



Original Paper

Phenotypic And Genetic Parameters for Growth Traits of Abergelle Goat in Community-Based Breeding Program Scale-Up Village

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Abstract— The objective of this research was to estimate genetic and phenotypic parameters for growth and milk production traits of Abergelle goats in a community-based breeding program (CBBP) scale-up village. The data used in the study was six years (2018-2023) data from the established village of goat community-based breeding program area. The traits studied were birth weight (BWT), weight at three months (TMWT), weight at six months (SMWT), weight at nine months (NMWT), yearling weight (YWT), direct heritability for growth and milk traits were computed by using WOMBAT software. A univariate mixed animal model was applied to estimate genetic parameters. Bivariate analysis was utilized to estimate correlations between traits. The overall least square mean of body weights $\pm$ standard errors (LSM $\pm$ SE) for BWT, TMWT, SMWT, NMWT, and YWT were 2.3 $\pm$ 0.04, 7.5 $\pm$ 0.03, 8.8 $\pm$ 0.040, 12.1 $\pm$ 0.067, and 15.3 $\pm$ 0.092 kg, respectively. The direct heritability estimates for BWT, TMWT, SMWT, NMWT, and YWT were 0.34 $\pm$ 0.070, 0.45 $\pm$ 0.062, 0.40 $\pm$ 0.040, 0.42 $\pm$ 0.07 and 0.41 $\pm$ 0.14, respectively. The phenotypic correlation of BWT with TMWT, SMWT, NMWT, and YWT was low but that of TMWT-SMWT, SMWT-NMWT, and NMWT-YWT was high and positive. The genetic correlations of birth weight with the studied growth traits were moderate but higher correlations were found among the other growth traits (SMWT, NMWT, and YWT), indicating as one of these traits increases; the others tend to increase as well. Therefore, birth weight as a growth trait had no strong relation with later stages of growth traits in this study for Abergelle goats in scale-up community-based breeding programs.

Keywords— Correlation, Estimation, Genetic parameter, Heritability, Repeatability

I. INTRODUCTION

Goats have been covering the widest ecological range and they can survive and reproduce on remote and marginal lands that often cannot be used for crop production. They occupy an important niche in the smallholder production system mainly due to low initial capital requirement, ability to produce food

and fiber at relatively low cost, production of milk and meat in readily useable quantities, relatively high rate of growth potential, marketability in a short period and ease of being managed by most family members [1]. Tropical Africa is largely characterized by an extensive production system, typically a low input-output system, which mainly depends on Indigenous goat's genetic resources [2, 3]. Ethiopia's large goat flock size was estimated to be 52.4 million [4]. They have been found in all agro-ecological zones. About one-third of goats in Ethiopia are found in the highlands. Almost all goat population is managed by resource-poor smallholder farmers and pastoralists under a traditional and extensive production system. In addition, smallholder farmers keep small ruminants for cash income, live bank as a failure of crop production, and meat, and milk consumption for their families [5]. But meat production per animal in Ethiopia was 9 kg which is less than Kenya by 3 kg and Sudan 6 kg. The total annual meat production from small ruminants was 154,000 tons per year [6]. It is relatively small compared with; the total flock size [7]. The potential for genetic improvement in economically important traits of goats in a selection program depends on the extent of the genetic variation and estimates of the genetic and phenotypic parameters [8]. However, before selection, knowledge of genetic variation and genetic parameters helps determine the method of selection, predict direct and correlated responses to selection, and choose a breeding system to be adopted for future improvement as well as in the estimation of genetic gains [9].

Abergelle goats are ever-present and an important component of the subsistence, economic, and social livelihoods of the rural poor farmers in the Wag-Himra zone. This breed has been found in all agro-ecologies and farming systems of Wag-Himera, along with the Tekeze River, Gondar, East Belsa, and in some parts of the Tigray region [10]. In all parts of the study area, goats are raised as a major source of cash income, milk, meat and manure for crop production [5]. In the Wag-Himra zone, the goat population was estimated to be

above 500,000 [4] more flocks were found in the lowland, and a huge flock size, which is 27 goats per household, was recorded [5]. The breed was characterized by its small body size compacted body structure and high adaptation to the harsh environment, and produce meat and milk for their producers in addition to cash income. Currently, the demand for red meat from small ruminants especially goat 'kurete' houses and hotels is increasing at domestic markets and Abergelle goat is contributing much more red meat supply to the local market. In the study area, selective breeding was implemented according to the breeding objective of farmers [5; 11] Scaling up a community-based breeding program in a participatory manner is the best approach for the sustainable breed improvement programs in the tropics [12, 13].

II. MATERIALS AND METHODS

A. Description Of The Study Area

The study was conducted on farms by the Sekota Dryland agricultural research center in Addis Mender and Alquzu villages in Sekota and Ziquala districts, respectively. Sekota and Ziquala districts were found in the Wag-Himra zone in the Amhara region in the northern parts of Ethiopia. Sekota district is located 720 km away from Addis Ababa and 430 km from Bahir Dar, the capital city of the Amhara Region at an altitude of 2200 m.a.s.l and at 12° 41' 11.92" N and 39° 00' 58" E. Annual rainfall ranges between 350 - 700 mm, falling mainly from July to September. The pattern and distribution of the rainfall is erratic and uneven. Average temperature ranges from 16-27°C [14]. The vegetation can be characterized as being semi-arid shrubs dominated by various *Acacia* species with a sparse ground cover of annual grasses. The district is characterized by a long dry season lasting from October to June [13].

