dimensions, hence, considerable difficulties may exist in measuring some of the outcomes and impacts that are less tangible than strict economic criteria. In general, an appropriate evaluation procedure is needed to evaluate the performances of CBBPs in terms of technical, socioeconomic, and cost-benefit analysis criteria at the community level (FAO, 2015; Lamuno et al., 2018).

2.5. Genetic evaluation under CBBP conditions with multiple sires joining and parental uncertainty

Genetic evaluation is a preliminary step towards the development of sound genetic improvement programs and provides information to estimate the genetic merit of animals for economically important traits (Praharani, 2004). It represents the synthesis of available information into a single value for each animal that can be used for purposes of ranking in selection. In this regard, CBPP's centered on their target of genetic improvement only within individual village flocks without showing how genetic improvement is implemented at the breed level and the difficulty of genetic evaluation using animal models of the BLUP procedure in village flocks. This could be due to the difficulty of accurate pedigree recording, multiple sires joining, and uncertainty at least from the sire side (Solomon Gizaw et al., 2014).

The performances of CBBPs (trends) and selection of males have been evaluated using selection index theory that lacked incorporation of the genetic variance component and with lower accuracy. The genetic evaluation includes the analysis of genetic trends (selection response) over years, breeding value estimation, estimation of inbreeding levels and genetic parameter estimates. The data collected from CBBP found complex to run genetic evaluation procedures in comparison to conventional breeding programs as the latter uses controlled mating. In contradiction with the above-mentioned limitations of CBBPs, different scholars have proved that genetic evaluations are possible in such situations of missing pedigree data, multiple sires joining, and parental uncertainty (Henderson, 1988; Perez-Enciso and Fernando, 1992; Kerr and Hammond, 1994; Birte et al., 2005; Francisco et al., 2017).

According to a report by Kerr and Hammond (1994), the substitution of the average for the complete numerator relationship matrix (NRM) in mixed model equations, recording sire group membership and dam identification under multiple-sire mating in genetic evaluation analysis resulted in little bias in genetic trend. In addition, 26-63% more genetic gain and reduced realized genetic gain were found compared with the individual performance selection (no genetic analysis) and compared with single sire mating by using complete BLUP analysis. Various methods were evaluated and recommended to analyze these types of data structures including the use of best linear unbiased prediction with genetic groups (BLUP-G) reported by (M. Perez-Enciso and R. L. Fernando, 1992), use of average numerator relationship matrix by (Henderson, 1988), use of the hierarchical animal model (HM) by (Francisco et al., 2017) and more other methods like use of randomly selected sire lines that can better estimate the genetic parameter estimates with better accuracy. On the other way, (Joaquín Mueller et al. 2020) described uncertain sire information can be used in breeding value estimation of animals with unknown sires with little extra recording and computation effort in the case of CBBPs. In this context, it is possible to estimate genetic parameters and breeding values of animals with some higher prediction error variances.

2.6. Productive and reproductive performances of Ethiopian goat populations

For designing effective and sustainable genetic improvement programs, the relative importance of small ruminants, and their genetic and production environment characteristics need to be evaluated and clearly understood (Kosgey & Okeyo, 2007). The productive and reproductive performance of goats differed in different agro-ecologies and management systems everywhere in the world and Ethiopia too.

2.6.1. Growth performance

Growth rates of kids have a strong relationship with both production and reproduction performances in goats. Thus, evaluating the growth performance of kids is important to evaluate the productivity and level of adaptation under a given production system. Though productivity of indigenous goats is generally considered low, performance is highly variable between different production systems and there is high potential under improved management systems (Dereje et al., 2015). The author also mentioned that in some cases, growth performances of goats were recorded lower in controlled management systems than in the traditional management system due to over confinement and treatment of animals against their physiological behavior in station-based management systems. In general, the growth performances of goats in lowland agro-ecologies are lower than in the other agro-ecologies as documented in (Dereje et al., 2015). The growth performance of goats extends for instance, from the smallest body weight reported value of mid rift valley breed (2 kg) to the larger Anglo-Nubian crossbreed (3.2 kg) at birth, documented in a review by (Solomon Abegaz et al., 2014). A higher level of variation in terms of growth performance is an opportunity to improve these traits through selection and improved management focusing on breeds.

2.6.2. Milk production Performance

Although the majority of goat breeds are raised primarily for meat production in the tropics, few breeds are known to produce a reasonable amount of milk. A review by (Dereje et al., 2015) indicated that the average lactation length (LL) of most tropically adapted indigenous and crossbred goats ranged (80-200 days) with lactation milk yield ranging from 24 kg for Afar goats in Ethiopia to 480 kg for Alpine goats in Burundi. Perhaps, the milk production potential of indigenous goats has not been adequately studied; some station-based studies indicated that the daily milk yield (DMY) of indigenous goats ranges between 0.3 and 0.45 kg. Similar result was reported for the Abergelle goat breed 0.35kg in the case of pilot CBBP (Mulatu et al., 2018).
Generally, past research results revealed that the milk production potential of indigenous goats clearly showed very low performance. However, there is an opportunity to increase the milk production performance from the reported value through an improved management system. Lowland goats produced relatively higher daily milk compared to the highland goats. Variation in milk production performance is also a good opportunity to genetically improve populations through selection.

2.6.3. Reproductive performance

The reproductive performance of goats is an indicator of productivity, adaptability, and economic viability of goat production. It is an important measure of the efficiency of females in a given environment. Doe productivity could be measured in terms of the average age at first kidding, litter size, twinning rate, total weights of litter weaned, and the proportion of survived kids. Reproductive performances of indigenous goat breeds are generally low. For instance, the average age at first kidding of most Ethiopian goat breeds is in the range of 8-14 months with the possibility of shorter kidding intervals under the traditional management system. This is due to controlled breeding to achieve the best breeding season and synchronization of birth in case of intensively managed conditions (Dereje et al., 2015; Temesgen Jembere, 2016). According to the same authors, most indigenous goats had a twinning rate below 20%, the smallest twinning rate in arid areas, and the highest twinning rate in humid areas of the country. Genetic and non-genetic factors are important factors affecting both the growth and reproductive performances of goats. Although the effects of non-genetic factors are not transmitted to the progeny, they may mask the expression of the genetic material of the individual.

2.7. Genetic parameters estimates

Knowledge of genetic and phenotypic parameters is required for planning efficient breeding programs in animal husbandry (Roman R M et al., 2000). The potential for genetic improvement of a trait largely depends upon genetic variation existing in the population. Genetic parameters including genetic correlations and heritability are required to plan breeding strategies and genetic evaluation programs in livestock (Willam et al., 2008). These parameters are specific to the population for which they are estimated. These estimates are dependent upon the model used to describe the data and the assumptions inherent in the chosen method of analysis. In conventional breeding programs, estimation of genetic parameters is simple as there is an organized data recording procedure; this is complex in the case of CBBPs. But, it is also possible to estimate genetic parameters in CBBPs with community pastoral flocks in the presence of multiple sires and uncertain paternity (Francisco et al., 2017).

2.7.1. Heritability

Heritability is a measure of the strength of the relationship between the phenotypic and genetic values for a trait (Bourdon, 2014) *i.e.* the proportion of phenotypic variation accounted for by genetic variation. Knowledge of heritability values is important in the selection of polygenic traits, for prediction of breeding values, and for producing abilities. Heritability of a trait is not a fixed value and may vary from population to population, vary across time and vary from environment to environment**.** Therefore, the determination of heritability estimates for traits of economic importance in a particular population would indicate the genetic progress expected from selection for improvement of that trait in that population (Praharani, 2004).

The magnitude of the heritability determines the expected response to selection in a population. The higher the heritability of a trait, the better performance record is as an indicator of an animal's true genetic values because when heritability is higher the prediction of breeding values will be more accurate. The value of heritability can be increased by making the environment more uniform, measuring the traits more accurately, adjusting for known environmental effects, and forming contemporary groups (Bourdon, 2014; Praharani, 2004).

Heritability estimate for growth traits

The heritabilities of most growth traits are classified in the moderate range (0.2-0.4) however variations are high from breed to breed, among species, and across environments (Bourdon, 2014). For instance, heritability values of 0.04 ± 0.06 and 0.54 ± 0.12 were reported for Arsi Bale and Ettawan grade goat breeds respectively (Mohamed Bedhane et al., 2013). Various results with possible variations of heritability values were reported for weaning weight (WWT), six-month weight (SMWT), nine-month weight (NMWT), yearling weight (YWT), and average daily gains at different ages (ADGs) for different goat breeds in different environments. A review report from a meta-analysis by (Temesgen, 2016) indicated that the average un-weighted direct additive heritability for growth traits ranged between 0.05 and 0.51.

Heritability estimate for reproductive traits

Reproductive rates are the most important traits in all small ruminant production systems, irrespective of the environmental condition considered. The heritability reported for reproductive traits in goats is generally small but variations exist depending on the breed and environment. The most important traits that affect reproductive performances of goats and need proper genetic parameter estimate includes age at first kidding, kidding interval, litter size at birth and weaning, litter weight at birth and weaning (Tesfaye et al., 2012). Perhaps various traits affect the reproductive rate of goats described in different research results. The un-weighted averages of heritability values for litter size are reported at 0.059 (Zeleke, 2019). In general, the average un-weighted direct additive heritability for reproductive traits was found to be in the range of 0.06 to 0.29 in a meta-analysis study by (Temesgen, 2016).

Heritability estimate for milk production traits

Milk yield and lactation length are the important factors to be considered here. Results for milk yield and durations in milk data are scarce. Heritability values for milk yield and its component traits are classified under lower to moderate levels. For instance, the heritability value for the total lactation milk yield of Saanen goats reported in Mexico is 0.17±0.04 (Torres-vázquez et al., 2009) whereas it was reported as 0.25±0.08 for Jamunapari goats which are reared as dairy animals in semi-arid tropics conditions (Rout et al.., 2017). Heritability of lactation length for this breed was found non-significant and it was reported 0.02±0.03 as described by the same author. In Ethiopia, such reports are lacking in indigenous goat breeds. One report for the Arsi Bale goat breed described direct additive heritabilities (h^2_a) for LL, LMY, and DMY traits varied from 0.00 to 0.03, 0.00 to 0.69, and 0.02 to 0.071, respectively (Mohammed et al., 2012). The average un-weighted heritability values for milk production traits ranged from 0.19 to 0.53 in goats from a meta-analysis study by Temesgen (2016).

2.7.2. Phenotypic and genetic correlation

Knowledge of the magnitude of genetic and phenotypic correlations is important for multiple trait evaluation, particularly when predicting correlated responses to selection. Substantial negative or positive correlations either indicate that selection for or against a trait would influence other correlated traits (Falconer, 1989).

A genetic correlation is defined as a measure of the strength of the relationship between breeding values of two traits (Bourdon, 2014). A genetic correlation represents the correlation between the additive breeding values for two traits or between the sums of additive effects of the genes influencing them. Genetic correlations of traits can result from pleiotropy (the phenomenon of a single gene affecting more than one trait) and can result from linkage effects (the occurrence of two or more loci that affect the same trait on the same chromosome). Therefore, when two traits are genetically correlated, selection for one will cause genetic change(s) in the other. Furthermore, the breeding value of one trait can be predicted based on the observed performance of another trait that is genetically correlated with that trait (Praharani, 2004). Phenotypic and genetic correlations can be estimated from CBBP data sets, as it is possible for genetic evaluation and estimation of genetic parameters in this program (Francisco et al., 2017). These parameters could be estimated for growth, reproduction, and milk production traits.

2.7.3. Repeatability estimates

Repeatability measures the correlation between the repeated measurements of the same individual and its value is greater than the heritability value since repeatability estimates include the permanent maternal environmental variance, in addition to the additive genetic variance component. It indicates the gain inaccuracy that may be expected from the use of the mean multiple measurements instead of a single measurement (Bourdon, 2014).

Repeatability is an important genetic parameter, frequently used to measure the ability of the animal to repeat its level of production at successive intervals in time. Its estimates usually range from moderate to high values for growth traits as observed from various research outputs. The repeatability values for reproductive traits are classified under lower to moderate levels.

2.8. Goat breeding cooperatives

By definition, a 'cooperative' is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise (Kumar et al., 2015). It is based on the values of the development of agriculture, forestry, banking, credit, agro-processing, storage, marketing, dairy, fishing, and housing and its network covers large number of rural households. In addition, it engaged in economic activities like providing credit, distribution of agricultural inputs (seeds, fertilizers, and agrochemicals).

In Ethiopia, enabling environments have been created to establish livestock breeding and fattening cooperatives in different regions including Amhara, Afar, Oromia, SNNP, and Somali regions. These days CBBP has created various opportunities to establish small ruminant breeding cooperatives in different parts of the country. In established CBBP project areas of sheep and goats, formal cooperatives are organized for the overall management of activities in the program. Perhaps, the participation of members, management, distribution of tasks and benefits, and stakeholder support is not equal and sustainable in most established cooperatives affecting their performance in various ways.

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted in Abergelle and Ziquala districts where the community-based Abergelle goat genetic improvement program has been implemented since 2013. Saziba and Bilaqu villages are the respective elite CBBP villages of Abergelle and Ziquala districts (**Figure**

3.1). Geographically, the villages are found at 12º56′02″N 38º 43′43″E and 12º 48’41″N 38º57′22″E with an altitude of 1311 and 1343 meters above sea level for Saziba and Bilaqu villages, respectively. Rugged topography, degraded mountains, steep escarpments, and deeply incised valleys characterize the areas.

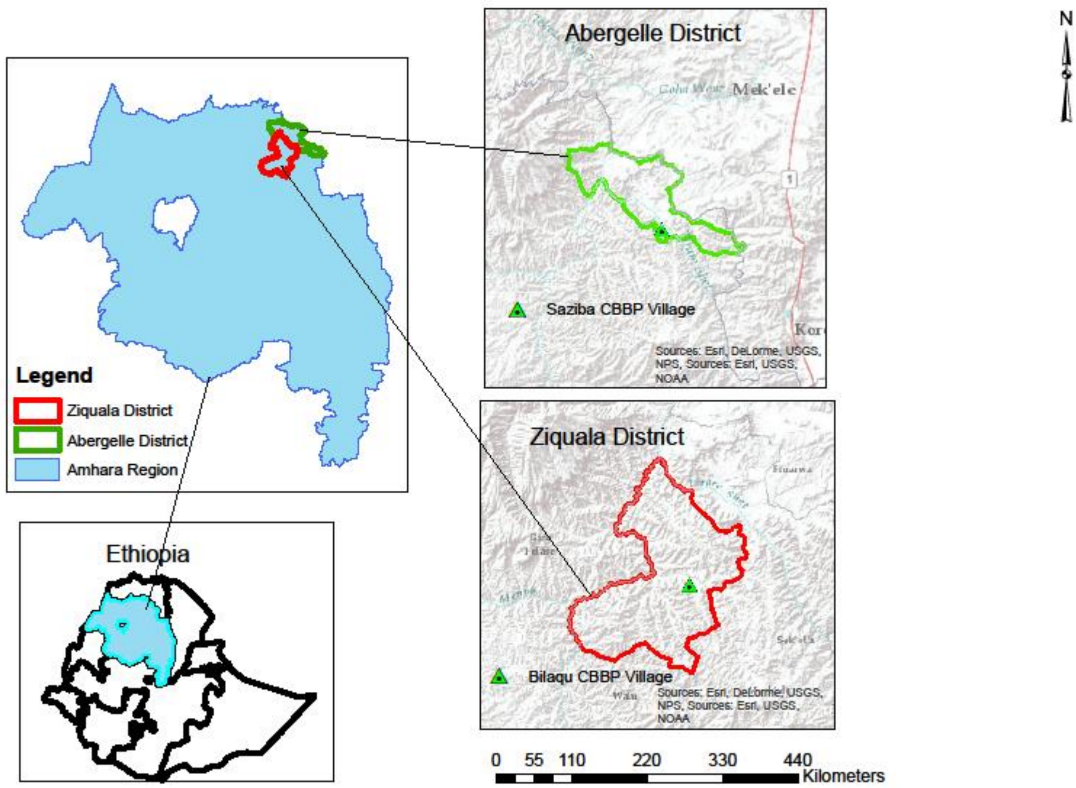
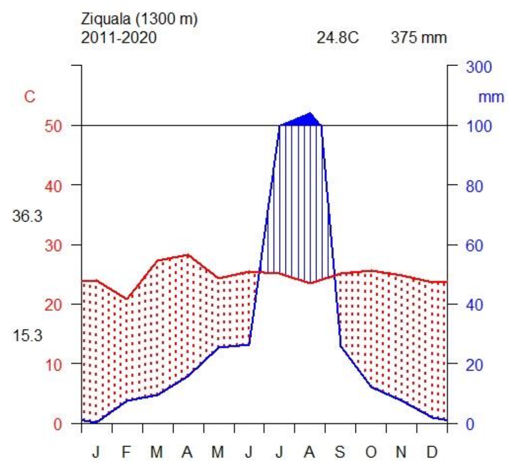


Figure3.1 Map of the study areas

The rainfall distribution of study district (Figure 3.2) is very erratic and little which comes in late July and stops in early September. Mean annual temperature ranges from 15.3^oC -36.3^oC for Ziquala and 22^oC -41^oC for Abergelle. The rainfall distribution over the past ten years was highly variable ranging from 175-540 mm across districts. Relative humidity during the previous ten years was in the range of 32-58% (Figure 3.3). The production system of the districts includes agro-pastoral and crop-livestock mixed farming system with a high priority on Abergelle goat production. In these areas, crop production is practiced on a smaller scale and seasonal flock migration is common during the dry season. The unpredictability and higher variability of rain make the area highly vulnerable to severe drought and food insecurity even during years of good rains. As a result, the area depends on food aid from the government and NGOs. Natural resource degradation is another serious development constraint of the area that cannot support sustainable crop production even at a smaller scale. Thus, smallholders in these areas are pushed to livestock production in general and small ruminant husbandry especially goats in particular.

Goats are the primary commodity of the community in the study area in terms of meat, milk, live animal sale, and other socio-cultural aspects. In addition, the area is characterized by low and very erratic rainfall patterns, degraded resources, and is less suitable for crop production magnifying the importance of goats to the community (Alubel Alemu, 2015; Solomon Abegaz, et al., 2014; Mulatu Gobeze et al, 2018). The average flock size of goats in the study sites was in the range of 27-49 heads per household (Alubel Alemu, 2015; Mulatu Gobeze et al., 2018).



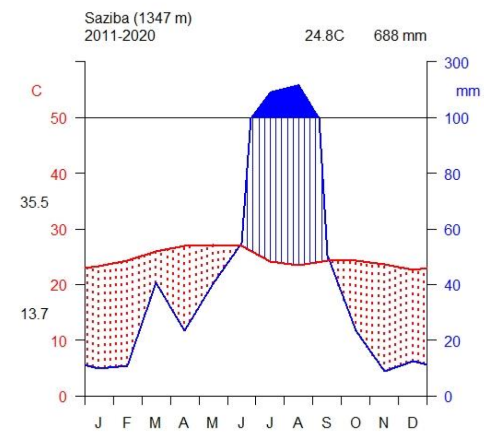


Figure3.2 Rainfall and temperature distribution of Bilaque (left) and Sazibas (right) CBBP villages across months (2011-2020)

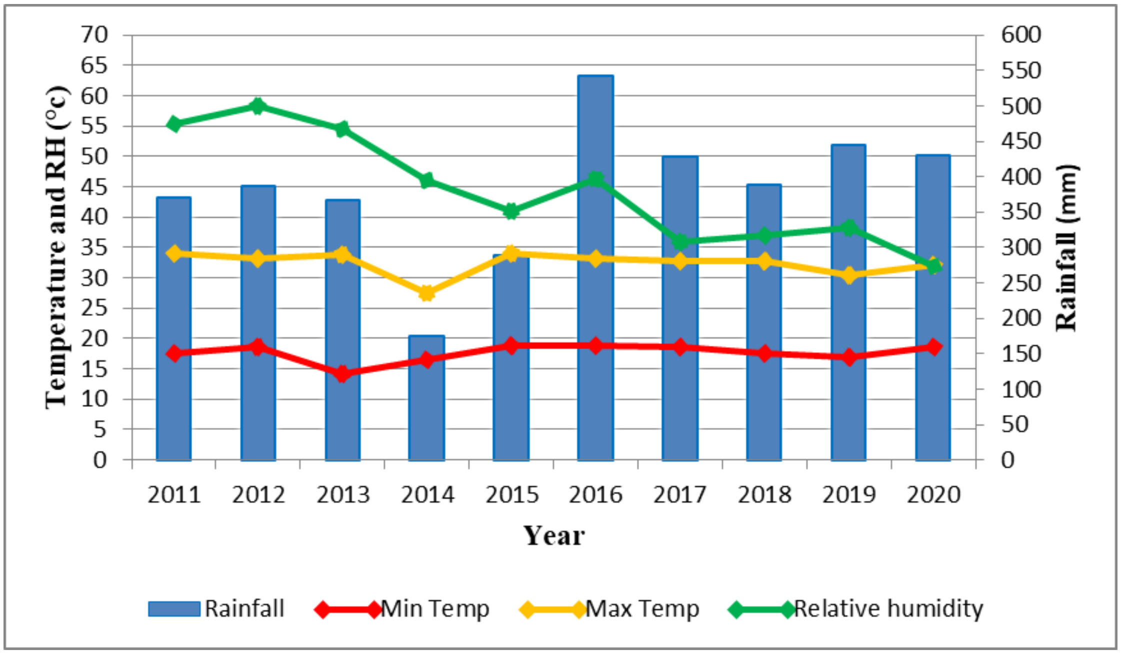


Figure 3.3 Rainfalls, temperature, and relative humidity distribution of Ziquala district across years

3.2. Study animals description

Abergelle goat breed, which is among the 12 physically described indigenous Ethiopian goat populations, under the rift valley route family, has an estimated population of over 300,000. The breed is distributed along the Tekeze River in Southern Tigray (Tembien and Inderta), Waghimra, Raya Azebo, and North Gondar (Simien) and kept by the Agew and Tigray ethnic groups (Farm Africa, 1996). The breed is physically described as stocky build; mostly reddish-brown color; males have magnificent spiral horns directed backward, straight to concave facial profile, mostly plain coat, short smooth hair, presence of ruffs and beards, and mostly the absence of wattles as presented in **Error! Reference source not found.** (Farm Africa, 1996; Solomon Gizaw, 2009). The breed is also characterized by its lower body weight, lower production potential (meat and milk), longer kidding interval, lower kidding rate, and lower litter size with better meat quality, adaptation to a harsh environment, and temperament in comparison to other indigenous goat breeds.