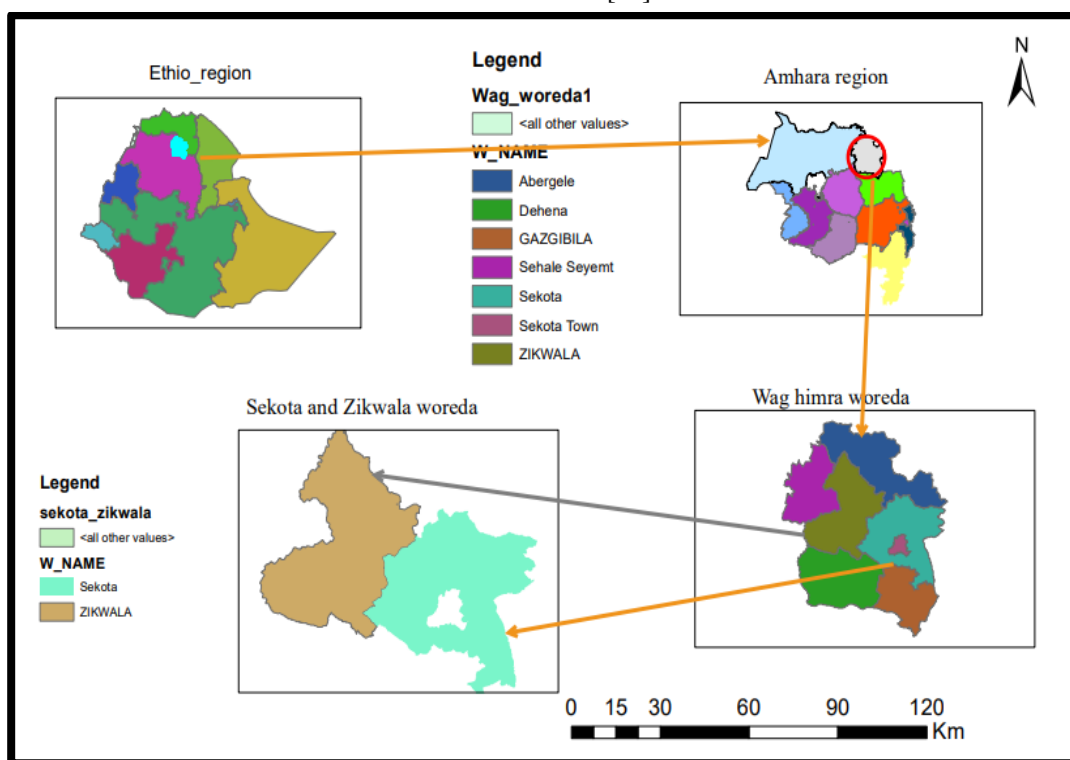


Fig. 1. Map of the study area

B. Data Source And Experimental Design

The empirical data and pedigree data for the study were obtained from this ongoing scale-up CBBP village in Addis Mender and Alquzu in Sekota and Ziquala districts, respectively, Under the Sekota Dry-land Agricultural Research Center (SDARC). The research staff of the program from SDARC and other partner institutes like ICARDA was carrying out regular follow-up of both functionality of scale-up village and record-keeping practices by enumerators. Performance data was recorded, as per the performance record format prepared by ICARDA. The performance data along with pedigree information is being maintained in data recording books of individual villages. The data routinely

collected by the enumerators were at birth, the relevant information about newborn kids such as owners, which is the name of farmers, birth date, kid sex, birth type, kids' birth weight, doe parity, sires ID, and doe ID were recorded. Periodically collected data were checked before entering the computer and reported to SDARC at least two or three times a month. The data utilized in the present study were (i) growth trait data, namely birth weight (BWT), three-month weight (TMWT), six-month weight (SMWT), nine-month weight (NMWT), yearling weight (YWT).

C. Data Adjustment

Three-month weight, six-month weight, nine-month weight, and yearling weights were adjusted at fixed ages of 90,180, 270, and 360 days, respectively, as under :

$$\text{Adjusted three-month weight (kg)} = \frac{90(TMWT - BWT)}{D + BWT} \dots\dots(1)$$

$$\text{Adjusted six-month weight (kg)} = \frac{180(SMWT - BWT)}{D + BWT} \dots\dots\dots(2)$$

$$\text{Adjusted nine-month weight (kg)} = \frac{270(NMWT - BWT)}{D + BWT} \dots\dots(3)$$

$$\text{Adjusted yearling weight (kg)} = \frac{360(YWT - BWT)}{D + BWT} \dots\dots\dots(4)$$

Where:

BWT = Birth weight;

TMWT = Three-month weight on a given fixed date;