3.3. Description of the breeding program and study animal management

A community-based breeding program was established for the Abergelle goat breed in 2013 first by ILRI/ICARDA project in collaboration with Sekota Dryland Agricultural Research Center following CBBP implementation guidelines. In the beginning, the project-supported program was started at Bilaqu elite village and the Saziba elite village was initiated by the research center. The structure of the CBBP was one tier i.e. all the breeding and multiplication of best bucks was done at farmers' village. The objectives of the program were to improve the growth and milk production performance of the breed through selective breeding by applying improved feeding, healthcare, and marketing systems and then to improve the livelihood of smallholder producers in the study area. CBBP villages are now expanded and have reached more than seven villages (two villages belong to production sites). Phenotypic characterization, production performance, identification of breeding objective traits, optimization of selection criteria traits, and productivity benchmark of the breed was extensively investigated before and at the early stages of the actual breeding program implementation (Solomon Abegaz et al., 2014; Alubel, 2015; Temesgen, 2016).

Field performance data monitoring and recording were started after the identification and registration of base flocks using plastic ear tags from two villages of 55 participating farmers (35 from Bilaque and 20 from Saziba villages). Participating farmers from these communities were organized into regionally certified goat breeding and fattening cooperative having their drafted local bylaws which govern the management of selected bucks and cooperative memberships. The project initiated a revolving fund to ensure that selected bucks were always available to avoid a shortage of breeding bucks during active mating seasons and for better sustainability of the program. Enumerators that are responsible for data recording were recruited by the project. At the start of the program, a total of 1611 base flocks were monitored from two villages (847 from Bilaque and 764 from Saziba) and currently, about 3250 birth and other parameter records at each village (the data recording problems at Saziba reduced the number of records) were used for this study.

All the goats were managed under a low-input extensive management system where they freely roam throughout the year with minimum supplementation of crop residues for selected animal groups during the dry season. Kids are managed at the house until weaning and after three months of age, they are mixed into the whole flock. Flock mix-ups among households were almost zero except for very few suspected occasions due to running away of bucks during watering and vaccination program. The major reasons of the farmers for zero flock mix-ups were their fear of disease transmission and the loss of their animals due to higher flock size. Animal health control services and scheduled vaccination for Anthrax, PPR, Pasteurllosis, goat pox, and other economically important diseases were provided year-round for all animals.

Data recording was started at birth of individual animals by measuring birth weight within 24 hours with hanging balance. During kidding season, enumerators visited each household flock on a routine basis and recorded birth weight, date of birth, dam identification number, the weight of the dam after parturition, birth type, sex of the kid, and parity of the dam. Kids were identified using plastic ear tags at three months of age because the farmers did not allow tagging before this period. The herdsmen were quite perfect in identifying animals by their local names until they are identified by ear tags, which were in parallel recorded using a data-sheet to avoid complications during ear tagging. Weights at different ages starting from three month weights were measured on the actual date. Dam milk production performance recording was measured once in 7-day intervals starting a week after kidding and up to twelve weeks. Daily milk yield of dams was recorded twice a day in the morning and in the evening. Kids were separately housed during day and night time up to weaning ages, and locally the farmers restricted kids from access to their dam during day time by lubricating does teats using dung or tying the teat with barks of trees/shrubs if the kid is not going to stop suckling. On milk data collection dates, kids were fostered by other does that were not milked on that day to ensure sufficient nutrition for the kids and complete milking of the dam.

During the program implementation period, only selection of the sire was employed. Selection of best bucks has been conducted once a year based on their estimated breeding value (EBV) indexed from the growth performance of individuals (yearling weight) and their respective dam's milk yield. During buck selection, candidates were grouped into three categories (first, second and third level) based on their breeding values for final decision by the farmers using their own selection criteria and visual observations. All unselected bucks were culled from the population through castration, sale, or slaughter with the possible sooner time after selection. The selected breeding bucks were purchased by the cooperative revolving fund and hence the participating households do not own the breeding bucks but have the right to use them. The selected breeding bucks were distributed into cooperative members by considering the previous sire rotation history to avoid the inbreeding effect. In addition, the inbreeding effect was minimized by following buck rotation modalities signed by the participating farmers, i.e., selected bucks were rotated to distant farmers across years until the bucks got aged and culled from the population. Maximum care was taken to avoid mating of bucks in the flock of its origin and even after rotation the bucks were used for only one round mating. The bucks' service period was for 2 to 4 years after it was selected and exchanged by participating members depending on their physical performance for mating.

Figure3.4 Abergelle goats: Breeding females (left) and bucks (right)

3.4. Data type, source and sampling method

Primary and secondary data sources were used in this study to generate quantitative data for the socio-economic and technical evaluations from the established CBBP villages and stakeholder organizations. Primary data sources were the socio-economic aspects of the breeding program and were collected using focus group discussions, questionnaire interviews of sampled farmers, and key informant interviews while quantitative data on biological performances were obtained from Sekota Dry Land Agricultural Research Center collected over the past 8 years (2013 to

2019). In addition, different publications and project reports were used as a guide and comparison study. Biological data for the breeding program was synthesized from the breeding objective traits of the Abergelle goat breed i.e. growth, reproduction, and milk production performances. These traits were subjected to detailed analysis and used for the evaluation of the technical criteria of the breeding program.

Focus group discussions (two, one at each village) were conducted to collect additional information and to validate whether changes are observed in the breeding program in terms of technical and socio-economic aspects and the self-sustainability of the program without research and organizational support. The sustainability of the breeding program depends on the positive gains in biological traits over years, socio-economic benefits gained, and the active participation of respective institutions in support of the program. To investigate the sustainability of the ongoing community-based breeding program and provide some inputs for that matter, goat-breeding cooperative members in the two sites were approached to collect data on the overall management of the breeding program and operational performances of cooperatives. Twelve farmers composed of different sex, age, and wealth status group participated in the focus group discussion at each site to collect information on the socio-economic aspects of the breeding cooperatives, to assess how cooperatives run the breeding program including; best-buck selection, its intensity, buck rotation, buck use lifetime, market linkage for selected and culled animals, management of the revolving fund, participation of farmers and distribution of benefits in the program by the communities, benefits derived from the improved genetic resource, consumption trends of animal source foods, farmers' perception of the breeding program and its perceived impacts in terms of income, and challenges faced in running the program. The checklist for focus group discussion is presented in Appendix II.

Key informant interviews were conducted with district up to zonal level livestock, cooperative and agriculture office staff and other non-governmental organizations in the area to learn if they were knowledgeable about the ongoing breeding program, how the breeding programs fit with their livestock development priorities, other enabling environments, the level of cooperation between these stakeholders, support given to the cooperatives and opportunities to scale out dissemination of improved genotypes to other production sites.

A retrospective study design was used for the biological data types. Comparison analysis was conducted with participating and non-participant households to learn the realized impacts of the program using a cross-sectional study design. Adjacent non-participant farmers that are engaged in goat rearing with an equal number of participant farmers in the two cooperatives were selected purposively for questionnaire interviews for this purpose. A total of 110 households (55 for each) members and non-members of the cooperative were interviewed purposively. In addition, informal discussions were held with non-participant members to understand their knowledge, attitudes, and perceptions about the CBBP using Likert scale data collection procedures. The household interview survey was conducted using a semi-structured questionnaire. The questionnaire was designed, pre-tested (using 7% of the sample size), and modified before the commencement of the actual administration to check its clarity to respondents and the appropriateness of the questions. The household interview checklist is presented in Appendix I.

3.5. Classification of study traits and data management

Data on kid growth performance, milk production, and reproductive performances of does collected from 2013 to 2019 were used for genetic trend analysis and genetic parameter estimation of the traits. Growth traits included birth weight, weaning (three months), six, nine-month, and yearling weights. In addition, average daily gain (g/day) from birth to weaning (ADG1), from 3month to six-month weights (ADG2), from six months to nine months weights (ADG3), and from nine-month to yearling weights (ADG4) were computed. Milk production traits included average daily milk yield (ADMY), 90-day milk yield, and lactation length. The lactation milk yield data collection procedure in the breeding program was conducted for twelve weeks after kidding. Due to harsh environmental conditions in the study districts, large number of the does even didn't produce milk for twelve weeks and the lactation length was calculated from lactation milk yield data (three months).

Reproductive traits like litter size at birth (LSB) and weaning (LSW), litter weights at birth (LWB) and weaning (LWW), and kidding interval were considered. Litter size at birth is the number of kids born alive or dead per doe kidding. Litter size at weaning is the number of kids present at three months per doe kidding, while their total weight denotes the litter weight at birth and three months per doe kidding.

The major fixed effects were classified into different sub-classes to quantify their effect on growth, reproductive, and milk production performance traits. The season was categorized into dry (beginning of January-end of June) and wet (beginning of July-end of December) based on the availability of browse and crop aftermath, not rain. How ever larger number of mating and births are concentrated in shorter period of time (mainly from September to December), births are sparsely distributed over the year so that incorporating season as a fixed factor in the model would be helpful to utilize variations connected to this situation. Due to the small number of does above 6th parity, it was coded into 1, 2, 3, 4, 5, and ≥6. The birth type was also included in the model and categorized into two levels (single and twin) however most of the births in Abergelle goats are single kidders but there are some cases of twinning while the numbers of triplets were almost negligible. The effect of year was grouped into 7 for birth up to six-month weights (2013-2019) and 6 for nine months and yearling weights (2013-2018).

The collected biological and survey data was edited and managed for consistency of pedigree information, correct dates of birth, kidding, weighing, disposals for the biological, and correctness for the survey part. Records with missed pedigree information and dates or those not enough for analysis either corrected when possible or discarded.

3.6. Data analysis

3.6.1. Analysis of fixed effects

For the biological data, preliminary data management and analysis were employed for screening of outliers, and a normality test was done before conducting the main data analysis to take appropriate data transformations if there were any. The generalized linear model (GLM) procedure of SAS (2009) software was used first for the overall statistical analysis of the biological data and for determining the important fixed effects that have significant effect on growth, milk production, and reproductive traits. Up to two possible interaction effects were considered for the fixed effects and there were no significant effects obtained so that not presented in the fixed effects analysis tables. Year of birth, parity, sex, birth type, and the season were considered factors for the analysis of fixed effects to develop the phenotypic trend analysis model. The least-squares means of traits was done using the Tukey HSD test for statistically significant effects based on the GLM analysis result. Fixed effects with significant ($P<0.05$) values were fitted into the model to estimate the genetic parameters.

The statistical models used for phenotypic and genetic trend analysis in this study were:

Model 1 Growth performance model

$Y_{ijklmn} = \mu + L_i + S_j + B_k + Y_l + X_m + P_n + e_{ijklmn}$

Where:

Y_{ijklmn} = the i^{th} record for location/site, j^{th} sex of the kid, k^{th} birth type, l^{th} year of birth, m^{th} season of birth, and n^{th} parity of doe

μ = overall mean

L_i = the effect of the i^{th} CBBP site (Bilaque, Saziba)

S_j = the effect of the j^{th} sex of kid (2 levels: 1= male and 2= female)

B_k = the effect of k^{th} birth type (2 levels: 1= single and 2= twin)

Y_l = the effect of l^{th} year of kidding (7 levels: 2013-2019 for BWt and SMWt traits, for the remaining traits it is 6 levels i.e up to 2018)

X_m = the effect of m^{th} season of birth (2 levels: wet and dry)

P_n = the effect of n^{th} parity of doe (6 levels: 1-5 and ≥6)

e_{ijklmn} = random error effect associated with each observation

Model 2 Milk production performance model

$Y_{ijklm} = \mu + L_i + B_j + Y_k + X_l + P_m + e_{ijklmn}$

Where

Y_{ijklm} = the i^{th} record for location/site, j^{th} birth type, k^{th} year of birth, l^{th} season of birth, and m^{th} parity of doe

μ = overall mean

L_i = the effect of the i^{th} CBBP site (Bilaque, Saziba)

B_j = the effect of the j^{th} birth type (2 levels: single and twin)

Y_k = the effect of k^{th} kidding year of the doe (6 levels: 2013-2018)

X_l = the effect of l^{th} season of kidding (2 levels: wet and dry)

P_m = the effect of m^{th} parity of doe (6 levels: 1-5 and ≥6)

e_{ijklm} = random error effect associated with each observation

Model 3 Reproductive performance model

$Y_{ijklmn} = Y_{ijklmn} = \mu + L_i + S_j + B_k + Y_l + X_m + P_n + e_{ijklmn}$

Where

$Y_{ijklmn} =$ the i^{th} records for location/site, j^{th} sex of the kid, k^{th} birth type of kid, l^{th} year of birth/kidding year, m^{th} season of birth/kidding season, and n^{th} parity of doe /parity of the animal

μ = overall mean

$L_{i=}$ the effect of the i^{th} CBBP site (Bilaque, Saziba)

S_j = the effect of the i^{th} sex of the kid (2 levels: 1= male and 2= female) for LWB and LWW

B_k = the effect of the j^{th} birth type of kid (2 levels: 1=single and 2= twin) for LBW and LWW

Y_l = the effect of k^{th} kidding year of the dam for KI (6 levels: 2013-2018)

$X_{m=}$ the effect of l^{th} kidding season for KI, LS, and LW traits

P_n = the effect of m^{th} parity of the animal itself for KI and litter size data (6 levels: 1-5 and ≥6)

e_{ijkl}= random error effect associated with each observation

3.6.2. Genetic parameters estimation

The genetic parameters for growth, milk production, and reproductive performances traits were estimated from single-trait analysis by the Restricted Maximum Likelihood method (REML), through the AI-REML algorithm (average information). WOMBAT software (Meyer, 2007) fitted animal models but after the identification of significant fixed effects from the phenotypic fixed effect, the model was employed for the genetic parameter estimation. The weight of does during kidding (doe postpartum weight) was fitted as a covariate in the genetic analysis model. The genetic trend was estimated by the weighted regression of the average breeding value of the animals on the year of birth for each targeted trait. As the pedigree data structure in this study was obtained from multiple sires, the analysis of genetic parameters was conducted from random assignment of a single buck of the paternal pedigree structure.

Additive direct heritability (h^2_a), additive maternal heritability (h^2_m), and maternal permanent environmental effects (c^2) were estimated as ratios of additive direct, additive maternal, and permanent environmental maternal variances to phenotypic variance, respectively. Genetic and phenotypic correlations were estimated from multivariate animal models. For growth performance traits, by ignoring or including additive maternal or permanent maternal environmental effects, six different models of analyses for each trait were evaluated. But, two different repeated models were used for the genetic parameter estimate of milk production and reproduction performance traits. Despite the size of recorded data were limited and structure of data (unbalanced number of dams with own records and number of kids for each doe), the covariance between direct and maternal additive genetic effects was tried to fit in the models.

The single trait animal models for growth performance (weight at different ages) traits except for yearling weight at Saziba village in matrix notation were fitted as:

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{e}$ **(Model 1)**

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{Z_2}m + \mathbf{e}$ with Cov (a, m) = 0 **(Model 2)**

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{Z_2}m + \mathbf{e}$ with Cov (a, m) = $\mathbf{A}\sigma_{am}$ **(Model 3)**

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{Z_2}c + \mathbf{e}$ **(Model 4)**

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{Z_2}m + \mathbf{Z_3}c + \mathbf{e}$ with Cov (a, m) = 0 **(Model 5)**

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{Z_2}m + \mathbf{Z_3}c + \mathbf{e}$ with Cov (a, m) = $\mathbf{A}\sigma_{am}$ **(Model 6)**

Single trait repeatability animal model for milk production and reproductive performance traits in matrix notation was fitted as:

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + Z_2pe + e$ **(Model 7)**

$\mathbf{y} = \mathbf{X}b + \mathbf{Z_1}a + \mathbf{Z_2}pe + Z_3m + e$ Cov (a, m) = 0 **(Model 8)**

Where, **y** is the vector of records/ observations; ***b, a, m,*** **c,** ***pe*** *and* ***e*** are vectors of fixed effects (fixed effects with a significant difference from the fixed effects model), additive direct genetic, maternal additive genetic, permanent environmental effects of the dam, permanent environmental effects of the animal and residual effects, respectively; **X,** $\mathbf{Z_1}$**,** $\mathbf{Z_2}$ and $\mathbf{Z_3}$ are incidence matrices that relate these effects to the records with the assumption that direct additive genetic, maternal additive genetic, maternal permanent environmental effects, and residual effects are normally distributed with mean zero. The (co)variance structure for the model was: Var (a) = $A\sigma^2_a$, Var (m) = $A\sigma^2_m$, Var(c) = I_Dc^2 and Var (ε) = I_ke^2

Where A is the numerator relationship matrix between animals; I_D and I_K are identity matrices with orders equal to the number of does and the number of kids, respectively.

Log-likelihood ratio test was performed to determine significant random effects and consequently the most appropriate model for each considered trait. An effect was considered to have a significant influence when its inclusion caused a significant increase in log-likelihood, compared with the model in which it was ignored. Significance was tested at $P<0.05$ by comparing differences in log-likelihoods to values for a chi-square distribution with degrees of freedom equal to the difference in the number of (co)variance components fitted for the two models. However, when the difference between the values of log-likelihood is not greater than a critical value of chi-square ($\chi 2$), the simplest model was considered the best model. A Chi-square distribution for $\alpha = 0.05$ and one degree of freedom was used as the critical test statistic (3.841) to compare the model which includes one random effect with two random effects. In addition, the critical value of chi-square ($\chi 2$) with two degrees of freedom (5.991) was used to compare a model which includes one random effect with a model that includes three random effects.

Maternal across year repeatability for doe performance was calculated as ($t_r = (Va + VPe)/Vp$) for models that need repeated records model like milk production, litter sizes, and kidding intervals. Total heritability (h^2_t) considering the maternal effect was estimated (Willham, 1972) as follows:

$$h^2t = (\sigma^2_a + 0.5\ \sigma^2_m + 1.5\ \sigma_{am})/\sigma^2 p$$

Where, σ^2_a = additive genetic variance

σ^2_m= maternal genetic variance σ^2_p = phenotypic variance

σ_{am} = the covariance between additive direct and maternal genetic effects.

Genetic and phenotypic correlations of important growth performance traits were calculated by fitting a multivariate animal model. The structure and number of records analyzed for growth traits of the Abergelle goat, as well as the average and coefficient of variations, are summarized in **Error! Reference source not found.** In addition, the data structure for reproductive and milk production traits are presented in Table 3.2.

Table 3.1 Data structure for growth performance traits of Abergelle goat under CBBP condition

Variables	BWT		TMWT		SMWT		NMWT		YWT		ADG1		ADG2		ADG3		ADG4	
	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz
Number of records	2105	1141	1990	982	1896	852	1418	655	1152	412	1990	982	1896	852	1418	655	1152	412
Number of sires with progenies	70	47	70	45	69	45	63	41	63	34	70	45	69	45	63	41	63	34
Number of dams with progenies	979	649	917	608	885	558	748	471	658	329	917	608	885	558	748	471	658	329
Mean	2.14	2.25	6.90	8.01	8.47	10.89	11.55	13.48	15.26	16.37	52.90	63.49	17.42	33.10	33.29	33.80	40.78	31.73
SD	0.28	0.4	1.14	1.72	1.34	2.25	1.67	1.80	2.58	2.48	12.94	17.91	9.34	20.01	14.87	21.91	26.02	21.77
Minimum	1	1	3	3.2	5	5	7	8.8	8.6	11.2	5.6	13.3	-23.3	-22.2	-17.8	-57.8	-40.0	-51.1
Maximum	3	3.4	12.2	14	17.6	18.8	24.6	19.2	28.4	23	113.3	126.7	86.7	128.9	122.2	95.6	215.6	95.6
C.V. %	12.9	10.49	16.51	16.82	15.87	17.54	14.43	12.01	16.89	13.81	24.45	25.77	53.59	59.86	44.66	52.68	63.81	60.97

Bil, Bilaque village; Saz, Saziba village; SD, standard deviation; CV, coefficient of variation; BWT, birth weight; TMWT, three-month weight; SMWT, six-month weight; NMWT, nine-month weight; YWT, yearling weight. ADG1, birth to weaning weight gain; ADG2, weaning to six-month weight gain; ADG3, six months to nine-month weight gain and ADG4, weight gain from nine-month to yearling age

3.6.3. Analysis of survey data

Focus group discussion and individual questionnaire interview data collected to assess socio-economic benefits, overall operational performances of the CBBP (sire selection and management, financial management, and income distribution) were analyzed using descriptive statistics like means and frequencies for the questionnaire interview. In addition, FGD data were directly narrated from formal and informal discussions. Statistical significance tests were used to see if there was significant variation between participants of the breeding cooperatives and non-participants as well as within members of the participant cooperatives (participant farmers widely varied in terms of flock size, consumption, and market participation during the intervening years). The variables tested were flock size, market participation opportunities (sale of goats/year), consumption of livestock products (meat, milk, and milk products), income, flock management, and other related variables. Key informant interview data collected from respective stakeholders for the assessment of institutional arrangements were analyzed by categorizing the responses into key themes and then by taking the frequency of the predefined themes.

Farmer’s perception and attitude change in the breeding program that was collected using the Likert scale was analyzed using simple descriptive statistics like central tendency and frequency distributions. Reliability and internal consistency of the scale were tested by Cronbach’s alpha test (Cronbach, 1951) using SPSS (version20) software. Indices were calculated for ranked variables using the formula Index = (5 x number of households who ranked a reason, criteria, or preference as first + 4 x number of households who ranked it as second + 3 x number of households who ranked it as third +2 x number of households who ranked it as fourth +1 x number of households who ranked it as fifth) given for an individual reason, criteria or preference divided by the sum of (5x number of household who ranked it as first + 4 x number of household who ranked it as second + 3 x number of household who ranked it as third +2 x number of household who ranked it as fourth +1 x number of household who ranked it as fifth) for all reasons, criterion or preferences.

Table 3.2 Data structure for reproductive and milk production traits of Abergelle goat under CBBP condition

Variables	**LSB**		**LSW**		**LWB**		**LWW**		**KI**		**ADMY**		**LL (Days)**		**MY90 (kg)**	
	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz	Bil	Saz
Number of records	2025	1100	1879	950	2025	1100	1879	950	1661	455	1925	981	1925	981	1925	981
Number of sires	40	30	30	26	40	30	30	26	40	20	57	48	57	48	57	48
Number of dams	340	265	335	258	340	265	335	258	300	100	927	853	927	853	927	853
Mean	1.04	1.03	0.96	0.89	2.22	2.32	10.83	11.70	363	348	342	478	80.0	64.9	30.	43
SD	0.19	0.18	0.19	0.18	0.50	0.57	1.86	2.48	51.3	65.9	76.5	115.6	9.21	19.7	7.02	10.3
Minimum	1	1	0.8	1	1	1	3.0	3.2	151	165	103.8	110.0	21	21	**7.**25	10.1
Maximum	2	2	2	2	5.95	5.4	19.3	24.6	499	501	700	961.	84	84	46.9	70.5
CV (%)	18.3	17.5	35.4	27.1	22.5	24.6	16.7	19.03	14.1	18.9	16.7	24.8	14.2	29.6	20.9	24.

SD, standard deviation; CV, coefficient of variation; BWT, birth weight; WWT, weaning weight; SMWT, six month weight; NMWT, nine month weight; YWT, yearling weight. ADG1, birth to weaning weight gain; ADG2, weaning to six month gain; ADG3, six month to nine month gain and ADG4, gain from nine month to yearling age.

4. RESULTS AND DISCUSSION

4.1. Phenotypic performances of Abergelle goats under CBBP condition

Phenotypic performance trends of the Abergelle goat breed for the major breeding objective traits during intervention years are described in the below criteria.

4.1.1. Growth performances

4.1.1.1 Weight at different age

Body weight at a specific age for Abergelle goat breed using various fixed effects in the analysis model is given in Table 4.1. The overall means of body weight at different age groups were 2.18±0.01, 7.27±0.03, 9.22±0.04, 12.16±0.04, and 15.56±0.09kg for birth, three-month, six-month, nine-month, and yearling ages, respectively.

The values for all investigated growth performance traits at all age groups in this study were lower than most of the reports of various scholars for other Ethiopian goat breeds. The values of this study were lower than the report by Netsanet et al., (2016) on Central highland Goats under traditional management conditions in the Meta-Robi district (2.68±0.04 kg birth weight, 9.42±0.19 kg three-month weights, and 15.73±0.54 kg six-month weights). It was also lower than the reports of Hulunim et al., (2019) on Bati goat (2.71 ± 0.04 kg BWT, 10.44 ± 0.18 kg TMWT and 16.31 ± 0.02 kg SMWT) and on Borana goat (2.36 ± 0.05 kg BWT, 10.34 ± 0.12 kg TMWT and 13.9 ± 0.22 kg SMWT); Hailai et al., (2016) on indigenous Begait goat (3.0+0.07kg) at birth , three months (9.75kg±0.56), six months (15.75kg±0.58) and nine months (21.12kg±0.48). But it was in line with the results of Hulunim et al., (2019) for short-eared Somali goats especially during pre-weaning ages (2.15 ± 0.08kg BWT and 8.52 ± 0.30kg TMWT); Hailai et al., (2016) for Abergelle goat at a different location for the birth weight (2.16±0.04 kg**)**. This author however reported higher values for TMWt (8.22+0.47), SMWT (11.8+0.49) and NMWT (13.98+0.54 kg) even though the sample size of his study was on 24 animals. On the other hand, the result of this study to some extent was slightly higher than the reports of Netsanet et al. (2016) for Woyto-Guji goat 2.03±0.04kg, Alubel (2015) for Abergelle goat at the same location and Tanqua Abergelle were 1.98± 0.06kg and 1.97± 0.06kg at birth and

Zeleke (2019) reported growth performance of Central highland goats managed at on-farm condition around North Wollo zone was 1.79±0.14, 6.77±0.43 and 10.6±0.60kg at birth, three month and six month weights, respectively. The values for all growth performance traits from birth to yearling weights at Saziba village was higher than Bilaque due to relatively higher rainfall distribution, availability of irrigation for small scale animal forage production and better market access at Saziba motivated farmers for better implementation of improved management practices in the breeding program.

The lower growth performances at different growth stages of the Abergelle goat in comparison to most other Ethiopian goat breeds was mainly due to the harsh environmental condition and unavailability of feed resources in the study area. Abergelle goat production environment is harsher than other areas that couldn't support the production of browsing and grazing forage crops even on smaller scales. In general, Abergelle goat breeds are mainly reared on the advantage of adaptation to extreme feed shortages and harsh environments with lower milk and meat production performances. According to Tewodros et al., (2020), the Abergelle goat and its cross with indigenous Begait had a good quality of carcass and sensory quality with adequate supplementation of concentrate feed sources. Temesgen et al. (2019) investigated the productivity indices of the Abergelle goat breed (0.34) using litter size at birth, three-month weight, survival up to weaning, number of parturition per year, and postpartum weight of doe's as a factor; was lower than Central highland (0.52) and Woyto-Guji (0.36) breeds due to harsh environments not favoring fastest onset of subsequent parturitions and perhaps not favoring faster growth of kids. It is possible to improve the production traits and then productivity at flock level by minimizing the effects of environmental sources. The relatively higher value of BWT in comparison to some other studies might be arises from the variations in sample size of studied animals and most importantly due to the positive selection trends of the current study.

Table 4.1 Least squares means (LSM±SE) of weight at different ages of Abergelle goats under CBBP condition

Source of variation		BWT (kg)		TMWT (kg)		SMWT (kg)		NMWT (kg)		YWT (kg)
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	**3244**	**2.18±0.01**	**2971**	**7.27±0.03**	**2748**	**9.22±0.04**	**2067**	**12.16±0.04**	**1562**	**15.56±0.09**
CV		**13.99**	**18.79**		**18.35**			**13.88**		**16.87**
CBBP Site		***		***		***		***		***
Bilaque	2103	2.06±0.01^{b}	1989	7.0±0.03^{b}	1896	8.56±0.08^{b}	1416	11.41±0.05^{b}	1152	14.79±0.11^{b}
Saziba	1141	2.17±0.01^{a}	982	7.85±0.05^{a}	852	10.76±0.04^{a}	651	13.56±0.07^{a}	410	16.81±0.02^{a}
Sex of kid		**		**		**		***		***
Male	1710	2.15±0.01^{a}	1575	7.49±0.04^{a}	1455	9.74±0.0^{a}	1089	12.63±0.07^{a}	789	16.06±0.15^{a}
Female	1534	2.08±0.01^{b}	1396	7.35±0.04^{b}	1293	9.57±0.05^{b}	978	12.34±0.07^{b}	773	15.53±0.15^{b}
Birth type		***		**ns**		**ns**		**Ns**		**ns**
Single	3000	2.23±0.01^{a}	2749	7.47±0.03	2554	9.69±0.04	1925	12.47±0.05	1453	15.93±0.11
Twin	244	2.00±0.02^{b}	222	7.38±0.10	194	9.63±0.15	142	12.51±0.17	109	15.67±0.38
Season		**ns**		***		***		***		***
Wet	2751	2.12±0.01	2590	7.23±0.03^{b}	2427	9.49±0.04^{b}	1850	12.96±0.05^{a}	1447	16.78±0.11^{a}
Dry	493	2.11±0.02	381	7.52±0.07^{a}	321	9.83 ±0.11^{a}	217	12.01±0.21^{b}	115	14.82±0.40^{b}
Year of birth		***		***		***		***		***
2013	513	1.95±0.02^{d}	475	7.65±0.09^{b}	442	9.89±0.11^{c}	385	11.69±0.11^{cd}	323	12.72±0.11^{d}
2014	480	1.97±0.02^{d}	444	6.80±0.05^{d}	405	8.84±0.07^{e}	269	11.92±0.12^{c}	193	15.07±0.28^{c}
2015	394	1.96±0.02^{d}	370	7.15±0.05^{c}	350	9.59±0.08^{cd}	288	11.64±0.11^{d}	507	14.75±0.27^{c}
2016	530	2.03±0.02^{c}	482	7.54±0.06^{b}	431	10.19±0.05^{b}	334	12.44±0.10 ^{b}	240	15.72±0.21^{b}
2017	704	2.23±0.01^{b}	635	8.26±0.08^{a}	577	10.40±0.08^{a}	498	12.13±0.08^{bc}	409	14.50±0.14^{c}
2018	416	2.27±0.02^{b}	364	7.46±0.06^{b}	342	9.40±0.08^{d}	283	13.43±0.11^{a}	209	19.50±0.24^{a}
2019	207	2.39±0.02^{a}	201	7.10±0.05^{cd}	201	9.30±0.08^{e}	10	14.14±0.13^{a}	-	-
Parity of dam		***		**		*		*		*
1	578	2.01±0.02^{c}	514	7.19±0.07^{b}	477	9.47±0.08^{b}	373	12.36±0.10^{b}	269	15.54±0.23^{c}
2	572	2.10±0.02^{b}	531	7.47±0.07^{a}	501	9.74±0.07^{ab}	375	12.61±0.11^{a}	281	15.62±0.24^{b}
3	539	2.10±0.02^{b}	498	7.50±0.07^{a}	459	9.63±0.08^{ab}	252	12.29±0.12^{b}	266	15.50±0.24^{b}
4	526	2.11±0.02^{b}	487	7.49±0.08^{a}	452	9.76±0.09^{a}	349	12.66±0.12^{a}	287	16.08±0.23^{b}

5	421	2.18±0.02[a]	384	7.52±0.09[a]	346	9.77[a]±0.11	269	12.54±0.14[ab]	205	15.90±0.29[b]
≥6	608	2.17±0.02[ab]	557	7.37±0.08[a]	513	9.56[ab]±0.07	349	12.46±0.12[ab]	254	16.15±0.29[a]

BWT, birth weight; TMWT, three-month weight; SMWT, six-month weight; NMWT, nine-month weight; YWT, yearling weight

***,p<0.0001; ***,p<0.01; *, p<0.05; ns, p>0.05; N, number of observation; CV, coefficient of variation; LSM, least square means

Least squares means with different superscripts within the same column and class are statistically different.

The phenotypic trend for body weight at different ages of goats is presented in Figure 4.1 and Figure 4.2 for Bilaque and Saziba villages, respectively. The phenotypic growth performance showed an undulating but positive trend at both sites except at three and six-month weights at Bilaque. Although there was a fluctuation in growth performance across the years, peak performance was observed in 2019 for BWT, 2017 for TMWT and SMWT, and 2018 for NMWT and YWT at the Bilaque site. The performances at Saziba were at peak value during 2018 for BWT, 2016 for TMWT and SMWT, and 2018 for NMWT and YWT. The peak performance in these years was probably due to relatively higher rainfall distribution during earlier stages of the breeding program (Figure 3.3) which is associated with feed availability and it could be due to the positive effect of selection at later stages.

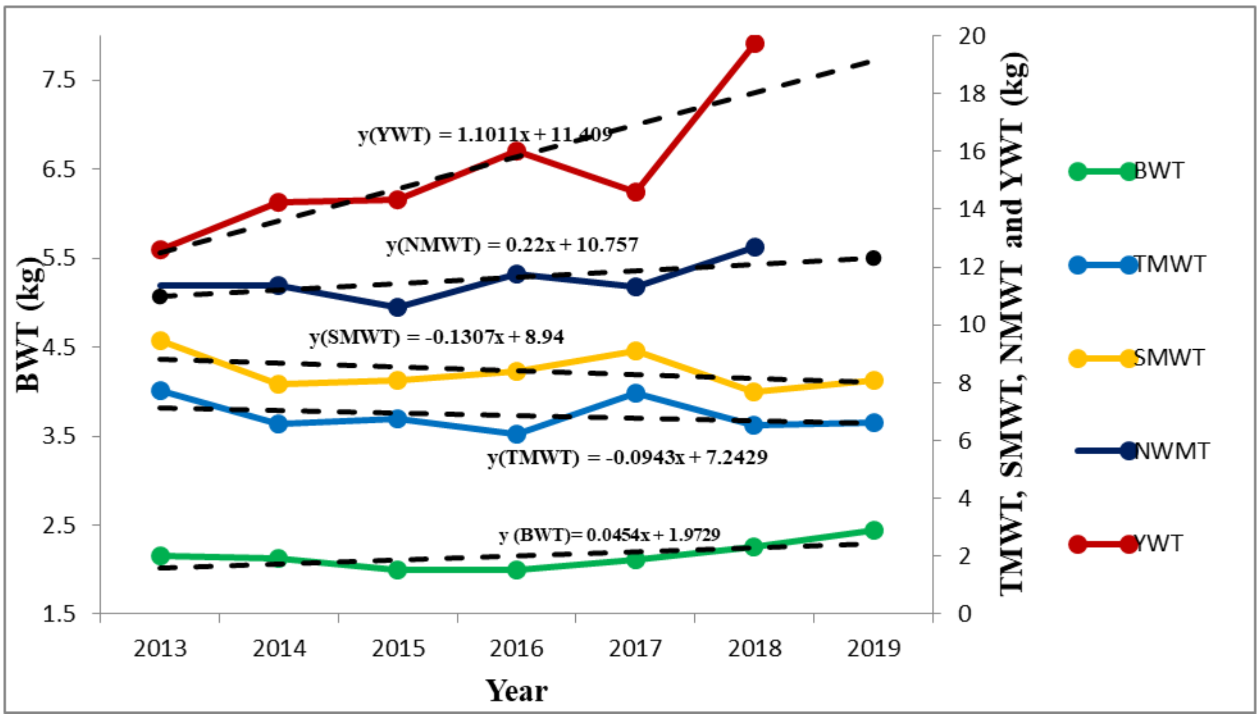


Figure 4.1 Phenotypic trends/year for growth traits of Abergelle goats under CBBP at Bilaque village

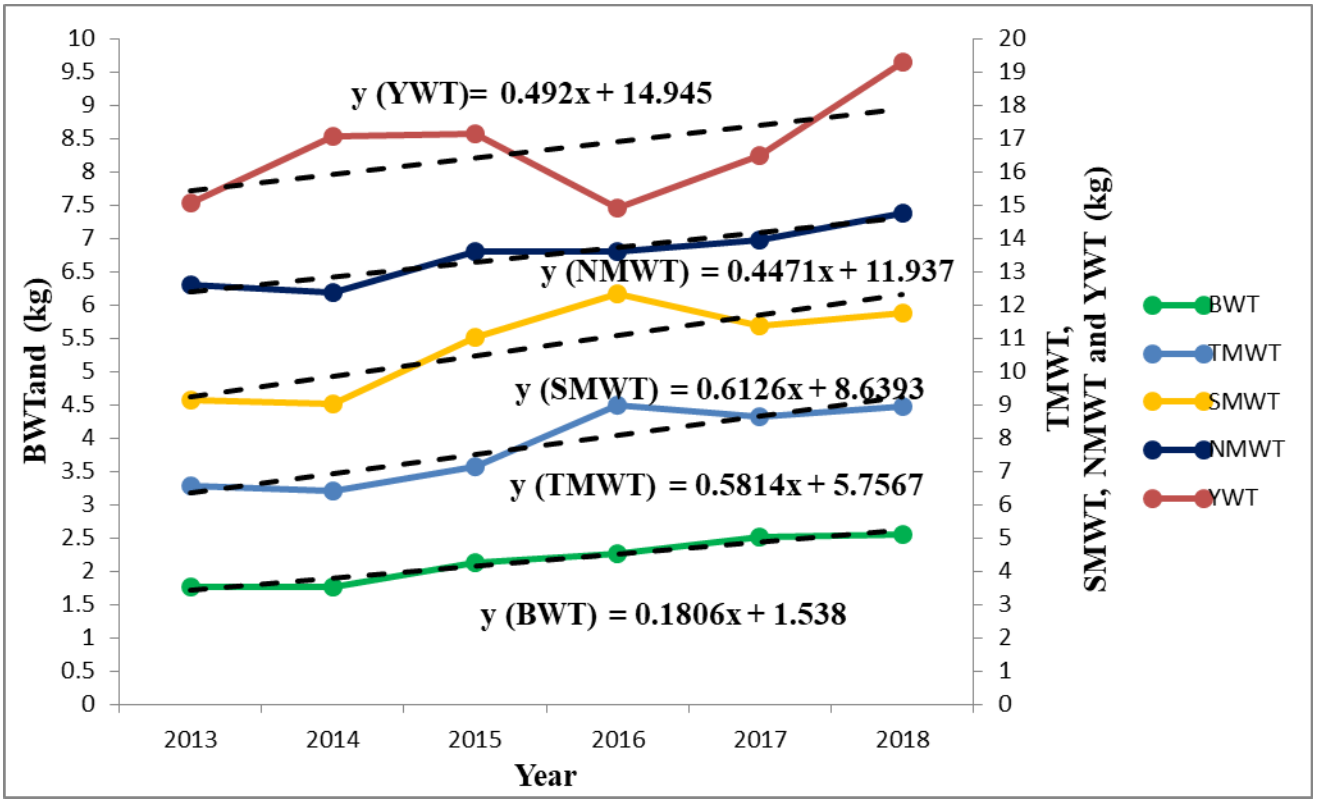


Figure 4.2 Phenotypic trends/year for growth traits of Abergelle goats under CBBP at Saziba village

Different genetic and non-genetic factors affect the growth performance of individuals at different stages of their development. Growth in animals is a function of genetic potential, hormones, nutrition, and other environmental factors. Environmental factors have the potential to complicate and mask actual breeding values in the selection process of superior animals and proper identification of these factors would help to eliminate biases caused by them so that a more accurate estimation of breeding values would be possible.

Unsurprisingly, sex had a significant ($p<0.001$) influence at all stages of growth, and the effect advances with post-weaning stages. Males are most importantly heavier than females at most of the growth stages. Various similar studies reported in the literature (Hailu et al., 2008; Sodiq, 2012; Zeleke et al, 2017; Never, 2020) confirmed the significant influence of this factor on weight at different ages in different breeds. The contribution of sex variation in influencing growth performance traits in this study (1.87% at birth to 4.3% during yearling weight) was lower in comparison to the result of (Hailu et al., 2008) who reported the effect of sex reached 10.8% to 20.4% weight difference at weaning and 18 months of age in Arsi-Bale goats, respectively. However no significant sex influence was reported in West African Dwarf goats in Ghana by (Ofori & Hagan, 2020), males grew relatively faster than their female counterparts. The growth superiority of male kids over female counterparts might be due to variations in androgen hormone, sexual chromosomes in the position of growth-related genes, endocrinal system differences, and the production of estrogen hormone in females affect the growth of long bones that restrict growth and development (Nkungu et al., 1995; Baneh & Hafezian, 2009).

The birth type had a significant ($p<0.001$) effect during pre-weaning growth stages (BWT and TMWT) but it didn't vary during post-weaning growth periods up to yearling weight at both study sites. Single-born kids were slightly heavier than twins at all stages of their growth even though the variation was not significant ($p>0.05$) except BWT. It has consistent significant influence at different stages of growth up to yearling weight in various similar studies (Hailu et al., 2008; Belay and Mengistie, 2013; Zeleke, 2019) unlike the results of this study. Higher body weight at different ages of single-born kids over multiple births might be linked with a better intrauterine environment which avoids competition and provides more space for singletons than twin births. In addition, increased litter size would possibly result in a decreased number of contact points between the embryo and the uterus probably creating nutrient competition and thereby lowering the weight of the fetus. The lower to non-significant difference in birth type during post-weaning growth stages in this study might be linked with the higher variations in observations (244 vs 3000 for twin and single born kids, respectively) and possibly due to critical feed resource scarcity and drought in the study area which couldn't support variation in growth performances of individuals at latter stages of growth.

Year of birth had a higher significant ($p<0.001$) influence on the bodyweight of goats at different ages (Table 4.1). Kids born in 2018 had higher NMWT and YWT than kids born in other years. On the other hand, kids born in 2018 and 2019 were lighter than kids born in other years for SMWT and TMWT respectively. In addition, BWT was at peak performance during 2019 than in other years of birth. The BWt and TMWt of kids at Bilaque and TMWt and NMWt at Saziba site were not significantly affected by season ($p>0.05$) CBBP site. It was significantly ($p<0.001$) affected six months to yearling weights at Bilaque and at birth, six months and nine-month weights at Saziba site. The effect of season was greater during post-weaning growth periods in this study. Different other scholars (Hailu et al., 2008; Belay et al., 2015; Zeleke, 2019; Never, 2020) reported the influence of the year of kidding and kidding season on weight at different ages of various goat breeds. Most of the kids (87%) were born during relatively higher feed resource available season (October- December) in the Abergelle goat breed and this condition might contribute to statistically non-significant difference of birth to three-month weights in this study. In general, performance variations occurring by year and season of kidding could be linked with climatic variability and inconsistent management of animals.

Parity was another important non-genetic factor that possibly affected the growth performance of kids in different age groups. It was found in this study that parity had a pronounced effect ($p<0.001$) on weight at different ages except six months weight in Bilaque and nine-month and yearling weights at Saziba site. Birth weight and yearling weight consistently increased for kids born from 2^{nd} to 6^{th} parity does' at both sites. Most of the peak growth performances of kids were recorded from 3^{rd} to 4^{th} parity dams in the current study. It was in agreement with the result reported by (Bemji et al., 2006) on West African Dwarf and (Hagos et al., 2019) on Begait goat breeds. The possible reason for increased growth performances of kids from medium parity does as described in (Bemji et al., 2006; Sodiq, 2012) that live-weight of does increase significantly with the parity that could be reflected on the birth weights of their kids, and the development of the physiological processes increases as parity of the dam advances.

4.1.1.2. Weight gain (growth rate) of Abergelle goats

The least-squares mean with its respective standard errors for investigated growth rate for different age groups is presented in Table 4.2. The average daily weight gains of kids in this study showed decreasing trend as the age advances. Specifically, ADG was sharply declined (44.3%) at six months weight compared with a pre-weaning growth rate up to three months and showed little improvements at the rest of subsequent ages. Except for the smaller values of average daily weight gains, the result of this study was in agreement with reports by Hulunim et al.(2019) and Zeleke (2019) concerning the pattern of growth rates in different age groups. The lower weight gain of kids during the post-weaning growth stages (ADG2-ADG4) than in the pre-weaning period was straightforward and associated with its dependency only on the genetic potential of individuals and some other environmental influences, unlike the pre-weaning weight gain as it depends on the maternal performances like good mothering ability and higher milk production in addition to direct additive effects.

The average daily weight gain of kids at all growth stages was significantly higher ($p<0.001$) at Saziba village than in Bilaque except for ADG4 which did not differ ($p>0.05$) in the two villages. The higher value recorded at Saziba was due to the relatively better feed availability which permitted better growth of kids. Sex of kids did not affect ($p > 0.05$) the total daily weight gain of animals up to ADG3 but it was significantly higher in males at ADG4. Hulunim et al (2019) reported the non-significant effect of sex on the average daily weight gain of Borena and Short-eared Somali goats up to ADG3. Moreover, Netsanet (2016) and Zeleke (2019) also reported similar results concerning the non-significant influence of sex on average daily weight gains for different indigenous and crossbred goat breeds. This could probably due to compensatory growth and forceful adaptation to the environment for multiple born kids. In contrast, Zeleke et al. (2017) reported the considerable effect of sex on the average daily weight gain of Central highland X Boar goat breeds.