SMWT = Six-month weight on a given fixed date

NMWT = Nine-month weight on a fixed date

YWT = Yearling weight on a fixed date

D = Number of days between weighing date and date of birth

D. Statistical Analysis of Data

1) Effects of Non-Genetic Factors

Data used for the analysis included birth weight, three-month weight, six-month weight, nine-month weight, and

yearling weight. Before conducting the main analysis, data were coded and entered into the computer for analysis, and preliminary data analysis such as a normality test was employed. Then, data were analyzed using the General Linear Model (GLM) procedure of SAS version 9.0 (SAS, 2003). The non-genetic factors used in the model included year of birth/kidding (2018 to 2023), season (wet and dry season), sex (male and female), parity (1, 2, 3, 4, 5, 6, and ≥ 7), birth type (single and twin) and site (Alquzu and Addis mender). The Tukey test was used to separate least squares means. Thus, the following statistical model was used.

Model for growth

$$Yijklmn = \mu + \pi_i + \sigma_j + \beta_k + \gamma_l + \delta_m + \epsilon_n + e_{ijklmn} \dots(5)$$

Where:

Yijklmn = growth and daily weight gain traits for each animal

μ = overall mean,

π_i = with parity (i=7; 1, 2, 3, 4, 5, 6, and ≥ 7)

σ_j = jth location (j= Alquzu and Addis mender)

β_k = kth birth type (k =2; single, twin)

γ_l = lth year (l= 6; 2018 -2023)

δ_m = mth season (m= wet and dry season)

ϵ_n = nth sex (n = male, and female)

eijklmn = random error.

Description of pedigree structure and performance data used for genetic parameter analyses is presented in Table1. The parent recorded in the pedigree data includes bucks, dams, and bucks with its progeny records and dams with its progeny records.

TABLE I. DESCRIPTION OF DATA SET FOR GROWTH

No of records	BWT	TMWT	SMWT	NMWT	YWT
Number of records	1989	1335	1211	986	846
Sires with records & progeny	54	54	54	48	43
Dams with records & progeny	635	607	428	404	344
Maximum	3.4	9.6	19.9	24.6	28.4
Minimum	1.1	3.8	7	8.6	10.4
Mean	2.06	7	7.2	11.5	15.3
SD	0.34	0.67	2.12	1.8	3.6
CV	19.5	18	17	19.4	21

Note: - BWT=birth weight, TMWT= three month weight, SMWT= six month weight, NMWT=nine month weight, YWT= yearling weight

2) Effects of Non-Genetic Factors

The variance components and resulting genetic parameters were estimated in a mixed animal model fitting fixed effects of parity, year of kidding, season of kidding, type of birth, and sex as fixed factors for growth and milk production traits. Genetic parameters estimation for growth and milk production traits were estimated using WOMBAT software [15]. WOMBAT is a freely available software package for mixed linear model analysis in quantitative genetics with a focus on the estimation of variance components and genetic parameters with restricted maximum likelihood (REML), primarily in animal breeding applications.

Then the fixed effects were fitted in the model for estimating genetic parameters. Mixed univariate animal models were used to estimate the genetic parameters. Direct additive genetic effect and permanent environmental effect was fitted as random effects for growth in the given model below.

$$y = Xb + Z_1a + Z_2pe + e \dots\dots\dots(\text{Model 1})$$

Where y is a vector of observed traits of animals; b, a, pe, and e are vectors of fixed effects, direct additive genetic effect of the animal, maternal permanent environmental effect of the dam, and residual effect, respectively; X, Z₁, Z₂= Incidence matrices, respectively relating fixed effects, direct additive genetic effects and maternal permanent environmental effects

Estimation of phenotypic and genetic (Co) variance components for traits was estimated with a multivariate animal model of five growth traits with the fixed effects of sex, season, parity, birth type, and year of birth, and a numerator relationship matrix was used.

$$Y = Xb + Z1a + e \dots\dots\dots(\text{Model 2})$$

WOMBAT software is used to estimate phenotypic and genetic correlations, often in the context of animal breeding and quantitative genetics.

where Y is vector of observations for traits, b is a vector of fixed effects for growth traits (sex, birth type, season of birth and year), a is a vector of random animal effects for the traits, and e is a vector of random residual effects for traits, and X and Z are incidence matrices relating records for traits to fixed and random animal effects, respectively.

III. RESULTS AND DISCUSSION

A. Growth Performance of Abergelle Goats in Scale-up CBBP Village

Season, year of birth, parity, and sex had significant effects ($P < 0.001$) on birth weight (Table 2). Nevertheless, the village did not a significant effect on birth weight ($P > 0.05$), but the birth type had a significant influence ($P < 0.05$) on birth weight. Regarding three-month weight, six-month weight, nine-month weight, and yearling weight, both village and season demonstrated significant effects ($P < 0.01$). Parity had a significant effect ($P < 0.05$) on three-month weight and nine-month weight but had no significant effect on six-month and yearling weights. Notably, the type of birth significantly influenced three-month weight, while year of birth and sex did not exhibit significant effects on three-month weight. Moreover, the birth year and season had highly significant effects ($P < 0.001$) on six-month weight, whereas birth type significantly affected three-month weight but not six-month, nine-month, and yearling weights ($P > 0.05$), as indicated in Table II.

B. Birth Weight (BWT)

Sex, year, and parity had a highly significant effect ($P < 0.001$) on birth weight. Moreover, season and birth type had a significant effect ($p < 0.005$) on birth weight but the village had no significant effect ($p > 0.05$) on birth weight. There was an incremental trend in birth weight based on the type of birth-born kids who showed higher birth weight than twin-borns. This study was in line with [16], who reported for the same breed, and the Rift Valley family reported by [17]. According to the authors, the possible reason for these trends should be the limited uterine space during pregnancy within twins rather than single and competition for nutrients of dam especially during the last trimester of pregnancy. In this study, males were heavier than female kids this should be due to the effect of hormones in males and females. This result is in line with the Central Highland goat breed [18]. The present study revealed that birth weight had shown significant increase and decrease across years the birth weight trends across the years. These factors, such as the availability of forage and management practices, potentially affect birth weight both positively and negatively. Additionally, the management

system fluctuates annually, and the dynamic environmental changes, consequently, birth weight may rise in one year and decline in the next due to these changeable factors, which lie out of the researcher's control. BWT of Abergelle goat 2.3 ± 0.02 kg was not comparable with BWT (2.68 ± 0.13 kg) of Central Highland goats [19] and it is higher than the same families Woyto Guji breed 2.03 kg [19]. BWT of Abergelle goat in the scale-up CBBP village was found to be greater than the one reported by [20], for the same breed which is 2.01 ± 0.03 kg and less than that of the Central Highland breed reported by [21], which is 2.66 ± 0.03 kg.

C. Three Month Weight

Season and village had a highly significant effect on three-month weight ($p < 0.001$). Parity, sex, and birth type also showed a significant effect ($p < 0.05$), but years of birth had no significant effect on three-month weight as shown in Table 2. The least squares mean (LSM $\pm$ SE) of TMWT in two scale-up villages were 8.13 ± 0.038 and 7.38 ± 0.09 kg in Addis Mender and Alquzu villages, respectively. The pair-wise comparison of the means showed that a TMWT difference between villages was highly significant; this may be due to variations in management and availability of feed in the study village. Single-born kids were 7.85 ± 0.053 kg, which is heavier than twin-born ones (7.51 ± 0.05 kg). This effect may be attributed to the lesser availability of uterine space horns for twin births, prenatal nutrition/ development, and also competition for dams' milk during the pre-weaning period [22]. Male kids were insignificantly heavier than female kids in three-month weight, and both male and female kids experienced shock due to weaning, feeding availability, and shortage. Goats are seasonal breeders; almost all the birth of goats is from September to October. In contrast to the result of this study, [23] reported male kids and female kids had significantly different three-month weights. The differences in three-month weight observed between the sexes might be due to differences in hormones and physiological functions.

TMWT was highest in kids born in the wet season (8.03 ± 0.03 kg) and lower in the dry season (7.68 ± 0.049 kg). Differences in TMWT in wet and dry season could be associated with surplus and availability of browsing and grazing forages and in dry season the kids face prolonged and severe shortage of browsing forage and lack of crop residues. This study disagrees with the report of [24], three month weight for Woyto Guji goats (9.32 ± 2.28 kg) which is greater than from the present study.

Three-month weight among possible pairs of years of birth had significant effects except between 2018-2022 and 2019-2021 years which were non-significant. The possible reasons for year-wise variation in the TMWT may be due to variations in the management and environmental conditions including feeding and uncontrolled factors of the year. Results obtained in the current study were nearly comparable with the same breed reported by [25]. However, the three-month weight of the Abergelle goat was lower than the Central Highland goat in the same management system as reported by [21] which is 9.32 ± 2.28 kg. On the other hand, under a similar management system in CBBP on the same breed, the TMWT of the current study (7.5 ± 0.036 kg) is higher than the three-month weight

(7.2 kg) reported by [16]. TMWT in this study was 7.5 ± 0.03 kg nearly comparable with the same breed reported (7.40 ± 0.09 kg) by [26]. However the three-month weight of the Abergelle goat was lighter compared with the Central Highland goat in the traditional management system [21]. In a similar management system in CBBP on the same breed, the three-month weight in the current study (7.5 ± 0.036 kg) was higher than the three-month weight (7.2 kg) reported by [16].