The influence of birth type on the average daily weight gain of animals in this study was not statistically significant ($p>0.05$) across all growth stages except for numerical differences in favor of higher daily weight gain for singletons. Hulunim et al. (2019) reported parallel results with this study on the average daily weight gain not affected by birth type in different age groups, but (Zeleke, 2019) described the average daily weight gain of kids as influenced by the birth type and multiple born kids were heavier than the single born counterparts during the post-weaning periods. Significant ($p < 0.05$) parity effect was observed in this study concerning kids' daily weight gain for ADG1 and ADG3 but it was not significant ($p>0.05$) for ADG2 and ADG4 with the exception of numerical superiority for larger parity does. Even though the increment of daily weight gain in the advancement of parity at different ages was inconsistent, in most cases, kids at 2^{nd}, 3^{rd}, $4^{th,}$ and 5^{th} parity had better daily weight gain than others. The result of this study had concurred with the reports of (Hulunim et al., 2019) on Bati, Borena, and Short-eared Somali goat types of Ethiopia.

Year of kidding substantially influenced ($p<0.0001$) the average daily weight gains of kids at all growth stages. Peak average daily weight gain performance was recorded in 2017 for ADG1, 2018 for ADG3 and ADG4, and 2016 for ADG2. Season of birth had also a pronounced effect on ADG1, ADG3, and ADG4 but did not influence ADG2. Kids born during the dry season showed superior average daily weight gain to those born in the wet season at the pre-weaning growth stage. But in the other subsequent growth stages, kids born during the wet season were superior in average daily weight gain performance to those born during the dry season. The significantly higher value of dry season-born kids over their wet season-born counterparts was in argument with various reports (Netsanet et al, 2016; Hulunim et al., 2019; Zeleke, 2019).

Table 4.2 Least square means (LSM±SE) of growth rates (average daily weight gains) of Abergelle goats under CBBP condition

Source of variation	ADG1 (g/day)		ADG2 (g/day)		ADG3 (g/day)		ADG4 (g/day)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	**2865**	**55.93±0.30**	**2666**	**21.59±0.29**	**2008**	**32.67±0.43**	**1976**	**39.48±0.90**
CV		**25.77**		**59.86**		**52.68**		**60.97**
CBBP Site		*******		*******		******		**ns**
Bilaque	1969	54.86±0.31[b]	1878	18.00±0.21[b]	1402	30.55±0.48[b]	1139	34.61±0.90
Saziba	896	63.49±0.60[a]	788	33.10±0.71[a]	606	33.80±0.89[a]	380	31.73±1.12
Sex of kid		**ns**		**ns**		**ns**		*****
Male	1517	59.44±0.40	1416	25.66±0.40	1060	32.68±0.61	767	34.51±1.06[a]
Female	1348	58.91±0.44	1250	25.43±0.42	948	31.68±0.60	752	31.83±1.01[b]
Birth type		**ns**		**ns**		**ns**		**ns**
Single	2652	58.49±0.31	2481	24.83±0.30	1872	31.53±0.44	1415	33.34±0.75
Twin	213	59.86±0.18	185	26.26±0.97	136	32.84±1.78	104	32.99±3.30
Season of birth		*******		**ns**		*******		*******
Wet	2505	56.64±0.89[b]	2366	25.92±0.31	1804	38.34±0.45[a]	1411	39.85±0.77[a]
Dry	360	61.72±0.34[a]	300	25.17±1.85	204	26.02±1.39[b]	108	26.48±1.86[b]
Year of birth		*******		*******		*******		*******
2013	462	62.57±0.78[b]	437	25.20±0.61[cd]	385	21.96±0.89[d]	324	13.40±1.03[d]
2014	443	53.87±0.63[ef]	400	23.45±0.59[e]	257	33.95±1.25[b]	187	26.69±1.72[c]
2015	364	58.09±0.55[cd]	340	28.00±1.23[ab]	281	26.54±0.86[cd]	175	33.27±1.56[bc]
2016	432	60.61±0.94[bc]	389	31.26±0.75[a]	309	30.75±0.93[bc]	232	35.92±1.75[b]
2017	595	67.09±0.58[a]	554	24.31±0.63[bc]	479	21.12±0.81[d]	396	25.81±1.33[c]
2018	330	57.87±0.91[de]	310	21.40±0.60[e]	257	46.89±1.11[a]	205	60.91±2.22[a]
2019	239	54.04±0.84[f]	236	25.22±0.72d[e]	40	44.06±3.82[b]	-	-
Parity of dam		******		**ns**		*****		**ns**
1	498	57.79±66[b]	466	26.48±0.71	364	32.85±0.91[b]	264	33.25±1.63
2	512	59.89±0.73[a]	486	25.85±0.68	363	32.55±1.01[b]	271	30.20±1.59
3	477	60.19±0.70[a]	446	24.51±0.51	340	30.45±1.03[b]	260	33.31±1.77

4	480	60.17±0.79[a]	441	25.91±0.74	343	31.90±1.05[b]	279	33.35±1.72
5	367	59.47±0.86[a]	332	25.12±0.73	262	31.81±1.12[b]	202	33.21±2.00
≥6	531	57.55±0.65[ab]	495	25.41±0.70	336	33.53±1.11[a]	243	35.68±2.08

LSM, least-square means; SE, standard error; ADG's, average daily weight gain at different age groups

*Ns, P>0.05; ***, P<0.001; **, P<0.01; *, P<0.05; N, number of observations*

The least-squares mean with different superscripts within the same column and class are statistically different

4.1.2. Reproductive performances

The kidding patterns of the Abergelle goat from the year 2013 to 2019 are presented in Figure 4.3. It was revealed in this study that kidding season was concentrated in the months with relatively better feed availability (October- December in the context of study areas) and more than 72% of kidding was recorded in these months. From these peak kidding months, 56% of kidding occurred only in December. This result was in argument with reports of (Netsanet et al, 2016) and (Zeleke, 2019) on Woyto-Guji goats around the Konso area and Central highland goats around North Wollo, respectively. These authors reported most of the kidding seasons of the described breeds of goats was from May to July. The most probable single factor for this variation in the kidding season was related to the first onset of rainfall in the Waghimra zone starts in June and the peak mating months occurred during July and early August.

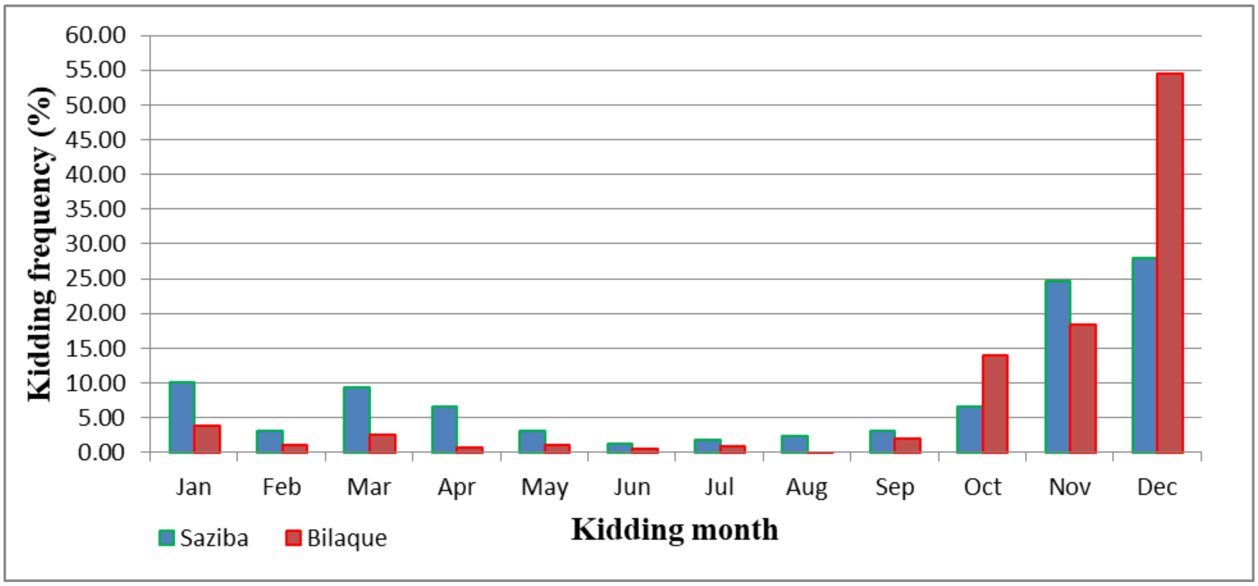


Figure 4.3 Distribution of kidding in Abergelle goat under CBBP condition

The least-squares mean and standard error for reproductive traits in Abergelle goat are presented in Table 4.3. The overall mean of LSB, LSW, LWB, LWW, and KI were 1.04±0.00 kids, 0.99±0.01 kid, 3.18±0.01kg, 11.24±0.04kg, and 356.05±1.68 days, respectively. In the present study, it was investigated that the twinning rate was very minimal (3.58%) in the intervened population. It was also recorded that during seven intervention years, 8 triple births (0.26%) occurred only in 2018 due to mass estrus synchronization and artificial insemination activities. Around 96% of Abergelle goat breed in the study areas thus was single bearers.

Litter size at weaning showed a 5% decline from litter size at birth and this reduction could be explained by the post-natal death of kids from different infectious and nutritional diseases and parasites.

Litter sizes at birth and weaning are considered an indicator of the fitness and adaptability capacity of the animals to their environmental conditions. The litter sizes at birth and weaning observed in this study was lower than many reports on indigenous and exotic breeds like 1.6 and 1.37 for Arsi-Bale goat breed (Hailu et al., 2008; Tesfaye et al., 2012), 1.4 for Central highland goat with their cross at North Shewa (Amine et al., 2019), 1.55 for Central highland goat with their cross at North Wollo areas (Zeleke, 2019), 1.74 for Saanen goat breed (Kasap et al., 2013) and 1.3 for Markhoz goats in Iran (Rashidi et al., 2011) while it was 0.67 and 1.2 for CHG with their cross in North Wollo and Markhoz goats in Iran for the litter size at weaning. Litter size at birth was in line with the report of the previous study in the same breed (Belay and Mengstie, 2014), but litter size at weaning was higher than Central highland goat with their cross at North Shewa around the Ataye area (0.65) reported by (Amine et al., 2019). The possible reason for such variations in litter sizes at birth and weaning age of different goat breeds could be environment, management, and genetic variations.

Litter weights at birth and weaning are important reproductive traits of does which reflect the capacity of the dam to produce higher kid weight at birth and it is a combined effect of litter size, pre-weaning growth rate, and pre-weaning survival of kids for the latter trait. Litter weight at birth found in this study was lower than most of the reports of other scholars. On the other hand, litter weight at weaning results reported by Temesgen et al., (2020) was significantly lower (7.6±1.5) on the same breed and Woyto-Guji goat breed. The LWW obtained in this study was also slightly higher than the reports by Tesfaye et al., (2012) and Amine et al., (2019). The variations in these findings might be explained by the smaller sample size of animals, the study was conducted at an earlier stage of the breeding program, and the only weight of single-born kids was considered in the Abergelle goat by Temesgen et al., (2020). In addition, lower pre-weaning survival of kids (84.51%, 76.3%, and 53.57%) for Arsi-Bale, Abergelle, and Central highland goats, respectively inevitably magnify the relatively higher LWW in the current study.

Available evidence from a literature review by (Dereje et al., 2015) shows that indigenous African goats have subsequent births at about in the range of 240 to 365 days with fewer exceptions that extended to 420 days due to environmental and management variations leading to controlled breeding to achieve the best breeding season and synchronization of birth for research purpose. The kidding interval observed in this study is longer than Arsi- Bale goats reported by Tesfaye et al., (2012) who described 280±13.7 days, Abergelle goat breed managed under an extensive system in mid-altitude areas reported as 289±17.3 days by Belay and Mengstie (2014) and it is in line with Shumuye et al., (2014) report for the same breed with different location and year. The variation in kidding interval might be explained by the difference in sample size, genetics, management level, and the use of controlled breeding for specific purposes. It is possible to shorten the kidding interval of does through optimum feeding and culling of inferior dams.

Except for LSB, all other reproductive traits investigated in the present study (LSW, LWB, LWW, and KI) were significantly influenced ($p<0.001$) by location. The goats at Saziba village had relatively higher litter sizes at weaning, litter weight at birth and weaning, and with shorter kidding intervals than at the Bilaque site. This variation in the two villages might be explained by the relatively better feed resource availability in the Abergelle district favored greater productive and reproductive performances of goats compared to Ziquala as these traits are dependent on environmental factors such as nutrition than genetics. The result of this study agreed with (Arati Johi et al., (2018) who described the reproductive efficiency of goats are influenced by altitude, better nutrition, and light conditions in Nepal. Sex was also another important factor influencing litter weights at birth and weaning as it was justified in the growth performance part.

Table 4.3 Least square means (LSM±SE) for reproductive traits of Abergelle goats under CBBP condition

Source of variation	LSB		LSW		LWB (Kg)		LWW (Kg)		KI (days)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	3125	1.04±0.00	2829	0.99±0.01	3125	3.18±0.01	2829	11.24±0.04	1114	356.05±1.68
CV		17.69		27.14		14.17		19.03		14.70
CBBP Site		**ns**		***		**		***		***
Bilaque	2025	1.05±0.00	1879	0.96±0.01[b]	2025	3.13±0.01[b]	1879	10.83±0.04[b]	858	363.94±1.75[b]
Saziba	1100	1.04±0.00	950	0.89±0.01[a]	1100	3.22±0.01[a]	950	11.70±0.08[a]	256	348.16±4.12[a]
Sex of kid		**ns**		**ns**		***		**		**ns**
Male	1652	-	1511	-	1652	3.21±0.01[a]	1511	11.34±0.06[a]	576	-
Female	1473	-	1318	-	1473	3.14±0.01[b]	1318	11.19±0.09[b]	538	-
Birth Type				**ns**				***		**ns**
Single	3013	-	2616	0.98±0.01	3013	2.22±0.01[b]	2729	7.47±0.03[b]	981	357.22±1.75
Twin	112	-	213	0.99±0.02	112	4.13±0.06[a]	100	15.06±0.3[a]	133	354.88±5.47
Season of birth		**		**		*		***		**ns**
Wet	2661	1.03±0.01[b]	2489	1.01±0.01[a]	2661	3.17±0.03[b]	2489	11.08±0.14[b]	935	357.47±1.71
Dry	464	1.06±0.01[a]	340	0.95±0.1[b]	464	3.18±0.01[a]	340	11.45±0.04[a]	179	354.63±5.38
Year of birth		***		***		***		***		***
2013	506	1.03±0.01[b]	466	0.94±0.01[b]	506	3.02±0.02[c]	466	11.49±0.09[c]	-	-
2014	468	1.03±0.01[b]	438	0.97±0.01[b]	468	3.03±0.02[c]	438	10.63±0.07[d]	220	358.89±3.84[bc]
2015	386	1.03±0.01[b]	365	0.95±0.01[b]	386	3.03±0.02[c]	365	10.99±0.06[d]	150	348.62±3.73[b]
2016	501	1.05±0.01[ab]	464	1.00±0.01[ab]	501	3.09±0.02[b]	464	11.36±0.13[bc]	216	343.75±3.42[b]
2017	663	1.07±0.01[a]	603	1.01±0.01[a]	663	3.30±0.02[a]	603	12.13±0.09[a]	249	331.26±3.86[a]
2018	343	1.07±0.01[a]	332	1.03±0.02[a]	343	3.34±0.03[a]	332	11.35±0.13[b]	192	376.21±3.97[c]
2019	258	1.03±0.01[a]	161	1.01±0.02[a]	258	3.43±0.03[a]	161	10.91±0.10[d]	87	377.56±3.01[c]

Parity of dam		***		***		***		***		**ns**
1	573	1.01±0.003[b]	504	0.95±0.01[b]	573	3.07±0.02[d]	504	11.02±0.07[c]	-	-
2	561	1.02±0.01[b]	515	0.97±0.01[b]	561	3.16±0.02[c]	515	11.31±0.09[ab]	202	363.02±3.76
3	528	1.02±0.01[b]	451	0.96±0.01[b]	528	3.16±0.02[c]	451	11.34±0.08[ab]	215	353.50±3.63
4	501	1.06±0.01[a]	461	1.01±0.01[a]	501	3.16±0.02[c]	461	11.32±0.10[ab]	193	358.63±4.00
5	402	1.06±0.01[a]	360	1.00±0.02[a]	402	3.25±0.03[a]	360	11.39±0.13[a]	195	354.51±4.07
≥6	560	1.08±0.01[a]	507	1.02±0.01[a]	560	3.24±0.03[b]	507	11.21±0.12[b]	309	350.59±3.34

LSB, litter size at birth; LSW, litter size at weaning age; LSB, litter weight at birth; LWW, litter weight at weaning; KI, kidding interval
****,p<0.0001; ***,p<0.01; *, p<0.05; ns, p>0.05; N, number of observation; CV, coefficient of variation; LSM, least-square means; SE, standard error*
The Least-squares mean with different superscripts within the same column and class are statistically different

The birth type had a significant effect ($p<0.001$) on LWB and LWW but it had not influenced LSW. It was found in this study that litter weights at birth and weaning were higher among multiple birth kids than single-born counterparts which were in agreement with the reports described elsewhere (Hailu et al., 2008; Tesfaye et al. 2012; Amine et al., 2019; Zeleke, 2019). It is quite clear that as the litter size increases, the total weight of litter also substantially increases, but the weight of individual kids may not be improved. It is also clear that the litter size at birth and weaning are directly correlated with litter weights at respective ages.

Year of kidding exerted a significant influence ($p<0.001$) on LSB, LSW, LWB, LWW, and KI. Litter sizes at birth and weaning were in peak performance during 2017 and 2018 while the lower performances were recorded in 2013 and 2014. Litter weight at birth showed consistent improvement across intervention years and a higher value was obtained in 2019. On litter weight at weaning, the higher value was recorded in 2017 but the lower value was in 2014. The kidding interval of does was shortened substantially up to 2017 but showed raise during the last consecutive years (2018-2019). This situation is linked to the smaller number of records investigated and fluctuation in feed availability in the last two years. Similar results were reported by Tesfaye et al., (2012) and Zeleke, (2019) on the variation of reproductive traits across years. In addition, (Hailu et al., 2008) reported significant variability of kidding interval in Arsi-Bale goat as it linked with the nutrition level of animals at a specific period. Season of kidding had considerable influence ($p<0.001$) on most of the reproductive traits like litter sizes and weight at birth and weaning ages except for kidding interval. It was noted in the current study that does which gave birth during the lower feed available season (January-June) had greater litter size at weaning, litter weights at birth and weaning, and shorter kidding intervals than those kidded during another season. Does that have better nutrition during their pregnancy period would have resulted in higher litter size and weight with the possible shorter time of next kidding. Does that have previous kidding during higher feed available season (October-December in the context of this study) had longer kidding interval than those that had in other months of the year which was in agreement with the previous report on the same breed (Belay and Mengstie, 2014).

The effect of parity was significant ($p<0001$) on LSB, LSW, LBW, and LWW but it had not to effect on kidding interval. In general, the reproductive efficiency of dams' increased with their parity, and dams from 3rd - 6th parity had the highest litter size and weight than those with lower parities. Similar other studies (Tesfaye et al., 2012; Zeleke, 2019) reported as dams get older, their chance to produce higher litter also increases. For lower parity does, nutrition demand for itself and for the fetus would have created competition that could not supported to reach higher body weights of dams. Parajuli et al. (2015) and Sharma et al. (2017) reported a non-significant effect of parity on the kidding interval of does in Nepal which was in agreement with this study while Tesfaye Kebede et al. (2012) reported that parity was significantly affected kidding interval of Arsi-Bale goats where the kidding interval shortened with increased parity. The kidding intervals of does are more likely affected by the plane of nutrition than their age/parity.

4.1.3. Milk production performances

The least-squares means with its standard error for ADMY, LL, and MY90D of Abergelle goats managed under CBBP condition is presented in Table 4.4. The overall means found in this study for ADMY, LL, and MY90D were 410 ±2.11 ml, 72.44±28 days, and 36.92±0.19 liters, respectively. The average daily milk yield obtained in this study was higher than the result reported by Mohammed et al. (2012) for Arsi-Bale goats (209 ± 10.7 g), Alubel (2015) for Abergelle goats (346.36 ±10.08 g), Minister (2018) for Abergelle goats (309.0 ±8.40 g), Temesgen et al.(2020) for the same breed (367.10 ±139.78 g), Zeleke et al. (2020) for Central highland goat with its F1 cross around North Wollo (340.0±20.0 g) while it was lower than that reported by Hagos et al. (2017) for Begait goats (610±10.1 g). The greater ADMY value investigated in the current study in comparison to the previous studies for the same breed might be explained by the variations in the year of evaluation as the other scholars reported this value during the beginning two or three years of the breeding program, and currently the overall phenotypic and genetic trends of the program are changing each year. In addition, the effect of genetic improvement program and associated management variations are also the reasons for the higher values.