D. Six-Month Weight (SMWT)

The overall least square mean of SMWT was 8.8 ± 0.040 kg. Village and season had a highly significant effect on six-month weight ($p < 0.001$) and year of birth had a significant effect ($p < 0.05$), while sex, parity, and type of birth had no significant effect on six-month weight as shown in Table 2. male and female in this study had same six-month weight, the possible reason that the sample size taken to this study was not equal, therefore it makes equal six months weight in six-month ages. While males and females may have different physiological responses to diets even if they are in the same management and feeding practice, differences in muscle mass, metabolism, or fat distribution), it is possible that both sexes adapted similarly over six months. Parity is also non-significant in six-month weight, as goats reach higher parities (6), their reproductive efficiency might begin to decline. After a certain number of parity, goats may experience a decrease in fertility, health, or vitality, which could cause the relationship between parity and reproductive outcomes, litter size, weight, or growth rates to become less significant at parity 6 [27]. The least squares mean (LSM $\pm$ SE) of SMWT for the village (locations) was 9.8 ± 0.038 and 8.5 ± 0.090 kg in the Addis Mender and Alquzu districts, respectively. The highest SMWT in Addis Mender village was due to the management of animals and availability of feed. Goat keepers in Addis Mender village used some improved forage crops cowpeas. In addition to this, there was the mobility of animals to search for surplus feed at times of feed shortage following the Tirari River around Zata, Korem, and East Belesa [28]. The least-square means of SMWT in the present study was 9.2 ± 0.05 kg for single and 9.18 ± 0.05 kg for twin births, respectively.

The single-born kids were not significantly heavier in SMWT than twin-born kids. This trend was not possibly like a carryover effect of BWT and TMWT where single-born kids had the highest respective weights. This might be due to Single-born kids not receiving better nutrition or growth conditions compared to twin-born kids during the specific measurement period for SMWT. And also Sex had no significant effect on SMWT ($p > 0.05$). The present result disagrees with previous studies in other Indigenous cross breeds [29, 30] and agrees with the same breed reported by [26]. SMWT has not linearly increased over the years; this stagnation could be attributed to several factors. One potential reason is the absence of precise selection of breeding bucks, implying that genetic factors influencing weight gain might not have been adequately addressed. Additionally, there may have been insufficient follow-up procedures or gaps in the skills of data recorders, leading to inaccuracies in data collection. Furthermore, variations in the availability of feed and other environmental conditions from year to year could also contribute to the observed differences in goat weights.

Seasonal fluctuations of weather conditions have positive and negative effects on browsing shrubs and trees and sometimes there can be a prolonged dry season and increased shortage of feed. The current study of SMWT (8.8 ± 0.040 kg) of Abergelle goats disagrees with the performance of Central Highland goats reported by [22], which is 10.6 ± 0.60 kg and disagrees with Woyto-Guji Goats under Traditional Management Systems 13.32 ± 1.59 kg reported by [24]. The result also disagrees with the performance of Bati, Short-eared Somali, and Borana which is (16.31 ± 0.02 , 13.9 ± 0.22 , and 13.75 ± 0.36 kg, respectively [17].

E. Nine-Month Weight (NMWT)

The overall least square mean of NMWT was 12.1 ± 0.067 kg as shown in Table II. Sex, village, season, and parity had significant effects on NMWT ($p < 0.05$) but type of birth and year of birth had no significant effect on NMWT ($p > 0.05$), as shown in Table 4.2. The least-square mean (LSM $\pm$ SE) of NMWT for the village was 14.1 ± 0.06 and 11.4 ± 0.12 kg in Addis Mender and Alquzu, respectively, ($p < 0.001$). The least-square means of NMWT for single and twin kids were 12.76 ± 0.11 and 12.69 ± 0.07 kg, respectively. This trend was possibly not a carryover effect of BWT and TMWT where single-born kids had the highest respective weights. The NMWT in males and females had no significant effect ($p > 0.05$). The present result disagrees with previous studies on Sirohi goat type 15.29 ± 0.41 kg [31]. Year of birth was a significant source of variation for NMWT and pairwise differences were significant in 2018-2019, but 2019-2020 and 2018-2023 had no significant effect. NMWT across years of birth showed that the highest NMWT was recorded in 2020, 12.96 ± 0.14 , and the lowest NMWT in 2021, 2020, and 2018. This may be associated with the lack of accurate buck selection, inadequate follow-up, and gaps in the enumerator's data recording skill. The other reason could be the difference in year-to-year variation in the availability of feed and other environmental conditions. The nine-month weight of Abergelle goat in the scale-up CBBP village was (12.1 ± 0.067 kg) not comparable with the NMWT of central highland goat (17.76 ± 1.01 kg) reported by (Solomon Abegaz. et al, 2020); and in line with the same breed [16] which is 12.76 ± 0.26 kg under community-based breeding program area. However, under the traditional management system, the present study on NMWT was lower than Woyto-Guji Goats, which is 15.89 ± 2.94 kg [24]. Nine months of weight in a year had the trends of decreasing except from 2019 to 2020, this might be the inefficient use of breeding bucks, and premature sale of breeding bucks in community-based breeding programs of Abergelle goats [32]. These results imply that factors such as sex, village, season, and parity significantly influence the NMWT of Abergelle goats, while the type of birth and year of birth do not have a significant impact on nine-month weight. Year of birth also plays a crucial role in NMWT as source variation, with certain years showing significant differences in nine-month weight. This study suggests the importance of considering these factors in breeding and management practices to optimize the weight of Abergelle goats in various contexts, such as community-based breeding programs or traditional management systems.