Table 4.4 Least square means (LSM±SE) for milk production traits of Abergelle goats affected by some non-genetic factors under CBBP condition

Source of variation	ADMY(g)		LL(days)		MY90D (kg)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	2906	410.63±2.11	2906	72.44±28	2906	36.92±0.19
CV		22.38		16.39		21.55
CBBP Site		***		***		***
Bilaque	1925	342.80±1.79[b]	1925	80.01±0.21[a]	1925	30.86±0.16[b]
Saziba	981	478.49±3.69[a]	981	64.89±0.63[b]	981	42.98±0.33[a]
Sex of kid		**ns**		**ns**		**ns**
Male	1526	409.73±2.89	1526	72.31±0.35	1526	36.84±0.26
Female	1380	411.57±3.09	1380	72.52±0.42	1380	37.00±0.28
Birth type		**ns**		**ns**		**ns**
Single	2695	409.97±2.21	2695	72.73±0.28	2695	36.82±0.20
Twin	211	411.32±7.19	211	72.17±0.98	211	36.99±0.64
Season of birth		*		***		*
Wet	2540	416.45±2.23[a]	2540	74.48±0.28	2540	37.45±0.60[a]
Dry	366	404.84±6.66[b]	366	70.42±1.05	366	36.40±0.20[b]
Year of birth		***		***		***
2013	454	356.57±6.47[d]	454	72.17±0.70[bc]	454	32.08±0.18[d]
2014	443	357.12±5.42[d]	443	69.51±0.77[d]	443	32.13±0.48[d]
2015	367	413.61±4.53[c]	367	72.87±0.77[cd]	367	37.19±0.40[c]
2016	495	412.33±4.57[c]	495	73.29±0.70[bc]	495	37.07±0.41[c]
2017	588	437.21±4.49[b]	588	69.86±0.70[e]	588	39.29±0.40[b]
2018	369	438.21±4.21[b]	369	75.32±0.63[a]	369	39.39±0.38[b]
2019	190	459.47±2.97[a]	190	74.06±0.28[ab]	190	41.29±0.27[a]
Parity of dam		***		**		***
1	497	389.56±5.07[d]	497	71.19±0.70[b]	497	35.06±0.45[c]
2	521	414.10±5.01[b]	521	71.47±0.70[ab]	521	37.23±0.45[b]
3	496	412.80±4.86[b]	496	73.43±0.70[a]	496	37.12±0.43[b]
4	477	403.36±5.61[c]	477	73.92±0.70[a]	477	36.27±0.50[b]
5	375	415.49±5.81[b]	375	73.22±0.70[a]	375	37.36±0.52[b]
≥6	450	428.27±4.52[a]	450	71.40±0.70[ab]	450	38.50±0.40[a]

ADMY, average daily milk yield; LL, lactation length; MY90D, ninety-day milk yield

***, p<0.0001; **, p<0.01; *, p<0.05; ns, p>0.05; N, number of observation

The Least-squares mean with different superscripts within the same column and class are statistically different

However, the LL in goats widely varied among breeds (35 days for Mid-rift valley goats in Ethiopia to 305 days for Anglo-Nubian breed) reported in a review paper by Dereje et al. (2015) and Ferro et al., (2017). The result obtained in this study was in agreement with some of the

Ethiopian goat breeds. Longer lactation lengths in contrast to the current study were reported by (Mohammed et al., 2012; Hagos et al., 2017; Zeleke et al., 2020) for different Ethiopian goat breeds. The 90-day milk yield, which literally means the total lactation milk yield in this study, was lower than the values reported by various scholars (Hagos et al., 2017; Zeleke et al., 2020) but higher than (Mohammed et al., 2012). The observed variations among different reports on milk production traits could be explained by differences in the genetic makeup of the breed, variability in management systems, and variations in data collection and evaluation procedures.

The average daily milk yield, lactation length, and ninety-day milk yield was significantly influenced ($p<0.0001$) by the location where these values are most importantly higher at Saziba village (ADMY and MY90D) than the Bilaque one. The lactation length was higher at Bilaque village even though there is no scientific justification for this variation except the accuracy of data collection were more extensive and strict at Bilaque than at Saziba village. Higher values of milk production traits at Saziba village is obvious and described elsewhere in the document for other growth performance and reproductive traits due to relatively better feed availability and access of irrigation for forage development at Saziba. Significant variations of milk production traits by location were reported by (Ferro et al., 2017) because milk production traits are significantly affected by the level of nutrition and other environmental characteristics. Samson and Olajumoke (2017) clearly described that milk productivity in goats mainly depends on the quality and quantity of feedstuffs and approaches targeting milk production improvement should first address the issue of nutrition.

Year and season of birth exerted a significant effect ($p<0.05$) on ADMY, LL and MY90D. These traits were significantly improved across different years and the higher values were recorded in 2018 and 2019 whereas lower values were obtained in 2013 and 2014. Higher daily and 90-day milk yield production and a longer lactation length period were found during the wet season than the other. Similar other reports confirmed the effect of year and season of kidding on milk production performance of does (Mustapha et al., 2015; Temesgen et al., 2020; Zeleke et al., 2020). The higher milk yield and longer lactation length during the wet season might be explained by the availability of better livestock feed resources than during the drier season.

The parity of does at kidding had a pronounced influence ($p<0.001$) on all studied milk production traits in the current study. The greater values of ADMY and MY90D were attained in later parity dams (4^{th} -6^{th} parity) than the earlier parity counterparts. (Mustapha et al., 2015 and Hagos et al., 2017) reported significant effect of parity on milk production traits in does while (Mohammed et al., 2012 and Zeleke et al, 2020) documented its non-significant influence on milk traits. In general, (Samson and Olajumoke, 2017) described milk yield increases with age because the hormonal status of the animal body, metabolic activity, secretory cells, and nutrient intake of the doe that are important for milk synthesis increases with its age. The authors also outlined that the significant effect of age and parity on milk traits suggest milk production tends to increase with parity probably due to increase in the accumulation of mammary alveoli from previous lactation until the process gets interrupted by advances in age.

The phenotypic trend for milk production traits of Abergelle goats managed under CBBP condition is presented in Figure 4.4. Except for a little decline in lactation length in 2017, all other traits showed a positive trend. This could be explained by the effect of selection on improving milk productivity was going in the right direction even though it is possible even to improve these traits beyond the current result through dam line selection.

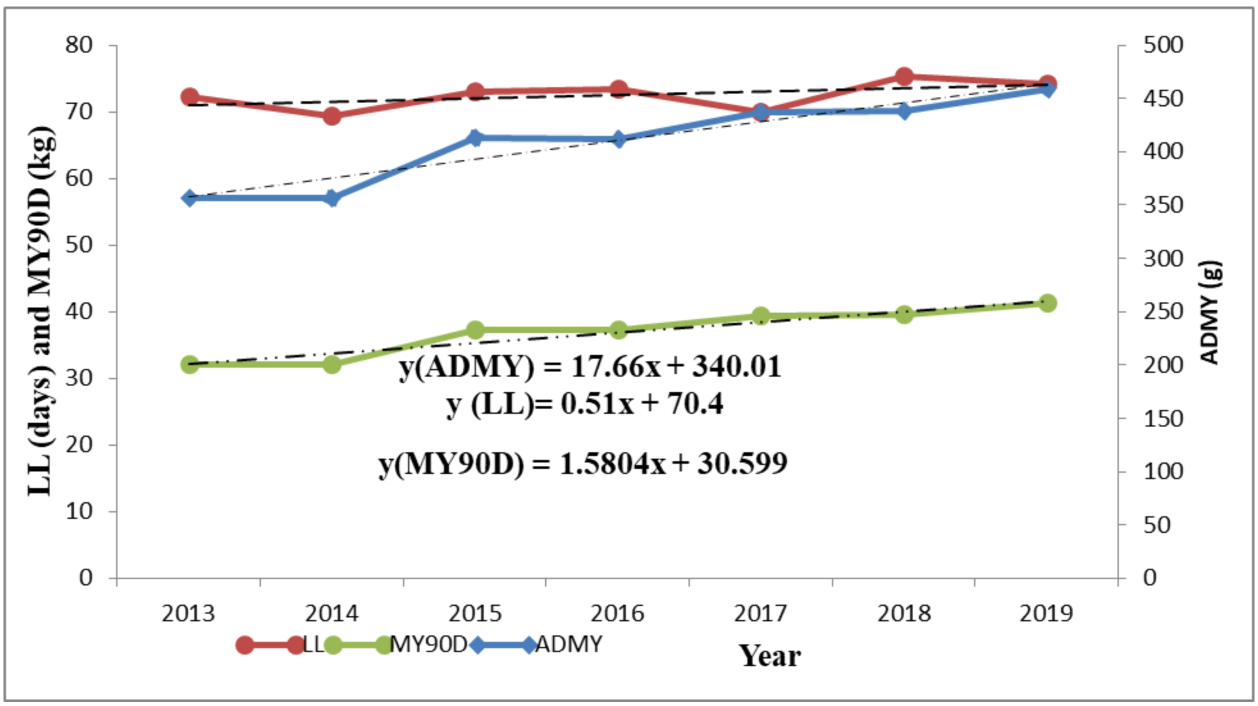


Figure 4.4 Phenotypic trends of milk production traits in Abergelle goat under CBBP condition

4.2. Genetic parameters estimation for Abergelle goat breed in the CBBP

4.2.1. Heritability estimates for growth performance traits

Variance components and genetic parameters estimated by the AI-REML procedure of Wombat software using univariate analysis for the body weights of Abergelle goats at different ages are presented in Table 4.5. From the six models, the best appropriate model of estimation identified by its likelihood ratio test value for a specific trait appears in boldface in the table. The direct additive heritability shows an increasing trend at consecutive growth stages starting from birth to yearling age which differed from the reports of Gowane et al., (2011) and Zeleke, (2019) who reported the declining trend up to six months and then increasing up to yearling age, but it was in agreement with (Mohammed et al., 2013) for Arsi-Bale goats. The maternal additive effect was increasing up to six months of age and decreased afterward based on the selected models while maternal permanent environmental effects reached a peak at weaning age and showed declining trend afterward. Other various studies reported on the declining trend of maternal effect during post-weaning growth stages by Roy et al. (2008) for the Jamunapari goat breed, Gowane et al. (2011) for the Sirohi goats, and Mohammed et al., (2013) for Arsi-Bale goats. These authors' in one or the other way reasoned out that a female provides an environment for its offspring in addition to its genetic contribution, to survive and grow particularly up to the weaning period and this effect could sustain up to post-weaning stages due to the positive correlation of growth traits.

The direct-maternal genetic correlation estimates obtained in this study were negative for all growth traits ranging from -0.62 to -0.98. Similar higher negative direct-maternal genetic correlation estimates were reported in other several studies (Boujenane & Hazzab, 2008; Gowane et al, 2011; Zeleke, 2019). The possible reasons for this negative correlation could be the existence of genetic antagonism among dams and their offspring, negative environment interaction with improved genetics (the genetic makeup of the population is improving across years with an unchanged or extremely degraded environment that could not support superior genotypes), and pitiable data structure (small number of progenies per dam with limited information on linked offspring-dam performances).

The model including the only direct additive effect (model 1) was sufficient to explain the variation in the birth weight, as the addition of other maternal genetic and permanent environmental effects did not significantly improve the log-likelihood value over this model at both sites. Additive direct heritability (h_a^2) for birth weight was 0.33±0.05 and 0.29±0.06 at Bilaque and Saziba sites, respectively. The value of the direct additive heritability estimate in the current study was higher than the reports of Roy et al. (2008) for the Jamunapari goat breed (0.14±0.04), Maghsoudi et al.(2009) for Iranian Cashmere goats (0.20±0.04), Rashidi et al. (2011) for Markhoz goat (0.22±0.05), Hasan et al. (2012) for Naeini goat (0.25±0.05) and Meysam and Mohammad (2019) for Markhoz goat breed (0.25±0.05). On the other hand, it was lower than the reports of Mike and Isaac (2008) for Nigerian Sahelian goats (0.41±0.08), Mohammed et al. (2013) for Arsi-Bale goats (0.39±0.08), Gowane et al. (2011) for Sirohi goats (0.39±0.05) and El-Awady et al. (2019) for Egyptian Zaraibi goats (0.43±0.05). The variations of estimate exhibited in these studies could be explained by differences in the data structure, accuracy of recording, management level, models used, and other inbreeding effects.

For TMWT, the model including both maternal additive and permanent environmental effects in addition to direct additive effect (model 5) was significantly improving the log-likelihood value at Blaque village but model 3 (fitting maternal additive with covariance) was sufficient to explain the variation at Saziba village. The direct additive, maternal additive, and maternal permanent heritability estimates in the current study were 0.29±0.05, 0.04±0.07, and 0.05±0.07 respectively at Bilaque site while it was 0.37±0.17 and 0.21±0.10 for the direct additive and maternal additive heritability, respectively, at Saziba village from selected models. When the maternal additive genetic effect was fitted in the model (Model 3), the direct additive heritability (h^2a) was considerably reduced at Saziba village. Similarly, when the permanent maternal environmental effect was fitted as the third effect (Model 5), h^2a was further reduced at Bilaque village. The direct additive heritability values for TMWT found in this study were higher than the estimate of 0.02±0.06 for the Arsi-Bale goat breed (Mohammed et al., 2013), 0.16±0.03 for the Markhoz goat (Rashidi et al., 2011), 0.12±0.03 for Sirohi goats (Gowane et al., 2011) but lower than the estimate 0.50±0.22 for Central highland and Boer cross goats (Zeleke, 2019).

Table 4.5 Estimates of (co)variance components and genetic parameters for body weights in Abergelle goat under CBBP condition

Site	**Trait**	**Model**	**σ^2_a**	**σ^2m**	**σ_{am}**	**σ^2c**	**σ^2_e**	**σ^2p**	**$h^2_a \pm SE$**	**$h^2_m \pm SE$**	**r_{am}**	**$c^2 \pm SE$**	**h^2t**	**LogL**
Bilaque	**BWT**	**1**	**0.03**	**-**	**-**	**-**	**0.06**	**0.09**	**0.33±0.05**	**-**	**-**	**-**	**0.33**	**1577.89**
		2	0.02	0.01	-	-	0.06	0.08	0.25±0.06	0.13±0.03	-	-	0.31	1576.93
		3	0.03	0.01	-0.01		0.05	0.09	0.33±0.10	0.11±0.07	-0.83		0.22	1580.60
		4	0.02	-	-	0.00	0.06	0.08	0.20±0.06	-	-	0.01±0.03	0.26	1577.33
		5	0.02	0.02		0.00	0.06	0.08	0.21±0.06	0.04±0.08	-	0.01±0.07	0.36	1572.56
		6	0.03	0.02	-0.01	0.02	0.06	0.09	0.33±0.10	0.19±0.14	-0.62	0.01±0.09	0.21	1577.53
	TMWT	1	0.44	-	-	-	0.87	1.31	0.33±0.05	-	-	-	0.34	-1242.24
		2	0.37	0.11	-	-	0.84	1.31	0.28±0.05	0.08±0.03	-	-	0.32	-1237.85
		3	1.02	0.89	-0.72		0.93	3.24	0.31±0.11	0.27±0.07	-0.88	-	0.12	-1238.05
		4	0.38	-	-	0.11	0.82	1.31	0.29±0.05	-	-	0.08±0.03	0.29	-1237.70
		5	**0.37**	**0.05**	**-**	**0.07**	**0.82**	**1.31**	**0.29±0.05**	**0.04±0.07**		**0.05±0.07**	**0.30**	**-1234.56**
		6	1.04	0.85	-0.72	0.56	0.93	3.26	0.32±0.11	0.26±0.12	-0.88	0.17±0.08	0.12	-1238.06
	SMWT	1	0.76	-	-	-	0.78	1.54	0.49±0.05	-	-	-	0.49	-1276.26
		2	0.62	0.15	-	-	0.77	1.55	0.39±0.07	0.10±0.04	-	-	0.45	-1266.39
		3	1.64	0.76	-0.55		0.73	3.44	0.48±0.11	0.22±0.08	-0.71	-	0.35	-1257.22
		4	0.66	-	-	0.15	0.74	1.55	0.43±0.06	-	-	0.10±0.03	0.43	-1266.29
		5	0.64	0.07	-	0.08	0.75	1.55	0.41±0.07	0.05±0.08	-	0.06±0.07	0.44	-1266.10
		6	**1.64**	**0.75**	**-0.50**	**0.78**	**0.74**	**3.42**	**0.48±0.11**	**0.22±0.12**	**-0.71**	**0.23±0.08**	**0.37**	**-1254.22**
	NMWT	1	0.79	-	-	-	1.72	2.50	0.31±0.06	-	-	-	0.32	-1343.35
		2	0.69	0.11	-	-	1.71	2.51	0.28±0.07	0.04±0.04	-	-	0.30	-1337.06
		3	1.73	1.00	-0.05	-	2.45	4.89	0.35±0.14	0.20±0.09	-0.89	-	0.44	-1338.67
		4	**0.71**	**-**	**-**	**0.10**	**1.70**	**2.51**	**0.28±0.07**	**-**	**-**	**0.04±0.04**	**0.28**	**-1337.09**
		5	0.69	0.07	-	0.04	1.71	2.51	0.28±0.07	0.03±0.10	-	0.02±0.09	0.29	-1337.05
		6	1.74	0.30	-0.04	0.40	2.55	5.02	0.34±0.14	0.06±0.16	-0.89	0.08±0.10	0.36	-1338.68
	YWT	1	3.03	-	-	-	3.88	6.90	0.44±0.06	-	-	-	0.44	-1655.64
		2	2.64	0.57	-	-	3.73	6.94	0.38±0.07	0.08±0.05	-	-	0.42	-1648.58
		3	2.84	0.82	-0.20	-	3.11	7.25	0.39±0.13	0.11±0.10	-0.83	-	0.41	-1648.61

		4	**2.75**	**-**	**-**	**0.51**	**3.67**	**6.93**	**0.40±0.07**	**-**	**-**	**0.07±0.04**	**0.40**	**-1648.94**
		5	2.63	0.57	-	0.00	3.73	6.94	0.38±0.08	0.08±0.11	-	0.00±0.11	0.42	-1648.58
		6	4.56	2.75	-2.93	-0.20	3.11	7.25	0.39±0.13	0.11±0.17	-0.83	0.09±0.12	0.21	-1648.62
Saziba	**BWT**	**1**	**0.07**	**-**	**-**	**-**	**0.10**	**0.24**	**0.29±0.06**	**-**	**-**	**-**	**0.29**	**964.08**
		2	0.02	0.00	-	-	0.05	0.07	0.26±0.07	0.03±0.04	-	-	0.29	949.70
		3	0.07	0.05	-0.04	-	0.11	0.10	0.39±0.15	0.31±0.10	-0.98	-	0.35	966.78
		4	0.02	-	-	0.00	0.05	0.07	0.26±0.06	-	-	0.04±0.04	0.29	950.00
		5	0.05	0.03	-	0.04	0.14	0.25	0.26±0.07	0.01±0.08	-	0.06±0.08	0.26	949.30
		6	0.06	0.05	-0.04	0.05	0.11	0.23	0.24±0.16	0.22±0.16	-0.69	0.20±0.10	0.11	964.76
	TMWT	1	0.70	-	-	-	1.05	1.76	0.40±0.07	-	-	-	0.40	-757.41
		2	0.71	0.00	-	-	1.07	1.78	0.40±0.08	0.00±0.04	-	-	0.40	-754.24
		3	**1.47**	**0.85**	**-0.85**	**-**	**1.76**	**4.01**	**0.37±0.17**	**0.21±0.10**	**-0.86**	**-**	**0.15**	**-743.68**
		4	0.71	-	-	0.00	1.07	1.78	0.41±0.07	-	-	0.00±0.04	0.40	-754.24
		5	0.71	0.00	-	0.00	1.07	1.78	0.40±0.07	0.00±0.07	-	0.00±0.07	0.40	-754.27
		6	1.47	0.95	-0.82	0.66	1.77	4.03	0.36±0.14	0.23±0.14	-0.7	0.16±0.07	0.18	-743.68
	SMWT	1	1.66	-	-	-	2.80	5.01	0.33±0.07	-	-	-	0.30	-978.68
		2	1.65	1.25	-	-	2.87	5.15	0.32±0.08	0.24±0.05	-	-	0.29	-969.43
		3	1.64	1.30	-1.30	-	2.54	5.02	0.33±0.16	0.28±0.12	-0.85	-	0.07	-967.96
		4	1.65	-	-	0.98	2.59	3.28	0.31±0.08	-	-	0.19±0.05	0.29	-969.43
		5	1.63	1.20	-	0.95	2.85	3.23	0.31±0.08	0.23±0.12	-	0.18±0.12	0.30	-969.46
		6	**1.63**	**1.21**	**-1.20**	**0.93**	**2.75**	**5.37**	**0.30±0.16**	**0.23±0.16**	**-0.85**	**0.17±0.12**	**0.08**	**-965.22**
	NMWT	1	1.19	-	-	-	1.53	2.72	0.44±0.10	-	-	-	0.44	-656.12
		2	1.02	0.16	-	-	1.56	2.76	0.37±0.11	0.06±0.07	-	-	0.40	-651.44
		3	0.91	0.15	-0.15	-	1.05	2.56	0.36±0.19	0.06±0.16	-0.84	-	0.30	-656.09
		4	**0.92**	**-**	**-**	**0.35**	**1.56**	**2.73**	**0.34±0.10**	**-**	**-**	**013±0.06**	**0.34**	**-651.44**
		5	0.85	0.12	-	0.36	1.56	2.75	0.31±0.12	0.04±0.16	-	0.13±0.15	0.33	-651.44
		6	0.89	0.16	-0.13	0.47	1.08	2.70	0.33±0.19	0.06±0.27	-0.84	0.17±0.16	0.29	-652.59
	YWT	1	2.99	-	-	-	1.88	6.87	0.44±0.11	-	-	-	0.44	-523.26
		2	2.45	0.25	-	-	1.85	6.90	0.36±0.12	0.04±0.10	-	-	0.37	-519.10

3	2.47	0.28	-	-	2.48	6.89	0.36±0.21	0.04±0.19	-	-	0.38	-517.55
4	**2.65**	**-**	**-**	**0.98**	**1.89**	**6.97**	**0.38±0.11**	**-**	**-**	**0.14±0.10**	**0.38**	**-518.70**
5	2.47	0.35	-	-	2.86	7.08	0.35±0.22	0.05±0.63	-	-	0.37	-519.61
6	2.45	0.33	-0.64	0.93	2.84	7.19	0.34±0.22	0.05±0.43	-0.72	0.13±0.32	0.23	-517.61

σ^2_a, direct additive variance; σ^2_m, maternal additive variance; σ_{am}, direct-maternal genetic covariance; σ^2_c, maternal permanent environmental variance; σ^2_e, residual variance; σ^2_p, phenotypic variance; h^2_a, the heritability of direct additive effects; h^2m, heritability of maternal additive effects; r_{am}, the correlation between direct and maternal genetic effects; c^2, maternal permanent environmental variance as a proportion of phenotypic variance; h^2_t, total heritability; BWT, birth weight; TMWT, three-month weight; SMWT, six-month weight; NMWT, nine-month weight; YWT, yearling weight.

Model 6 compared with other models were appropriate in estimating heritability as it improves the likelihood value for SMWT. The result found in this model revealed that maternal additive and environmental effects were an important source of variation even during post-weaning ages up to yearling. Direct additive heritability estimate values found in the current study were higher than the estimate of 0.06±0.02 reported by (Gowane et al., 2011) for Sirohi goats, 0.13±0.04 for Jamunapari goats (Roy et al., 2008), 0.17±0.03 for Markhoz goats (Meysam and Mohammad , 2019), and 0.02±0.10 for Arsi-Bale goats (Mohammed Bedhane et al., 2013). The maternal genetic effect in this model ranged from 23%-28% which was higher than the estimates of 4-7% reported for Sirohi goats by (Gowane et al., 2011) and 4-6% for Arsi-Bale goats. The higher direct additive, maternal additive, and maternal environment estimate in this study could be explained by the variation of selected models among different studies and the strong positive correlation between TMWT and SMWT resulted in continued maternal contribution.