F. Yearling Weight

In the present study, the overall least square mean (LSM±SE) of YWT was 15.3±0.04 kg. The effect of birth type, parity, and sex was non-significant on yearling weight ($p>0.05$) as shown in Table II. This study revealed that multiple birth was encouraged because at market age the single and twin born animals had similar weight. The least squares mean (LSM±SE) of YWT were 16.1±0.17 and 14.9±0.10 kg in Addis Mender and Alquzu, respectively. The pair-wise comparison of the means showed that YWT differences between pairs of villages were highly significant ($p<0.001$). Single and twin-born animals had a yearling weight of 15.43±0.14 and 15.37±0.15 kg respectively; that birth type had no significant effect on yearling weight. Other authors mentioned that the differences in yearling weight between the sexes might be due to differences in hormones and physiological functions

between the two sexes [22;33]. Yearling weight was lower in the dry season (14.6±0.16 kg) and higher in the wet season (15.8±0.103 kg), since the wet season possibly provided optimum conditions for the growth of animals. The variation in kids' growth up to yearling age in the dry season was distinct from those observed in the wet season. The seasonal impact correlates with variations in both feed availability and disease prevalence [34]. The YWT differed significantly among potential pairs of birth years, notably between 2018-2019, 2018-2021 and 2018 with 2023, as well as between 2019 and subsequent years. However, there was no significant effect on yearling weight observed between 2019-2021 and 2020-2023. Variations in YWT across different years could be attributed to differences in management practices and environmental conditions, including feeding regimes and inefficient selection of breeding bucks and mating modality followed.

TABLE II. LEAST SQUARES MEANS (LSM±SE) OF WEIGHT AT DIFFERENT AGES OF ABERGELLE GOATS

Source of	N	BWT LSM±SE	N	TMWT LSM±SE	N	SMWT LSM±SE	N	NMWT LSM±SE	N	YWT LSM±SE
Overall	1989	2.3±0.04	1335	7.5±0.03	1211	8.8±0.040	986	12.1±0.067	846	15.3±0.092
CV%		16.5		18.08		19.4		17.3		15.6
Village		NS		***		***		***		***
Addis mender	793	2.2±0.05	275	8.1±0.038 ^a	304	9.8±0.038 ^a	230	14.1±0.06 ^a	230	16.1±0.17 ^a
Alquzu	1145	2.2±0.08	1060	7.3±0.09 ^b	907	8.5±0.090 ^b	756	11.4±0.12 ^b	616	14.9±0.10 ^b
Sex		***		*		NS		*		*
male	974	2.3±0.05 ^a	671	7.60±0.05 ^a	613	9.1±0.12	461	12.8±0.11 ^a	461	15.6±0.14 ^a
female	964	2.2±0.07 ^b	664	7.47±0.09 ^b	598	9±0.13	525	12.6±0.07 ^b	525	15.4±0.18 ^b
Type B		*		*		NS		NS		NS
single	1785	2.30±0.05 ^a	1227	7.8±0.04 ^a	1129	9.2±0.05	938	12.7±0.1	812	15.5±0.14
twin	153	2.20±0.05 ^b	108	7.5±0.05 ^b	82	9.18±0.05	48	12.6±0.07	34	15.3±0.15
season		*		***		***		*		**
wet	1287	2.3±0.08 ^a	904	8.0±0.04 ^a	807	9.3±0.6 ^a	652	13.2±0.08 ^a	543	15.8±0.103 ^b
dry	651	2.2±0.05 ^b	431	7.6±0.04 ^b	404	8.9±0.04 ^b	334	12.3±0.08 ^b	303	14.6±0.16 ^c
Year		***		*		*		*		*
2018	527	2.2±0.08 ^c	319	7.7±0.08 ^b	272	8.9±0.08 ^c	162	12.8±0.19 ^a	117	16±0.24 ^a
2019	300	2.3±0.01 ^b	208	7.9±0.06 ^a	187	9.1±0.09 ^c	157	12.6±0.14 ^b	144	14.7±0.22 ^c
2020	338	2.2±0.01 ^c	229	7.9±0.09 ^a	212	9.09±0.09 ^c	185	12.9±0.14 ^a	147	15±0.24 ^b
2021	365	2.4±0.01 ^a	228	7.9±0.09 ^a	218	9.3±0.10 ^b	178	12.5±0.16 ^b	135	15.4±0.21 ^b
2022	408	2.3±0.07 ^b	351	7.7±0.06 ^b	322	9.2±0.07 ^b	304	12.5±0.11 ^b	303	15.2±0.141 ^b
2023	472	2.1±0.02 ^d	384	7.2±0.05 ^c	334	9.7±0.04 ^a	124	12±0.01 ^d	62	15.2±0.13 ^b
Parity		***		*		NS		*		*
1	323	2.2±0.01 ^c	239	7.5±0.09 ^e	221	8.8±0.08	189	11.8±0.15 ^c	158	15.2±0.21 ^c
2	330	2.2±0.01 ^b	239	7.6±0.06 ^c	223	8.8±0.09	175	12.3±0.18 ^c	155	15.5±0.24 ^b
3	402	2.4±0.04 ^a	220	7.7±0.08 ^b	214	8.8±0.07	179	12.5±0.15 ^b	154	15.2±0.21 ^c
4	354	2.3±0.08 ^a	242	7.4±0.08 ^c	232	8.8±0.10	186	12.2±0.12 ^b	168	15.0±0.17 ^c
5	229	2.2±0.01 ^c	179	7.4±0.09 ^e	149	8.9±0.10	126	11.6±0.17 ^c	110	15.5±0.27 ^b
6	246	2.2±0.01 ^c	191	7.6±0.11 ^d	148	8.7±0.12	113	11.9±0.19 ^c	83	15.1±0.30 ^b
7≥	54	2.2±0.03 ^c	25	8.5±0.34 ^a	24	9.2±0.34	18	14.6±0.44 ^a	18	16.9±0.62 ^a

Type B=Type of birth, BWT, birth weight; TMWT, three-month weight; SMWT, six-month weight; NMWT, nine-month weight; YWT, yearling weight***, $p<0.001$; **, $p<0.01$; *, $p<0.05$; NS, $p>0.05$; N, number of observations; CV, coefficient of variation; LSM, least square means, Least squares means with different superscripts within the same column and class are statistically different.

Estimation Of Genetic Parameters For Abergelle Goats In CBBP Scale-Up Village

Genetic parameters are very important tools that help to make decisions on the fate of individuals and on the strategy on how to exploit the population sustainably. It includes Heritability (h^2) Repeatability (r) and Correlation. Estimates of direct heritability for growth traits in goats in the CBBP scale-up village were shown in Table III. For birth weight, 44.4% of the variance is due to genetic factors, and 55.6% is due to environmental factors. The direct additive variance shows an increase as the age of animals increases at different growth

stages starting from birth to yearling weight. The variance increases as the age of animals increases, from birth to yearling weight; it suggests that the genetic contribution to growth is becoming more pronounced as the animal matures. There may be several potential reasons for this: increasing genetic expression with age at younger ages, the growth of animals may be more influenced by environmental factors (such as nutrition, disease, or maternal effects) than by genetic factors. As animals age, their genetic growth potential may begin to more fully express itself. this study used selective breeding and selection was at yearling weight which may increase the direct

additive variance at these stages. In such cases, genetic improvement might be targeted more towards growth later in life, so the genetic differences between animals become more evident at those ages. This would lead to an increase in the proportion of variance attributable to direct additive genetic factors. Growth in animals was not linear rapid from birth and three months or weaning age and decreased from six month age to yearling age. Heritability results at different age groups for growth traits varied from low to high. The estimates of direct heritability (h^2) for BWT, TMWT, SMWT, NMWT, and YWT were 0.34 ± 0.070 , 0.45 ± 0.062 , 0.40 ± 0.040 , 0.42 ± 0.07 and 0.41 ± 0.14 respectively. Direct heritability in birth weight was low from other growth traits. Direct heritability (h^2) reflects the proportion of phenotypic variance attributable to direct genetic effects. A high direct heritability estimate (h^2) for three-month weight was found which is 0.45 ± 0.062 and potentially high influence of genes on three-month weight which agrees on three-month weight direct heritability of Nigerian Sahalian goat and similar to small ruminant on Bharat merino sheep that direct heritability as a report of [35;36] which is 0.45 and 0.43. Notably, the direct heritability demonstrates an increase across successive growth stages, starting from birth weight to three-month weight and then decreasing to six-month weight. The present result is in line with the report of [37;38], who observed a decline up to six months followed by an increase up to the yearling age and also similar to the report for Arsi-Bale goats [1]. In the present study, the direct heritability of three-month weight was greater than Balkan goat which is 0.110 ± 0.044 [39]. However, the relative contribution of direct heritability for each growth trait can vary depending on the management practices of animals [40]. In the present study, environmental factors such as browsing and grazing forage, quality and quantity of feed can significantly impact the expression of genes on the growth traits in goats. Nutritional deficiencies or imbalances can affect growth rates, and overall health. Potentially difficult to estimate genetic parameters and environmental effects on phenotypic expression, management practices can have significant effects on how an animal expresses certain traits. For instance, if goats are housed in crowded conditions, this could lead to increased stress and poor health outcomes, which could affect their growth traits. The observed phenotypic expression of the growth traits might not solely reflect genetic potential but also the environmental conditions they are raised. Therefore, the estimated genetic parameters may be skewed or influenced by environmental factors, making it harder to isolate the true genetic influence. Management practices, such as housing conditions, sanitation, and handling procedures can influence goat behavior, stress levels, and susceptibility to diseases. These environmental management practices can relate to genetic factors, making it challenging to accurately estimate genetic parameters.