The model fitting maternal permanent environmental effect in addition to the direct additive effect (Model 4) was sufficient to explain the variations in NMWT and YWT by improving the log-likelihood value compared with other models. The maternal permanent environmental effect contributed 2-17% variation in this model. In this study, it was found that after weaning age, maternal permanent environmental effects exerted an important source of variation up to yearling age. Direct additive heritability estimates were found in the range of 0.28±0.07-0.44±0.11. The direct additive heritability estimates obtained from the best-fitted model for NMWT in this study were found to be at a relatively higher level (0.28±0.07 at Bilaque and 0.34±0.10 at Saziba villages) which suggests the possibility of effective selective breeding sill exists in the population. The direct heritability estimates for NMWT found in this study is higher than the estimates of 0.25±0.04 for Markhoz goats (Meysam and Mohammad , 2019), 0.17±0.05 for Jamunapari goats (Roy et al., 2008) but it was comparable with the estimate 0.28±0.05 by (Zeleke Tesema, 2019). The direct additive heritability estimate for YWT is also higher than the reports of these authors but lower than the estimate of 0.45±0.28 for Nigerian Sahelian goats (Mike and Isaac, 2008). These variations could happen due to breed, environment, and model of analysis and data structure differences among reports.

From best-fitted models of growth performance traits in Abergelle goats, the phenotypic variations explained by maternal genetic effects were 4-21% for three-month weight and 22-23% for SMWT while the variations due to maternal permanent environmental effects were 4-13% for NMWT and 7-14% for YWT. Maternal genetic heritability estimates from this study are higher than the values reported by Mohammed et al. (2013) for Arsi-Bale goats (3-7% for WWT and 4-6% for SMWT), Gowane et al. (2011) for Sirohi goats (9-10% for WWT and 4-7% for SMWT) and (Roy et al., 2008) for Jamunapari goats (8% for WWT) while it was in accordance with the 5-32% estimate for WWT by (Hasan et al., 2012) for Naeini goat breeds. Lower c^2 values (2-6% for NMWT and 4-5% for YWT) than this study was also reported by Gowaneet al. (2011) and Meysam and Mohammad (2019) for Markhoz goats (2% for NMWT). The total heritability values, which are used to calculate the expected response to selection, were in the ranges of 0.11-0.36, 0.12-0.40, 0.07-0.49, 0.28-0.44, and 0.21-0.44 for BWT, TMWT, SMWT, NMWT, and YWT, respectively. From all best fitted models selected by its log likelihood values, all investigated growth traits in this study exhibited some scope of response to selection.

4.2.2. Heritability estimates for reproductive traits

Genetic parameter estimates with their respective standard errors for reproductive traits of Abergelle goats managed under CBBP conditions are presented in Table 4.6. Due to the smaller data size for reproductive traits at Saziba village, only Bilaque village reports are presented in the genetic parameter estimation table. Both the estimates of direct additive genetic variance with its corresponding direct additive heritability (Model 7) was relatively higher than the other models for all reproductive traits in this study. Inclusion or exclusion of maternal genetic or permanent animal environmental effects did not substantially influence direct heritability and log-likelihood values for all investigated reproductive traits. Estimates of direct heritability were in the range of 0.00 to 0.07 from different models. Direct heritability estimates from best fit models in the current study were 0.03±0.00, 0.07±0.09, 0.03±0.19, 0.03±0.13, and 0.00±0.20 for KI, LSB, LSW, LWB and LWW traits, respectively.

Table 4.6 Variance components, heritability estimates, and log-likelihood values for reproductive traits in Abergelle goats from different animal models in Bilaque site

Trait	Model	σ^2_a	σ^2_m	σ^2_c	σ^2_e	$\sigma^2 p$	$h^2_a \pm$ SE	$h^2_m \pm$ SE	$c^2 \pm$ SE	$h^2 t$	Log L
KI	**1**	**72.00**		**292.20**	**2026.40**	**2320.00**	**0.03±0.00**		**0.13±0.88**	**0.00**	**-532.32**
	2	66.00	170.3	122.96	2026.20	2320.10	0.03±0.89	0.07±0.01	0.05±0.08	0.04	-532.25
LSB	**1**	**0.001**		**0.00**	**0.03**	**0.03**	**0.07±0.09**		**0.03±0.08**	**0.03**	**835.78**
	2	0.001	0.001	0.00	0.03	0.04	0.06±0.31	0.06±0.43		0.04	828.57
LSW	**1**	**0.005**		**0.001**	**0.17**	**0.18**	**0.03±0.19**		**0.01±0.05**	**0.03**	**241.58**
	2	0.003	0.001	0.001	0.17	0.18	0.02±0.19	0.07±0.04	0.09±0.06	0.02	243.14
LWB	**1**	**0.001**		**0.001**	**0.05**	**0.06**	**0.03±0.13**		**0.02±0.14**	**0.02**	**640.55**
	2	0.002	0.001	0.001	0.05	0.06	0.03±0.14	0.02±0.00	0.02±E	0.04	639.25
LWW	**1**	**0.001**		**0.001**	**2.04**	**2.04**	**0.00±0.20**		**0.00±0.22**	**0.00**	**-603.28**
	2	0.001	0.001	0.00	2.05	2.06	0.00±0.08	0.00±0.71	0.00±0.71	0.00	-603.34

***σ^2_a**, direct additive variance; **σ^2_m**, maternal additive variance; **σ^2_c**, permanent environmental effect variance for the animal; **σ^2_e**, residual variance; **$\sigma^2 p$**, phenotypic variance; **h^2_a**, direct additive heritability; **h^2_m**, maternal additive heritability; **c2,** permanent animal environmental heritability; **SE**, standard error; **Log L**, log-likelihood value; **KI**, kidding interval; **LSB**, litter size at birth; **LSW**, litter size at weaning age; **LWB**, litter weight at birth; **LWW**, litter weight at weaning age.*

The lower direct heritability estimates suggest that direct selection for reproductive traits would lead to smaller annual genetic progress. The lower values for all reproductive traits were due to the smaller data size but, it also indicates the importance of non-genetic factors affecting reproductive traits. Permanent environmental animal effect estimates were almost in the same range of contribution as the direct additive estimates and were in the range of 0.00-0.13 for all reproductive traits. Maternal additive effects were slightly lower than the direct additive and permanent environmental estimates.

The estimates of direct heritability for reproduction traits obtained in the present study were low, in agreement with published results of Hamed et al. (2009) for Zaragbi goat breeds (0.05-0.08), Rashidi et al. (2011) for Markhoz goats (0.01-0.03), Hossein et al. (2012) for Raeini goats (0.05-0.16), Tesfaye et al. (2012) for indigenous Arsi-Bale goats (0.05-0.16) and Kasap et al. (2013) for Sannen goats (0.04-0.07). Small genetic variability in reproductive traits indicates these traits were not selection criteria traits in the program and it suggests selection would not be effective to improve the trait. More effective changes could be implemented using alterations in management and design of other mating systems with effective application of reproductive biotechnology tools and others like crossbreeding.

4.2.3. Heritability estimates for milk production traits

Estimates of (co) variance components and genetic parameters for milk production traits in Abergelle goats managed under CBBP condition are presented in Table 4.7. The estimates of direct additive heritabilities for LL were low and varied slightly from 0.05 to 0.06 while the average daily and ninety-day milk yield estimates were slightly higher, which varied from 0.07 to 0.20. The estimates of direct additive heritabilities (h^2a) from the best-fit models were 0.05 for LL and 0.20 for both ADMY and MY90D traits. In the current study, the estimates of maternal additive heritability from model 8 for LL, ADMY, and MY90D were 0.00, 0.06 and 0.03, respectively. The estimated permanent environmental effects of the animal (c^2) were also in the same range varying from 0.00 to 0.00 for LL, 0.06 to 0.12 for ADMY, and 0.03 to 0.05 for MY90D, respectively.

In the current study low (for LL) to moderate (ADMY and MY90D) heritability estimates were found for milk production traits of Abergelle goats. The heritability estimate value for LL found in this study was in line with the value 0.00-0.03 for Arsi-Bale goats (Mohammed et al., 2012) and 0.02 for Jamunapari goats (Rout et al., 2017). On the other hand, most of the genetic parameter estimates of milk production traits found in this study were lower than the reports of various scholars on different breeds of goats like Temesgen et al., 2020 from a meta-analysis study, Torres-Vázquez et al. (2009) for Saanen goats, Mohammed et al. (2012) for Arsi-Bale goats and Rout et al. (2017) for Jamunapari goats. The lower estimated value for all milk production traits obtained in this study compared to other findings might be explained by the environment, data size and quality, models, and time frame variations. Data quality, in this case, means the data were collected under an on-farm condition with measurement and other technical errors than those collected in a very controlled one.

Table 4.7 Estimates of (co)variance components and genetic parameters for milk production traits in Abergelle goat under CBBP condition at Bilaque village

Traits	Model	σ^2_a	σ^2_m	σ^2_c	σ^2_e	$\sigma^2 p$	h^2_a ± SE	h^2_m ± SE	c^2 ± SE	e^2± SE	$h^2 t$	LogL
ADMY	**1**	**158.48**		**266.6**	**1728.80**	**2153.90**	**0.07±0.09**		**0.12±0.08**	**0.80±0.05**	**0.07**	**-3024.42**
	2	158.45	130.98	135.7	1728.80	2153.90	0.07±0.09	0.06±0.08	0.06±0.00	0.80±0.05	0.10	-3024.42
LL	**1**	**0.23**		**0.00**	**4.07**	**4.30**	**0.06±0.34**		**0.00±0.07**	**0.94±0.05**	**0.05**	**-874.87**
	2	0.24	0.00	0.00	4.07	4.31	0.06±0.34	0.00±0.07	0.00±0.00	0.94±0.06	0.06	-874.88
MY90D	**1**	**5.71**		**2.04**	**31.76**	**39.50**	**0.15±0.10**		**0.05±0.08**	**0.80±0.06**	**0.14**	**-1637.77**
	2	5.7	1.03		31.76	39.50	0.14±0.34	0.03±0.00	0.03±0.08	0.80±0.06	0.16	-1637.77

σ^2_a, *direct additive variance;* ***σ^2_m***, *maternal additive variance;* ***σ^2_c***, *permanent environmental effect variance for the animal;* ***σ^2_e***, *residual variance;* ***$\sigma^2 p$***, *phenotypic variance;* ***h^2_a***, *direct additive heritability;* ***h^2_m***, *maternal additive heritability;* ***c2,*** *permanent animal environmental heritability;* ***SE***, *standard error;* ***Log L***, *log-likelihood value; ADMY, average daily milk yield; LL, lactation length; MY90D, 90 day milk yield.*

4.2.4. Phenotypic and genetic correlations among growth traits

The estimates of phenotypic and genetic correlations for different growth traits obtained from the multivariate animal model are presented in Table 4.8. Phenotypic correlations are better at evaluating the effect of both genetic and environmental variations while genetic correlations merely evaluate genetic contributions obtained from common ancestral relationships. Genetic correlations among growth traits in this study were higher than the corresponding phenotypic correlation values which agreed with the result reported by (Zeleke, 2019). Phenotypic correlations of BWT with later growth stages were low in comparison to other various studies. On the other hand correlation values for TMWT-SMWT, SMWT-NMWT and NMWT-YWT are higher and positive which are comparable with the results of (Mohammed Bedhane et al., 2013 and Zeleke, 2019) for indigenous Arsi-Bale and Central Highland X Boer goat breeds, respectively. These higher phenotypic correlation values suggest that heavier weight kids at weaning tend to attain heavier weights at later stages of growth.

Table 4.8 Phenotypic (below diagonal) and genetic (above diagonal) correlation for growth traits of Abergelle goats at Bilaque CBBP site

	BWT	TMWT	SMWT	NMWT	YWT
BWT		0.21±0.17	0.08±0.15	0.04±0.16	0.05±0.15
TMWT	0.07±0.02		0.85±0.04	0.66±0.07	0.62±0.08
SMWT	0.04±0.02	0.77±0.01		0.83±0.04	0.69±0.07
NMWT	0.03±0.03	0.52±0.02	0.67±0.02		0.77±0.06
YWT	-0.02±0.03	0.33±0.03	0.45±0.02	0.57±0.02	

BWT, Birth weight; TMWT, Three-month weight; SMWT, Six month weight; NMWT, Nine month weight and YWT, Yearling weight

The genetic correlations for growth traits ranged from lower (0.04) to higher values (0.85) for different combination of traits. The lower estimated values were from the correlation of birth weight with the rest of the later growth stages. The genetic correlations of BWT with SMWT, NMWT, and YWT were very small except for a moderately higher relationship with TMWT with values of 0.08, 0.04, 0.05, and 0.21, respectively. The genetic correlation values for BWT with later growth stages found in this study were small in comparison to other reports of different goat breeds (Rashidi et al., 2011; Mohammed et al., 2012; Zeleke, 2019). This could be explained by BWT greatly affected by the genetic and environmental effects of the dam so that early stage selections would not supported in most of small ruminant breeding programs. In addition, the data recording problems of BWT in a routine manner which is also supported by the report of (Temesgen, 2016) who described the inaccuracy of BWT recording in goat CBBP's due to a lower number of enumerators that could not be reached by households at an appropriate time but could be solved by increasing the number of data collectors.

Higher and positive genetic correlations were obtained among TMWT-SMWT, SMWT-NMWT, NMWT-YWT, and SMWT-YWT traits with the respective correlation values of 0.85, 0.83, 0.77, and 0.69. The results found in this study are comparable with the reports of (Mohammed et al., 2013 and Zeleke, 2019). It was also comparable with (Rashidi et al., 2011) for Markhoz goats and (Boujenane & Hazzab, 2008) for Draa goats. The higher and positive genetic correlation of growth traits has a genetic basis that selection in one trait usually affects other two or more traits due to the occurrence of pleiotropy as described in Bourdon, (2014). The situation is called correlated response to selection in which the breeding value of one trait that are expressed in later ages of the animal could possibly be estimated indirectly from the selection of other traits in earlier stages to reduce costs of keeping surplus bucks according to this author.

4.2.5. Genetic trend estimation for growth, reproductive, and milk production traits

Genetic trend estimation helps to understand the rate of improvement and breed direction within the intervention periods of the genetic improvement program. The genetic trends of growth traits for the Abergelle goat breed are presented in Figure 4.5. Genetic trend coefficients found in this study were -0.002, 0.01, 0.04, 0.05, and 0.14 kg/year for BWT, TMWT, SMWT, NMWT, and YWT traits, respectively. These values revealed BWT decreased genetically by 0.002 kg/year while other later age body weight traits of Abergelle goat increased by 0.01, 0.04, 0.05, and 0.14 kg/year for TMWT, SMWT, NMWT, and YWT traits, respectively. In general, the genetic trend for growth traits was lower and even inconsistent over the intervening years in all sites at birth but reasonable in the rest of growth traits.

However, the results found in this study are higher than the report of (Zeleke, 2019) for Boer X Central highland goats under a semi-intensive station management system who reported negative trend values for BWT, TMWT, and SMWT traits but higher values (0.13 and 0.21kg/year for

NMWT and YWT) traits. Rout et al., (2018) reported relatively comparable values but higher in some later stage growth traits of Jamunapari goats (0.04, 0.08, 0.12, 0.14, and 0.20 kg/year for BWT, TMWT, SMWT, NMWT, and YWT traits). The negative (for BWT) and lower genetic trend values (the rest of body weight traits) could be attributed to the lower genetic correlation of BWT with other later age weights and the absence of accurate selection of bucks and does based on their estimated breeding values especially during the starting periods of the breeding program. However, the comparably higher and positive genetic trend for NMWT and YWT reflects the fact that most selection weights were placed on these traits relative to other growth traits.

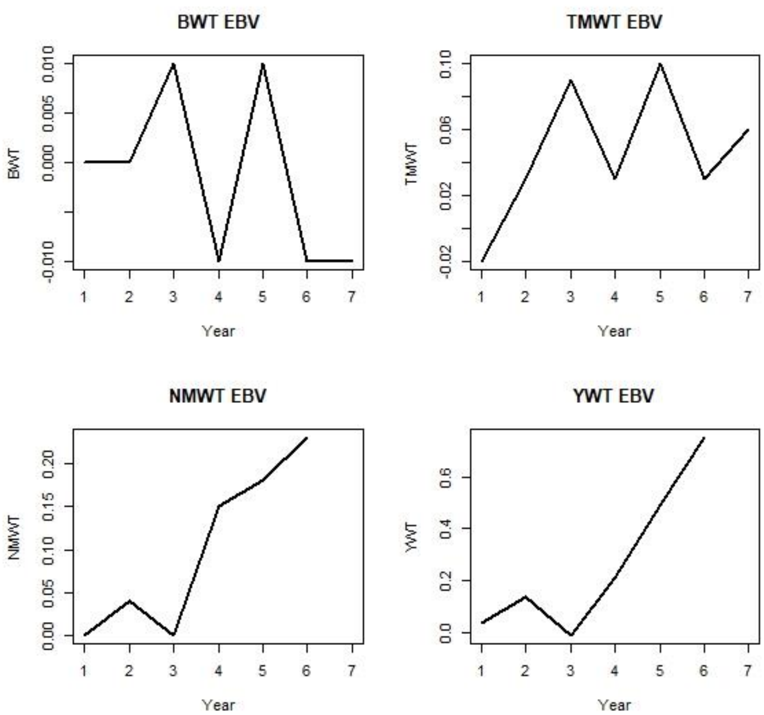


Figure4.5 Genetic trends of growth traits in Abergelle goats at Bilaque village

The genetic trend for reproductive traits (KI and LSB) of Abergelle goats are illustrated in figure 4.6. Declined genetic progress for LSB and unchanged to very small progress for KI was detected which reveals the absence of genetic progress for these traits. This could be explained by the absence of selection based on estimated breeding values of these traits in the breeding program. In addition, the lower level of heritability obtained for all these traits is the reason for the lower to negative genetic trend. The genetic trend result for LSB found in this study agrees with the report of (Kasap et al., 2013) who reported negative trends of litter size traits for the Saanen goat breed.

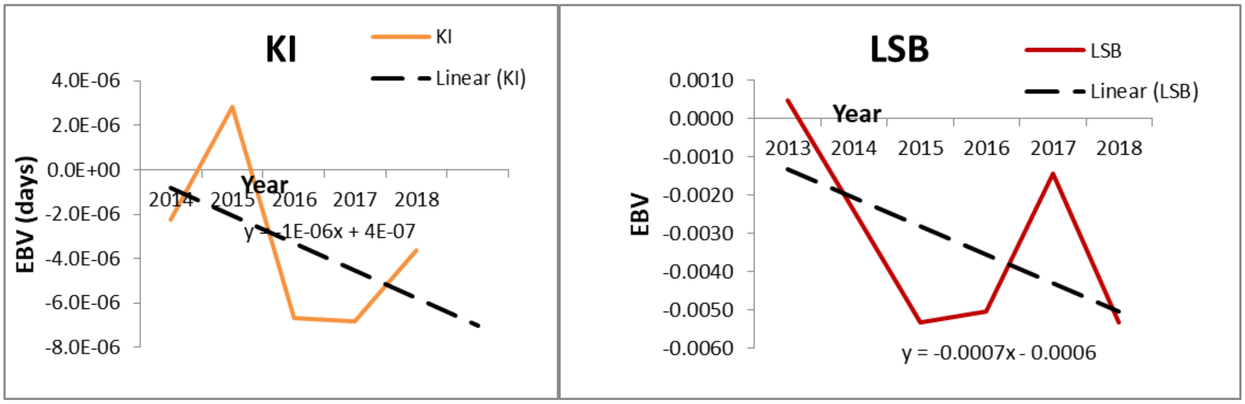


Figure 4.6 Genetic trends estimation of reproductive traits (KI left and LSB right) in Abergelle goats at Bilaque site

A positive genetic trend was observed for the ADMY trait of Abergelle goats which is presented in Figure 4.7. There was an increase of 0.4kg/year milk yield for this breed during the intervening years. This could be explained by milk production traits are considered important traits and positively responded to the selection program. However, the values obtained in this study are low in comparison to the value reported by Rout et al., (2017) for the Jamunapari goat breed. In addition, it was also lower than the value reported for Alpine and Saanen goat breeds described in the same study.

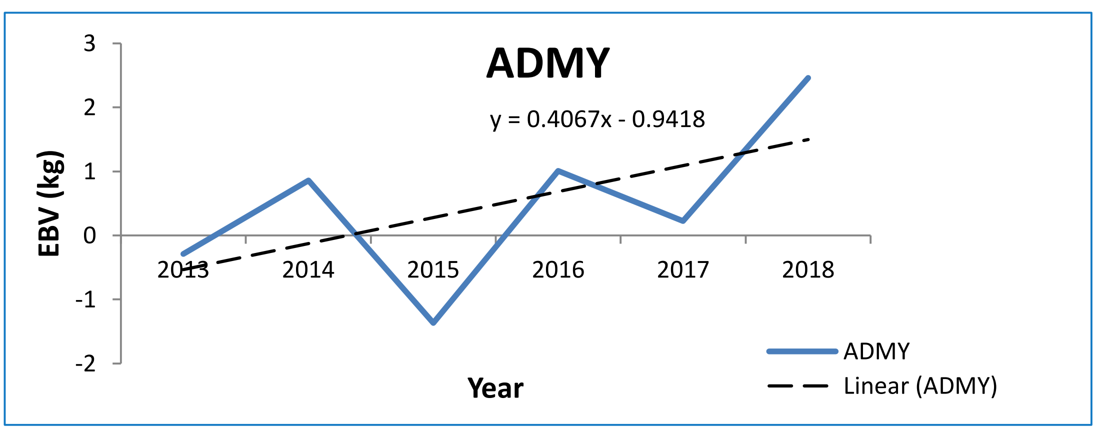


Figure 4.7 Genetic trends estimation of average daily milk yield in Abergelle goats

4.3. Socio-economic aspects of community-based Abergelle goat breeding program

4.3.1. Demographic characteristics of households

About 91.82% of the respondents in this study were males while 8.18% were female which was similar between members and non-members of the cooperative breeding. The average age (±SD) of the respondents was 47.69±14.33 and 39.89±12.94 for members and non-members respectively. The reason for the variation in age between the two groups was the difference in sampling method i.e. purposive sampling method targeting households having at least six does was used to select the members of the cooperative during the beginning of the breeding program resulting in a higher age value while non-participant members were selected randomly that could address various age groups. The average family size of households (±SD) was 6.78±2.44 for members and 5.78±2.36 for non-members of cooperatives. The larger proportion of respondent households (59.14%) was illiterate while the remaining (40.86%) were either able to read and write, attended adult education, attended primary or secondary education. The mean landholding size (±SD) of the respondents was 1.45±0.90 and 1.28±0.85 ha for members and non-members of the cooperatives, respectively. All the interviewed participant households practiced a mixed crop-livestock production system while about 15% of non-participants engaged only in livestock rearing without having other agricultural activities. About 23.64% of the cooperative members owned pasture lands along irrigation canals while the rest of the respondents did not own pasture land.

The mean flock size distribution of participants and non-participants of CBB's is presented in Table 4.9. Flock size distribution was compared based on the flock sizes currently owned in comparison to flock size during the beginning of the breeding program for participant households while it was the deviation of current flock size from the households owned during the last 10 years for non-participants. The mean flock size of cooperative members was increased by more than 37% while it has shown around 24% reduction for non-members during the program implementation period. Respondent households described their reasons for the change in mean flock size and about 90% of participant households' reasoned out that the increase in mean flock size is due to the positive effect of the breeding program as they keep all of the females to ensure higher number of kids for the next selection round. The remaining 10% of participant households described that their flock size was increased when they are shared with others and separated from families' thereby getting goats from them. But, most of the non-participant households described that their flock sizes are gradually declined due to their animals being highly exposed to various diseases and parasites in addition to the critical feed shortage in the area. They had not gotten regular vaccination, treatments, deworming, and supplementary feed for their animals like the participant members. In addition to the above mentioned differences, the sampling method and size of respondents could be affected the flock size.

Table 4.9 Distribution of mean (±SD) goat flock size of households by district and membership

Variables		**Past flock size**	**Current flock size**	**Percent in change**
	N	**Mean ± SD**	**Mean ± SD**	
Overall	**110**	**38.65±32.76**	**42.85±28.30**	**9.8%**
CV		82.2	65.39	
CBBP Site		**ns**	**ns**	
Abergelle	40	41.55±29.52	46.9±28.67	11.4%
Ziquala	70	37.00±34.57	40.54±28.04	8.7%
Membership		*******	**ns**	
Member	55	29.91±22.26	47.40±28.19	37%
Non-member	55	47.40±38.93	38.31±27.93	-23.73%

4.3.2. Institutional arrangements and sustainability of the CBBPs

As described in detail in the materials and methods part, the initiative for implementing the program emanated from ILRI/ICARDA-BOKU. The two international research organizations collaborated with BOKU University to conduct a detailed production systems study, identification of breeding objective traits, design of feasible alternative programs, and finally initiated implementation of a selected breeding program. Technical aspects of the program were facilitated and closely supervised by scientists from ILRI/ICARDA. Sekota Dry-land Agricultural Research Center (SDARC) took the responsibility for organizing the program. Then enumerators were recruited to undertake data recording tasks. In connection, cooperative participant households assigned some of the members to lead the local operational procedures of the breeding program. These elected farmer groups/committees follow up the financial management, facilitate community meetings, buck selection, and management aspects. At this stage, involvement of the extension system was not in place. District and zonal level livestock agencies are aware of the program and tried to be involved during different pieces of training and stakeholder meetings but were not fully engaged in the program implementation.

In recent days, there are some efforts by zonal livestock agencies to replicate the breeding programs in other districts. At times of requests for support from the cooperatives like vaccination and financial auditing activities, the districts like Ziquala were exemplary for their quick actions however the same responses did not come from other districts. More efforts could have been done in engaging the extension system to establish better cooperation. Involvement in the livestock extension system could have helped extension staff to acquire technical skills and knowledge through training and working with breeders. This could also help the CBBP in terms of promoting the technology during further scaling out and scaling up stages. But, cooperative members are strongly witnessed during a focus group discussion that institutional supports are limited and the only support they are getting is from the research side. The program should be conducted with concerted efforts by involving various government agencies and other NGOs for better sustainability. Community-based breeding programs are proven for improving the biological performance of the livestock population thereby improving the livelihood of the community but they need further public and private support and investments as described in Aynalem et al., (2019).

The sustainability of the CBBP largely depends on effective and well-functioning breeders' cooperatives in terms of technical and socio-economic aspects. To this end, the institutional capacity of the cooperatives to handle the breeding program should be strengthened. The cooperatives now have legal rights and functioning structures for management however, it needs more effort to ensure effective management in the future. Specifically, management of breeding bucks and financial resources and effective functioning of some committees and members in the process needs further tasks. Households are currently constrained by limited financial capacity but they perceive there is a possibility to maximize benefit from the breeding program if linkages to better markets are facilitated. Strengthening the financial capacity of the cooperatives by linking them to better markets could contribute to the sustainability of the CBBP.

Table 4.10 Distribution of CBBP participant households on their knowledge for sustainability of the breeding program

Sustainability issues	**Frequency**	
	Yes (%)	**No (%)**
Did you know it was supposed that you would run the program without external support	35 (63.64)	20 (33.36)
Do you believe you will run the program without external support in the future	30 (54.55)	25 (45.45)
Will you continue as a member if technical and financial support ceased	42 (76.36)	13 (23.64)
Are you satisfied with the skill and management role of committees	40 (72.73)	15 (27.27)

As obtained from the FGD and individual interview survey presented in Table 4.10 above, about 33.36% of participant households did not know external support would be cut, more than 54% of households believe they would sustain the program without external support and about 23.64% of households told they would leave the cooperative if technical and financial supports ceased. About 27.27% of the participant members in the cooperatives are not satisfied with the skill and management role of previously selected committees. In general, even though these cooperatives build relatively strong institutional and financial capacity in the short run that is mainly from the research side, they could hardly run the breeding program without technical and financial support like hiring their experts, and management of selected bucks would less likely happen in the near future. Some of the reasons mentioned by households for self-sustaining the program were lack of adequate skill and capital, poor educational background, animal health problems, lack of support from the extension system, and poor capacity to find a market by the cooperatives. Therefore, continuous technical and financial support to the cooperatives is crucial for the sustainability of the program considering the skill needed to run a breeding program and strategic supporting mechanisms should be designed to provide technical and institutional backing.

4.3.3. Farmers' perception of the breeding program

In this part, the distributions of members and non-members of the cooperative perceived attitude in terms of various comparison variables are discussed. These include comparisons in terms of perceived impacts on fertility, growth, milk production, market price, consumption, and other trends over the program implementation periods.

The distributions of CBBP members and non-members by their perception of fertility (litter size), reproductive traits (AFK and KI), inbreeding effects, reverting of negative selection, growth performance, and milk production performance traits in their flocks are presented in Table 4.11. As presented in the table, comparisons of the perception level of households on fertility, growth, and milk production improvements for members and non-members is straight-forward. It is shown that the fertility, growth performance, and milk production performances are highly improved for cooperative members than non-members. Almost all these traits are either showed no change or those changes, if any, were not perceived by non-cooperative members. These variations arise from the difference in experience and skill of cooperative members as they gained frequent support and training from the research center. In the case of AFK, 90.9% of the participant members of the CBBP believed the program resulted in moderate to strong reduction of the trait while 64.4% of non-participant households responded there was not change at all. Similarly, participant households (90.9%) believed to have a reduced KI than non-participants (7.0%). These positive improvements were supported by the least square mean value of the traits presented and discussed in above i.e. these traits showed a reduced phenotypic trend. About 4.0% and 10.0% of non-participant households described there was rather a reduction in growth and milk production performance of their flock in the last 10 years due to critical feed shortage and disease outbreaks in recent years. Result from analysis of biological data revealed that good progress was achieved in performance at nine months and yearling age which supports the improvement obtained in participant households.

Only 4.4% of non-participant households were knowledgeable and believed able to reduce the inbreeding effect in their flock while the remaining 46.7% did not know what the inbreeding effect is. This value is quite larger than cooperative members as only 2.3% are still do not understand the effect of inbreeding. Most of the households who are not a member in the CBBPs described they are using bucks selected from their flock every time without introducing from external sources. Surprisingly, larger proportion of the non-participant households (30.1%) do not understand negative selection effects and about 57.7% of them sold faster growing male kids. The negative selection problem are now drastically reduced in participants of the CBBPs and about 80% of the members confidently described they understood and able to reduced negative selection problems in their flock.

Table 4.11. Perception of the respondents on the improvements of some economically important traits compared between members and non-members of the CBBPs

		Perception level (%)				
Variables	Membership	Strongly improved	Moderately improved	Not changed yet	Negatively changed	I don't know
Fertility of does	Member	9.1	54.5	31.8	0.0	4.6
	Non-member	2.2	8.9	73.3	4.4	11.2
Age at first kidding	Member	27.3	63.6	9.1	0.0	0.0
	Non-member	0.0	28.9	64.4	0.0	6.7
Kidding interval	Member	36.4	54.5	9.1	0.0	0.0
	Non-member	0.0	7.0	90.7	0.0	2.3
Inbreeding effect	Member	63.6	18.2	9.1	6.8	2.3
	Non-member	2.2	2.2	48.9	0.0	46.7
Negative selection	Member	43.2	36.3	20.5	0.0	0.0
	Non-member	6.7	15.6	20.0	26.6	31.1
Growth performance	Member	70.5	18.2	9.1	2.2	0.0
	Non-member	16.0	20.0	50.0	4.0	10.0
Milk production	Member	31.8	50.0	11.4	6.8	0.0
	Non-member	14.0	30.0	40.0	10.0	6.0

The effect of CBBP programs on income improvement of households

The potential impact of the CBBP on farmers' income improvement was approximated as households' market participation consumption of goat meat and milk. In addition, the cooperatives financial capital reached more than half a million at Saziba and 0.38 million at Bilaque village which are managed under one group account at each village. Furthermore, financial improvement measures are taking by the cooperative members through persuading them to save 200 ETB when there sale of one goat. Market participation of CBBP households measured by the number of sales per year and the income they gained was higher than non-participants. On average, participant households supplied nine goats to market within a year and earned an average 2500 ETB per sold goat while non-participants brought 6 goats with individual selling price of 1600 ETB. Respondents from both the CBBP members and non-members described during the FGD and individual interviews that about 500 to1000 ETB additional market prices for those goats sold from the CBBP are common in the market and non-participant households are even willing to pay that additional price for participant members as explored from informal discussion with non-members. The comparatively higher market participation by members of the CBBP could be attributed to the observed variation in flock size and performance of the flock kept by members of the CBBP. The majority of CBBP participants (60%) reported that consumption of goat meat in the household had not changed after the introduction of CBBP but 35% of the households described an increase in goat meat consumption while 5% of the households reported rather reduced goat meat consumption due to reduction in flock size.

The meat consumption trend of households found in this study was in argument with the report of Zelalem et al., (2015) who reported about 53% of participant households in sheep CBBPs of Ethiopia showed increased motton consumption trend. The variations observed in terms of meat consumption trend could be explained by the fact that participant households in Abergelle area consume higher more number of goats (4/year) at home even before the beginning of the program because they have larger flock sizes and goats are the main source of food in the household. These days, they are planning to deliver more animals to market without reducing the number of animals consumed at home. Even though there was no significant variation in meat consumption trend of participants and non-participants, about

20% of the participant households started to slaughtering goats at any time of the year which is not common for non-participants. In general, most of the participant households in the cooperatives (67.27%) described that they obtained substantial improvements in their total income from the breeding program (Table 4.12). Farmers reasoned out for their household income improvement that the cooperative breeding has helped them a lot in the form of reduced kid mortality, increased market price, improved skill and better management practices. However the difference in values of income improvement not quantified in this study, the program resulted in substantial households income improvement which is in agreement with the values reported by Aynalem, et al. (2019) from the ongoing sheep CBBPs as he reported about 20% of household income improvement. On the other hand there are some households (around 2%) in the cooperative breeding who has faced rather reduction in household income due to loose of the whole flock by natural catastroph.

Table 4.12 Distribution of CBBP participants by level of household income improvement

Level of household income improvement	**Frequency**	**Percent**
Significantly improved	37	67.27
Moderately improved	5	9.09
Little improvement	4	7.27
Not changed yet	8	14.55
Rather reduced income	1	1.82

In addition to understand the level of their income improvement, participant farmers are conscious and knowledgeable on the use of the income they generated from goats sale. In Table 4.13, the major reasons of expense from live animals sale specifically, from goats is presented. In the study area, as explored from the FGD, households primarily used the income generated from goat sale for food purchase (0.38 index value) followed by educational and related materials purchase for their children (0.29). The farmers also used the income from goats sale for purchasing agricultural and household inputs but they gave less emphasis for bank saving. These values implies that goats are the most important animals that most of the households rely on their livelihood improvemennt.

Table 4.13 Distribution of participant household rankings in the use of income generated from goats sale from CBBPs

Use of income from goats sale	Number of households ranking						
	1st	2nd	3rd	4th	Sum	Index	Rank
Food purchase	36	8	1	0	170	0.38	1
Input purchase	4	16	24	3	115	0.26	3
Children's education expense	4	26	17	0	128	0.29	2
Bank saving	1	0	3	20	30	0.07	4

Challenges of CBBPs

Major factors influencing the implementation of CBBPs in sustainable ways for participanting households was identified and ranked from the collected focus group disscussions. The most important challnge identified in this study was delayed provision of services (Table 4.14). About 31% of the participant households mentioned selection time, supporting the cooperative committes, auditing of the cooperatives finance, and responding for requests on animals treatment services are not timely responded by the research center.

Another important challenge detected during focus group disscution was the issues related to the use and ownership of the cooperatives revolving fund. Most of the respondent households described that they believed and promised from researchers during the beginning of the program, they would capable of using the revolving fund as being a member of the cooperative but they still not aware of the amount of the capital and legal rigts for using the money for their own purposes.

Feed shortage, breeding buck shortage specially for those using selected bucks in groups, and limited trainings and support are some of additional challenges in CBBPs that would potentially affect the sustainability of the breeding program. On the other hand around 18% of the cooperative members described that they are not faced any challenges so far in the program.

Table 4.14 Major challenges in CBBP participants

Challenges	Frequency	Percentage
Delayed service provision	17	30.91
Buck shortage	4	7.27
Limited support	7.0	12.73
Use of saved capital	12.0	21.82
Feed shortage	5.0	9.09
No challenge	10.0	18.18

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study evaluated the status and performances of Abergelle goat CBBP implemented in the lowland areas of Wag-himra zone based on technical and socioeconomic criteria. The evaluation looked into the technical issues like phenotypic and genetic performances, estimation of genetic parameters including heritability, phenotypic and genetic correlations and genetic trends for economically important traits of the breed. In addition, the study also looked on socio-economic aspects including implementation of the CBBP, institutional arrangements, participation of farmers, challenges and future sustainability of the breeding program.

Phenotypic performances of Abergelle goat breed for the breeding objective traits (growth, reproduction and milk production) resulted in an increased trend in comparison to the performance of base flocks before the implementation of the CBBP and from those households not participating in the breeding program. The reasons for increased phenotypic performances of the breed for participant households are mainly connected with proper application of the procedures required in the implementation of CBBPs including use of phenotypically and genetically superior bucks in their flock, reduced inbreeding effects through proper sire rotation, reverted negative selection, and an increased perception of participants for most of these procedures through frequent trainings. The coefficients of phenotypic performances trend values of the studied breed were however varied from lower to medium and even varied with location than the performances of most indigenous and international breeds due to level of management, environmental variability, and method of evaluation variations.

The CBBP being implemented for Abergelle goat breed allowed for estimation of population specific genetic parameters. Moderate heritability estimates for most of the growth and milk production traits was found and it implies that sufficient additive genetic variance exists for these traits that could be used for selection in the existing CBBP. On the other hand, genetic improvement of reproductive traits through selection would be less effective due to low heritability estimates. Most of the studied growth traits from best fitted models were affected by both direct additive and the maternal effects while for the reproductive and milk production traits the simplest model (direct additive with permanent animal effect exerted the significant role. In addition, moderate to high positive phenotypic and genetic correlations among growth traits during the later growth stages suggests the selection for one trait would result in improvement in the other traits and thus could be advantageous for selection of goats at an early age. The genetic trend for growth, and milk production traits found in this study was relatively higher and promising in the context of the area because the area is quit harsher and such positive trends need to be sustainably improved. However the progresses are not consistent and even the rate of improvement is lower than other breeds which calls for optimization of the program in the future. But, the genetic trend for reproductive traits were very small and relatively unchanged which depicted slow progress that needs proper technical and management practices in the future like effective feeding and use of reproductive biotechnology tools to improve this trait.

Improved socio-economic characteristics of the households was observed in this ongoing CBBP including increased flock size, improved skill on effective implementation of required procedures, improved perception of households to the breeding program, increased market participation role, relatively better institutional arrangement during the start of the program, increased market price and meat consumption trend, and improved income and livelihood of households. Formation of cooperatives with a well-functioning organizational structure and the very participatory nature of the CBBP for inception would contribute to sustainability of the breeding program. However, given the skills, institutional capacity, and infrastructure required to run the breeding program it could be impossible for the cooperatives to run and sustain the program without external support. It is, therefore, important to have a clear exit strategy to ensure sustainability of the breeding program.

5.2. Recommendation

Based on the findings from the current study, the following measures are recommended;

- With all the challenges, the ongoing community-based breeding program implemented for Abergelle goat generated substantial phenotypic performance and genetic improvements in growth and milk traits however the values are not consistent over years and location. Thus, optimizing the breeding program considering use of uncertain sire scenario, increasing the selection intensity, economic selection index and reducing male to female ratio are suggested to maximize the overall profit of the breeding program.

- Biological reproductive potential of goats restricted by feed availability due to the short and seasonality of rainfall so that integrated forage development, dry season supplementation, range land rehabilitation and application of reproductive biotechnology tools like estrus synchronization and AI is crucial to benefit from reproduction traits.
- Better performances of milk production traits in the CBBP need to be promoted for the community by adopting cost effective milk processing and utilization technologies.
- Selection of bucks should be planned to be conducted at nine months of age instead of yearling weight due to positive and higher genetic correlation value for NMWT-YWT and it will help to get better animals with superior genetic values before the farmers sell them for household needs.
- Implementation procedures of the community-based breeding programs including accurate data recording, sire rotation and management, retaining superior male kids in the flock up to selection, arranging time for selection of bucks before festive periods, access of adequate selected sires for mating, and frequent follow up of these procedures in routine basis still needs maximum care and attention for better progresses.
- On time response for required calls on vaccination and treatment of diseased animals, and frequent follow up of data collectors should be emphasized from the research side for better phenotypic and genetic progresses in the breeding program.
- Organizational capacity of cooperatives and monitoring system of implementing organizations should be enhanced. There should be a transparent and frequent auditing of the cooperatives revolving fund to build trust on the overall benefit from the program. There need to be a method that will benefit them in a short run from the common account.
- Subsequent and sustainable capacity development supports for members as considerable number of households still lack the understanding of the program implementation procedures as well as for the non-participating communities is crucial.

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APPENDICES

Annex 1 Survey questionnaire for participant cooperative members

Introduction

This study is part of SDARC-ICARDA/ILRI project collaboration work on community-based goat genetic improvement program. The purpose of this study is to evaluate the overall performances of currently undergoing CBBP cooperatives in terms socio-economic and technical criteria's. The objectives of this program at the start were improving the performances of indigenous Abergelle goat breed and enhancing the livelihood of smallholders from goat production. It's now 8 or more years since the program being implemented in these areas and it is time for evaluation of the impact that the program made to the community. This survey is aimed to evaluate the achievements of the program so far, lessons learned for next corrections and challenges faced in the program that needs future attention for wider scaling out of the program. We want to assure you that the information collected in this survey is confidentially used only for this research study.

Interviewer name:____________________________________ Date:__________________

District______________ Kebele ____________

GPS Reading: Altitude____________ Longitude_______________ Elevation___________

Questionnaire code:__________________

I. General demographic information

1. Farmer's name___________________________________Sex _________Age ________
2. Total family size________Male______Female_______
   No of family members that can read and write_______ Male______ Female_____
3. What is your major farming activity?
   a. Livestock production b. Crop-livestock mixed production c. other activities
4. Total land size ________(local unit)____________(hectare)
   Do you have own pasture land ________________ if yes, total pasture size________(ha)

5. Goat flock structure

Category	Before the program	Sale in last 12 months	Died in last 12 months	Predated/lost in last 12 months	Currently owned	Reasons for trend change
Male Kid						
Female Kid						
Weaned Male						
Weaned female						
Does						
Bucks						
Castrated						

This data for participant farmers will be cross checked with the actual monitoring and evaluation data.

II. Management of flocks and farmers knowledge of the breeding program

1. How did you judge fertility of does before the program
   a. Always single kidder b. Mostly single kidder c. Mostly twin kidder d. Rarely triplet kidder
2. Do you believe that the fertility rate has been improved in the program?
   a. Strongly improved b. Moderately improved and twin kidding increased c. No change at all d. I don't really know e. Totally not improved
3. Do you appreciate changes on age at first kidding and kidding interval of your does before and after the program?
   a. Yes I appreciate it clearly and reduced in month's b. Yes it reduced moderately c. Little reduction in kidding interval d. Not changed yet e. I don't really know
4. If your answer is yes in Q3 what do you believe the reasons for changes?____
   ____
   Do you know kidding interval before ____(months) and after the program____ (months)
5. Did you observe and appreciate inbreeding problem in your flocks? a. Yes, it has strongly reduced b. Yes, it has shown little reduction c. No change d. I don't know it e. it has increased
6. If your answer is yes in Q5 how sever is the problem? a. Very critical b. Critical c. Moderate d. easily manageable e. Not a problem
7. Do you think negative selection is a problem for productivity in your flock? a. Yes, it's a big problem b. Yes, it has some problem c. Not a problem d. I don't know it
8. What would you usually do with the 'best' buck born in your flock before the program?
   1. Sell them soon before they mature(less than one year)

2. Keep them for breeding for about three years
3. Keep them for breeding for more than three years
4. Keep them for fattening for some time
5. Others ________________________

9. What would you usually do with the 'best' buck born in your flock now?
   1. Sell them soon before they mature(less than one year)
   2. Keep them for the selection process
   3. Keep them for breeding for my flocks
   4. Keep them for fattening for some time
   5. Others ________________________
10. Do you have a breeding buck in your flock? A. Yes B. No
    If yes, where do you get the buck? a. selected from the community b. I'm using my own buck c. I'm using shared buck d. I don't really know where the does are mated
    If no, what is your reason not having breeding buck? a. Due to smaller flock size b. Due to shortage of selected bucks c. Due to lack of knowledge d. Others specify ____________________________.
11. How long would you keep breeding bucks in your flocks?
    a. Only for one year b. For two years c. More than two years
12. Did you observe changes on the growth performance of your goats at different ages like birth weight, weaning weight etc. after the program? a. Yes I observed much increase b. Moderately increased c. No change d. I don't know e. Decreased
13. Did you observe changes on the milk production performance of your goats after the program? a. Yes I observed much increase b. Moderately increased c. No change at all d. I don't know e. Decreased
14. What do you believe for the reason on the major changes in growth and milk production performance of your flock after the program if your answer is yes in the above questions? a. It is because of the impact of selection program b. It's because of the animal's natural performance c. I'm not sure on the change d. I don't know really about it
15. Do you provide supplementary feed to your animals? A. Yes B. No
    If yes, do you classify your animals in terms of age and service (pregnancy, milking) ? a. Yes b. No
16. Which group of the animals you provide supplementary feeding? a. Kids b. Pregnant does c. Milking does d. Older goats
17. Did you get veterinary health services like vaccination and treatments for your flocks? A. yes B. No
    If yes, how often do you get the service? ____________________________________.
    If yes, who provide this service? ______________________________.
    If yes, who covered the expense for the service ______________________________.
    If no, what is your reasons ____.

18. Have you ever trained on the following goat production and genetic improvement practices? How often? By whom? Fill in the table.

Types of trainings	Frequency/year	Who provided it	Remark
Goat husbandry and management (feeding, housing, health)			
Breeding objective traits and its importance in genetic improvement			
Selection of best animal and its use (rotation, lifetime)			
Record keeping for characteristics of goats			
Financial record keeping related to livestock management			
Marketing of goats (age, market type, conditioning, savings)			
Animal identification procedures and practices			

III. Socio-economic practice and progress

1. Would you practiced to keep performance records of your flock at your household? a. Yes always b. Most of the time c. Rarely d. Not at all
2. If your answer in Q1 is no, how could the performance of your flocks being recorded? a. It is done by enumerators' b. Performance data yet not recorded c. I don't see the benefit d. I don't know performance records
3. Do you keep records on expenditure and income from goat keeping? a. Yes, always b. Yes, most of the time c. Yes, rarely d. Not at all
4. If your answer in Q4 is no, what is your reason? a. I don't see the benefit b. It is time taking c. The format is to complicate d. No one can read and write e. Others specify ___________________
5. Does cooperative approach to improve goat breed suit the locally established social norm? 1. Yes 2. No
6. Is cooperative approach problematic to improve goat breed when it comes to work in group? A. Yes B. No
7. Is cooperative approach problematic waste of time as it involves only meetings? A. Yes B. No
8. Is cooperative approach to improve goat breed workable and widely acceptable in the community? A. Yes B. No
9. When would you sell your goats? Age category, season and reasons for sale

Category	Sex	Season of sale	Reasons for sale
Kids (< 6monts	Male		
	Female		
Yearlings	Male		
	Female		
Mature	Male		
	Female		

Seasons could be described as any time of the year, during festive periods….

10. Which age category of goat would you usually target for sale? a. Breeding buck b. Doe c. Young male (for meat) d. Young female e. Castrated

11. Marketing prices for your goats before and after the breeding program? How much did you sell your goat?

Category	Sex	Price before the program (range) ETB	Current Price (range) ETB	Trend in price change	Trend in no of animals sold
Kids (< 6monts	Male				
	Female				
Yearlings	Male				
	Female				
Mature	Male				
	Female				
Breeding	Male				
	Female				
Castrated					

12. Which category of your flock is usually planned for sale? a. Weaned males b. Weaned females c. Breeding does d. Breeding bucks e. Old does f. Unselected bucks

13. At what stage do you usually sell unselected bucks? ___________years.

14. Do you usually castrate unselected bucks in your flock for fattening purpose? A. Yes B. No

15. Do you practice fattening of unselected animals in your flock before selling? A. Yes, always B. Yes, sometimes C. Not started yet

16. If your answer in Q16 is yes, do you buy in some goats to your flock for fattening? A. Yes B. No

17. Average price of your unselected goats fetched in the market? Minimum_________ ETB Maximum________ETB.

18. Average price of your breeding goats (after finishing breeding service) fetched in the market? Minimum_________ ETB Maximum________ETB.

19. What would you say about income gained from sale of goat and its products in the last 8 years? a. Improved significantly b. Not changed c. Decreased

20. If your income from goat keeping increased over the last 8 years, what is the reason?
    a. Completely due to improvement in the goat breed
    b. Partly due to improvement in the breed
    c. Just due to increase in demand and price of goat over years
    d. Not easy to tell
    e. Other reasons_______________________________

21. Tell us for what purpose do you use the income from goat sell in order of importance?

Income from goat sale used for	Food purchase	Input purchase	Child study materials purchase	Bank saving	Others	Remark

22. Have you practiced slaughter of goat from the flock for household consumption over the last years? A. Yes B. No

If yes, how many goats you slaughtered for home consumption in a year? ____________

23. If your answer in Q22 is yes, when you slaughtered goats? a. Always as we want b. Sometimes c. Only during holidays

24. Consumption of goat meat at your household level after this program? a. Increased b. Decreased c. No change at all

25. Did you sell goat milk and its products in your community? A. Yes B. No

If yes, please describe the details in the following table

Category	Hh consumption (%)	Sold at local market (%)	Who mostly consume milk	Trend in consumption and sale before & after the program		Market price/kg
				Consumption	Sale	
Milk						
Milk products (specify the product						

26. What are the possible reasons for over all increased/decreased goat meat, milk and milk product consumption at your household?

____

27. How can you get your share of money from the cooperative? a. I'm saving my own money at all-time b. It is in common account c. I don't know where the money is d. Other specify______________

28. Did you face a problem for using the money from your sold animals to the community? A. Yes B. No

29. If yes, what are the problems you faced for

____

IV. Sustainability of the breeding program

1. Do you have a problem to access selected breeding bucks during peak breeding season? A. Yes B. No
2. Did you get frequent support from stakeholders (NGO, GO) other than research center? A. Yes B. No
3. Do you believe that the breeding program can suit with your seasonal flock migration in terms of accurate record keeping procedures? A. Yes B. No
4. Do you think the cooperative would sustain and continue to benefit its members if the migration seasons extended? 1. Yes 2. No
5. If no in Q2, what do you plan in the future? a. Leaving the cooperative b. Continuing the data collection through mobile (seasonal follow up) during migration c. I don't decide what I am doing
6. Do you know that the cooperative is supposed to sustain and operate without external support? 1. Yes 2. No
7. Do you believe the cooperative could sustain without external support? 1. Yes 2. No
8. Are you satisfied with the leadership of the committee? 1. Yes 2. No
9. Do you believe the committee (or member of the cooperative) have gained adequate skill to select best bucks? 1. Yes 2. No 3. I don't know
10. Have you been involved in any of the committees at any one time since its formation? 1. Yes 2. No
11. Would you continue to be a member of the breeding cooperative if technical and financial support stops? 1. Yes 2. No

V. Challenges in the CBBP

1. Mention all your challenges to participate in the CBBP?
2. Tell us your future stand to participate in the CBBP?

Annex 2. Questionnaire survey for non-participants

Interviewer name:______________________________________ Date:___________________

District_______________ Kebele _____________ Village ____________________________

GPS Reading: Altitude_____________ Longitude________________ Elevation____________

Questionnaire code:___________________

I. General demographic information

1. Farmer's name ____________________________________Sex _________Age ________
2. Total family size _________Male ______Female_______
   No of family members that can read and write_______ Male______ Female_____
3. What is your major farming activity?

b. Livestock production b. Crop-livestock mixed production c. other activities

4. Total land size ________(local unit)____________(hectare)
   Do you have own pasture land ________________ if yes, total pasture size________(ha)

5. Goat flock structure

Category	Flock size in the last 8 years	Sale in last 12 months	Died in last 12 months	Predated/ lost in last 12 months	Currently owned	Reasons for trend change
Male Kid						
Female Kid						
Weaned Male						
Weaned female						
Does						
Bucks						
Castrated						

VI. Management of flocks and farmers knowledge of the breeding program

1. How did you judge fertility of does in the last five or more years
   b. Always single kidder b. Mostly single kidder c. Mostly twin kidder d. Rarely triplet kidder
2. Do you believe that the fertility rate has been improved in your flock in these days?
   b. Strongly improved b. Moderately improved and twin kidding increased c. No change at all d. I don't really know
3. Average age at first kidding and kidding interval of your does ____________and ________ months in the last seven years.
4. Would you observed any change in traits at Q3 in current days?
   b. Yes I appreciate it clearly and reduced in month's b. Yes it reduced moderately c. Little reduction in kidding interval d. Not changed yet e. I don't really know
5. If your answer is yes in Q3 what do you believe the reasons for changes?____
   ____
6. Did you observe and appreciate inbreeding problem in your flocks? a. Yes b. No c. I don't know it
7. If your answer is yes in Q5 how sever is the problem? a. Very critical b. Critical c. Moderate d. easily manageable

8. Do you think negative selection is a problem for productivity in your flock? a. Yes b. No c. I don't know it

9. What would you usually do with the 'best' buck born in your flock?
   2. Sell them soon before they mature(less than one year)
   2. Keep them for breeding for about three years
   3. Keep them for breeding for more than three years
   4. Keep them for fattening for some time
   5. Others ___________________________

10. Do you have a breeding buck in your flock? A. Yes B. No
    If yes, where do you get the buck? a. selected from the community b. I'm using my own buck c. I'm using shared buck d. I don't really know where the does are mated
    If no, what is your reason not having breeding buck? a. Due to smaller flock size b. Due to shortage of selected bucks c. Due to lack of knowledge d. Others specify ________________________________.

11. How do you select breeding buck in your flock?
    a. ____
    b. ____

12. How long would you keep breeding bucks in your flocks?
    b. Only for one year b. For two years c. More than two years

13. Do you provide supplementary feed to your goats? A. Yes B. No
    If yes, do you classify your animals in terms of age and service (pregnancy, milking)? a. Yes b. No

14. Which group of the animals you provide supplementary feeding? a. Kids b. Pregnant does c. Milking does d. Older goats

15. Did you get veterinary health services like vaccination and treatments for your flocks? A. yes B. No
    If yes, how often do you get the service? ____.
    If yes, who provide this service? ___________________________________.
    If yes, who covered the expense for the service ____________________________________.
    If no, what is your reasons ____.

16. Have you ever trained on the following goat production and genetic improvement practices? How often? By whom? Fill in the table.

Types of trainings	Frequency/year	Who provided it	Remark
Goat husbandry and management (feeding, housing, health)			
Breeding objective traits and its importance in genetic improvement			
Selection of best animal and its use (rotation, lifetime)			
Record keeping for characteristics of goats			
Financial record keeping related to livestock management			

Marketing of goats (age, market type, conditioning, savings)			
Animal identification procedures and practices			
Other trainings not described here			

VII. Socio-economic practice and progress

1. Would you practiced to keep performance records of your flock at your household? a. Yes always b. Most of the time c. Rarely d. Not at all
2. If your answer in Q1 is no, how could the performance of your flocks being recorded? a. It is done by enumerators' b. Performance data yet not recorded c. I don't see the benefit d. I don't know performance records
3. Do you keep records on expenditure and income from goat keeping? a. Yes, always b. Yes, most of the time c. Yes, rarely d. Not at all
4. If your answer in Q4 is no, what is your reason? a. I don't see the benefit b. It is time taking c. The format is to complicate d. No one can read and write e. Others specify ____.
5. Are you aware of goat breeding cooperatives in your district? A. Yes B. No
6. If yes, how did you hear about it?
   a. From friends
   b. From Kebele DA's
   c. From local meetings
   d. Personal observation of the cooperative
7. How much do you agree or disagree on goat flocks of the cooperative members are better than none members?
   a. Strongly agree b. Agree c. Neutral d. Disagree e. Strongly disagree
8. Do you think improving local goat breeds through best buck selection would bring significant change in goat productivity and performance? A. Yes B. No C. Not sure
9. Do you think your doe's have access to mate in selected bucks in the breeding cooperative? A. Yes B. No C. Not sure
10. Did you see some of your kids sharing physical characteristics of selected bucks in the cooperative? A. Yes B. No
11. Do you share communal grazing land with the cooperative members? A. Yes B. No
12. If yes in Q11, how many months do you share grazing lands with cooperative members? _______________months.
13. Would you take your doe's to the best selected buck in your neighbor for mating? 1. Yes 2. No
14. If you are given a chance to buy best selected buck by the breeding cooperative would you be willing to pay higher premium and get the best selected buck? 1. Yes 2. No 3. Not sure
15. If you are given technical support by agricultural extension systems, will you be interested in forming similar goat breeding cooperative? 1. Yes 2. No 3. Not sure
16. How much do you agree or disagree on best buck selection is crucial for goat breed improvement?
    a. Strongly agree
    b. Agree

c. Neutral
d. Disagree
e. Strongly disagree

17. Do you think a cooperative approach to improve goat breed is widely acceptable and workable in this community? 1. Yes 2. No

18. When would you sell your goats? Age category, season and reasons for sale

Category	Sex	Season of sale	Reasons for sale
Kids (< 6monts	Male		
	Female		
Yearlings	Male		
	Female		
Mature	Male		
	Female		

Seasons could be described as any time of the year, during festive periods….

19. Which age category of goat would you usually target for sale? a. Breeding buck b. Doe c. Young male (for meat) d. Young female e. Castrated

20. Marketing prices for your goats before and after the breeding program? How much did you sell your goat?

Category	Sex	Price in last seven years (range) ETB	Current Price (range) ETB	Trend in price change	Trend in no of animals sold
Kids (< 6monts	Male				
	Female				
Yearlings	Male				
	Female				
Mature	Male				
	Female				
Breeding	Male				
	Female				
Castrated					

21. Which category of your flock is usually planned for sale? a. Weaned males b. Weaned females c. Breeding does d. Breeding bucks e. Old does f. Unselected bucks

22. At what stage do you usually sell unselected bucks? ____________years.

23. Do you usually castrate unselected bucks in your flock for fattening purpose? A. Yes B. No

24. Do you practice fattening of unselected animals in your flock before selling? A. Yes, always B. Yes, sometimes C. Not started yet

25. If your answer in Q16 is yes, do you buy in some goats to your flock for fattening? A. Yes B. No

26. Average price of your unselected goats fetched in the market? Minimum__________ ETB Maximum _________ETB.

27. Average price of your breeding goats (after finishing breeding service) fetched in the market? Minimum__________ ETB Maximum _________ETB.

28. What would you say about income gained from sale of goat and its products in the last 8 years? a. Improved significantly b. Not changed c. Decreased

29. If your income from goat keeping increased over the last 8 years, what is the reason?

a. Completely due to improvement in the goat breed

b. Partly due to improvement in the breed

c. Just due to increase in demand and price of goat over years

d. Not easy to tell

e. Other reasons__________________________________

30. Tell us for what purpose do you use the income from goat sell in order of importance?

Income from goat sale used for	Food purchase	Input purchase	Children study materials purchase	Bank saving	Others	Remark

31. Have you practiced slaughter of goat from the flock for household consumption over the last years? A. Yes B. No

If yes, how many goats you slaughtered for home consumption in a year? ____________

32. If your answer in Q22 is yes, when you slaughtered goats? a. Always as we want b. Sometimes c. Only during holidays

33. Consumption of goat meat at your household level after this program? a. Increased b. Decreased c. No change at all

34. Did you sell goat milk and its products in your community? A. Yes B. No

If yes, please describe the details in the following table

Category	Hh consumption (%)	Sold at local market (%)	Who mostly consume milk	Trend in consumption and sale before & after the program		Market price/kg
				Consumption	Sale	
Milk						
Milk products (specify the product						

35. What are the possible reasons for overall increased/decreased goat meat, milk and milk product consumption at your household?

____.

Annex 3 Focus Group Discussion Checklists

District ___________________ Community (Village) ___________________.

GPS coordinate of meeting location

Easting ________________ Northing _______________ Elevation ______________.

Number of participants present: Male _________ Female _____________.

I. Demographic characteristics of the goat breeding cooperative

1. Number of the household in the community (village) ________________.
2. Current number of members in the cooperative: Male ______ Female ______ Total __
3. Years in operation as formal cooperative: _________years.
4. Why and how did you form the cooperative?

____.

5. Members joining and drop-outs in the cooperative

   New members joining to cooperative: Male _______ Female ______ Total _____.

   Drop-outs from cooperative: Male _______ Female _____ Total ________.

6. Reasons for drop-outs

____.

II. Leadership

1. How many committees do you have (management structure, role of each, how they are supporting each other)?
2. How leadership committees are usually elected?
3. Number of committee members (for each)______Male _____Female______
4. Has change in leadership ever happened in the cooperative?
5. How many times leadership role rotated among members since its establishment and criteria to be elected? Who set the criteria?
6. How do you (mainly the committee members) assign responsibilities? Are there circumstances when particular responsibility is usually shared?
7. How do you manage the revolving fund (book keeping, participatory decision, conflict of interest, responsibility among committee members...etc)?

III. Technical performances and related issues

1. How would set the price for best bucks for the owners?

2. Benefits you gained from the cooperative (buck sharing, cash income, access to other support service due formation of the cooperative, experience sharing, better market, etc)? How income is distributed or capitalized to cooperatives asset.
3. What criterion do you use to select best bucks?
4. Mating ratio (male to female), proportion of bucks selected from all candidates for next mating and what drives the criteria?
5. How many rounds did you conduct selection of best bucks for serving the community?
6. How could you manage buck rotation modalities as per the by-law agreed at the start?
7. How would you ensure better management of the selected bucks?
8. What governs buck sharing practice in the cooperative?
9. How long would the selected bucks serve (serving bucks' age on average)?
10. Do you think all the principles at your by-law didn't create conflict with social norms in the area? Do you think some of them are barrier to progress in the cooperative?
11. Would you attempt to protect non members of the cooperative from using your selected bucks?
12. Did you totally avoid mating from unselected bucks in the cooperative?
13. Had any of bucks selected (and bought) by the committees had been found to be unacceptable by cooperative members? Or any complain?
14. Do you communicate progress and developments (including data and feedback about acceptance and functionality of the breeding program) in the cooperative regularly with the researchers? At what time intervals or how many times in a year or month?
15. Do you share information to and work with the district extension system? Is it on regular basis?
16. Do you think the breeding program is best suit with your seasonal flock migration pattern for future interventions? What do you think the best option for better data recording and best buck selection in this situation?

IV. Achievements and progress of the CBBP from farmers perception (perspective)

1. How the community perceived about the breeding program in comparison to non-participants and the activities they performed before the program like reverting negative selection and inbreeding problems?
2. How do you compare the performances (growth, milk production and reproduction and other characters) of your flock before and after the breeding program?
3. Do you believe your breeding cooperative is successful in meeting the breeding objectives set at the beginning of the program?
4. Did you appreciate overall management practices difference between participant and non-participants (value addition, supplementary feeding, health care etc…)?
5. Do you think and appreciated market price difference in selected bucks compared to other nonmember bucks?
6. Have you sold selected bucks out of the cooperative? Price difference of selected bucks sold to other community (individual) in comparison to unselected bucks?

7. How do you see government support, extension capacity to take over the activities and scaling out the breeding program?
8. How do you see access to other packages to the breeding program (forage development, fattening, health care and marketing)?

V. Capacity building, institutionalization and sustainability of the breeding program

1. How the participating community members in this area perceived about the cooperative breeding?
2. Do the committee members hold regular meeting with themselves and the whole members? Do they keep munities to share with the respective stakeholders?
3. Did the committee members receive any training related to cooperative management and related issues? By whom? Frequency? Experience to share with other members?
4. What supports do you get from district extension and cooperative offices? And what supports from research centers and international research organizations? Please compare the support they provided?
5. Revolving fund gained from supporting institutions (ICARDA/ILRI), how many rounds and management? What do you do with it?
6. The skill of cooperative committees and whole members to select best bucks without the help of technical researchers?
7. Do you think, the committee could select the best buck by its own and maintain management and functioning of the cooperative without technical support from outside (researchers, Government and ICARDA/ILRI)?
8. Do you think institutional arrangements starting from the organized cooperative committee through the higher international organizational levels were safe in the proper implementation of the cooperative breeding? Would these arrangements needed for the continuity of the program or the cooperative take over the whole task? Or do you believe that the continuation of the program always needs support from the respective institutions?
9. If the CBBP supported by ICARDA/ILRI and research systems phases out, what will happen to this breeding cooperative? Until what stage you need support?
10. Challenges encountered in the cooperative breeding (solved and unsolved)

Annex 4 Checklists for stakeholders (district livestock and cooperative offices, zonal livestock agency, NGO's, research organizations)

1. Information about the breeding cooperative in your district.
   a. Specific locations
   b. Year of establishment
   c. Objectives of the cooperative
   d. Direct and indirect benefits
   e. How your office work with the cooperative

2. Did you consider CBBSPs as a potential source of improved genotypes in your intervention areas (NGO's in the CBBP areas)?
3. How the CBBP line up with the district livestock development intervention?
4. How do you do to make the breeding scheme to be part of the extension system and possibility of scaling up?
5. How would you support the breeding cooperatives in terms of input provision, training and other services?
6. Do you have any comments on the different characteristics and applicability of the breeding scheme?
7. Did you use the breeding scheme as part of innovations (experiences) visited by farmers from other district or experts from (other) offices of agriculture?
8. What contributions do you think the breeding scheme has made in improving farmers' livelihood (thoughts, perceptions and attitudes)?
9. Challenges and opportunities?

BIOGRAPHICAL SKETCH

The author of this thesis, **Mr. Mulatu Gobeze Alamirew** was born on March 20, 1988, in Woynima Asess, Womberima District, West Gojjam Administrative Zone of Amhara Region, Ethiopia. He attended his primary school education in Woynima primary School, in Horeseka secondary school for his secondary education, and then, he attended his preparatory education at Burie Preparatory School in the Burie district. Then he joined Jimma University in 2099 to pursue his BSc study and graduated with a Bachelor of Science degree in Animal Science in June 2011. After graduation, he was employed by the environmental protection, land administration, and use office in Burie district and had been served as an animal science expert for 2 years. In December 2014, he was employed by Amhara Region Agricultural Research Institute at Sekota Dry-land Agricultural Research Center with a position of assistant researcher in forage development for two years and then transferred to small ruminant breeding in 2016. After working for five years in the center, he joined the School of Graduate Studies of Hawassa University in January 2020 to pursue his postgraduate study in Animal Breeding and Genetics.