The harsh climate and weather conditions environmental variables like temperature, humidity, and precipitation can affect goat productivity and health. Extreme weather events or seasonal changes may impact traits such as milk production, growth rates, and disease resistance, complicating genetic evaluations. Goats are susceptible to external parasites, including worms, ticks, and lice. Parasite infestations can reduce feed efficiency, stunt growth, and weaken immune responses, potentially masking genetic differences among

animals. Health status and disease outbreaks or chronic health issues within a goat population can influence the accuracy of genetic parameter estimates. The estimate of direct heritability in six-month weight in this study exceeded those reported by [41] for the Jamunapari goat breed (0.14 ± 0.04) and, Markhoz goats 0.22 ± 0.05 [42] for Naeini goats 0.25 ± 0.05 , and [43] and [44] for Markhoz goat breed (0.25 ± 0.05). However, it is in line with the values reported by [45] for Nigerian Sahelian goats (0.41 ± 0.08) and [1] for Arsi-Bale goats 0.39 ± 0.08 , [46] for Sirohi goats 0.39 ± 0.05 and similar for Egyptian Zaraibi goats was 0.43 ± 0.05 [47]. The direct heritability (h^2) of nine-month weight was determined to be 0.42 ± 0.07 in the scale-up CBBP village. For six-month weight, about 87% of the variance is due to genetic factors, while the remaining 13% is due to environmental factors and for birth weight, 44.4% of the variance is due to genetic factors, and 55.6% is due to environmental factors. The differences in the estimates among these investigations can be attributed to variations in data organization, recording accuracy, management techniques, utilized methodologies, and potential impacts from inbreeding (in this study the inbreeding coefficient is zero and the breeding bucks were allocated randomly but inbreeding occurred in the real situation. Random mixing of different flocks happened in the communal land during browsing and grazing. The direct heritability of the yearling weight of Abergelle goats in the present study was 0.41 ± 0.14 which agreed with the report of [35]. In general, for the weight traits, heritability varies from low to high. This result implied that high estimated heritability indicates that the live weight of the animal might be simply improved by the selection of breeding bucks.

TABLE III. HERITABILITY ESTIMATE OF WEIGHT AT DIFFERENT AGE GROUPS

Trait	BWT	TMWT	SMWT	NMWT	YWT
h^2	0.34 ± 0.070	0.45 ± 0.062	0.40 ± 0.040	0.42 ± 0.07	0.41 ± 0.14
σ_a^2	0.04	0.28	0.67	0.7	0.71
σ_p^2	0.09	0.08	0.77	0.88	0.75
σ_e^2	0.05	0.04	0.06	0.84	0.93

BWT=birth weight, TMWT=three month weight, SMWT=six month weight, NMWT=nine month weight, YWT=yearling weight, h^2 = heritability, σ_a^2 = additive variance, σ_p^2 = phenotypic variance, σ_e^2 = residual variance, h^2_a = direct additive variance

G. Phenotypic and Genetic Correlations

The estimates of phenotypic and genetic correlations for different growth traits obtained from the bivariate analysis of the animal model are presented in Table VI. Phenotypic correlations are better at evaluating the effect of both genetic and environmental variation 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 agree with the result reported by [48]. Phenotypic correlations of BWT with later growth stages were low in comparison to the reports of [48] and [1]. 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 [1] and [48] for indigenous Arsi-Bale and Central Highland X Boer goat breeds, respectively. These higher phenotypic correlation

values mean that heavier weight of kids at three months of age tend to attain heavier weights at later stages of growth.

TABLE IV. PHENOTYPIC (BELOW DIAGONAL) AND GENETIC (ABOVE DIAGONAL) CORRELATION FOR GROWTH

TRAITS	BWT	TMWT	SMWT	NMWT	YWT
BWT	1	0.23±0.014	0.12±0.128	0.09±0.15	0.091±0.04
TMWT	0.068± 0.02	1.00	0.87±0.043	0.67±0.071	0.71±0.017
SMWT	0.044±0.025	0.84±0.08	1.00	0.89±0.053	0.72±0.05
NMWT	0.029±0.026	0.65±0.02	0.68±0.017	1.00	0.74±0.014
YWT	0.018±0.043	0.42±0.03	0.47±0.026	0.58±0.03	1.00

BWT, BIRTH WEIGHT; TMWT, THREE-MONTH WEIGHT; SMWT, SIX-MONTH WEIGHT; NMWT, NINE-MONTH WEIGHT AND YWT, YEARLING WEIGHT

Phenotypic correlation is a statistical measure that evaluates the strength and direction of the relationship between two observable traits. In the context of this study, the focus is on the birth weight (BWT) of Abergelle goats and its association with other growth traits. When examining BWT about other traits such as three-month weight (TMWT), six-month weight (SMWT), nine-month weight (NMWT), and yearling weight (YWT) was low, there are higher correlations b/n TMWT with SMWT, SMWT NMWT and SMWT with yearling weight. This implies that as SMWT increases trends to other growth traits that is TMWT, NMWT, AND YWT. The genetic correlation coefficients, which quantify the strength of these associations, ranged from 0.091 to 0.232. Despite being moderate, these correlations were not particularly strong, suggesting that while there is some relationship between BWT and the other traits, it may not be significant enough to base decisions solely on BWT when considering the growth of the animal. Additionally, higher correlations were found among the other growth traits (SMWT, NMWT, and YWT), indicating one of these traits increases; the others tend to increase as well and vice versa. Genetic correlation assesses the extent to which the variation in one trait is attributable to genetic factors that also influence another trait. In the case of BWT and other growth traits, the genetic correlations were generally small, indicating weak genetic relationships with later growth stages. However, there was a moderate genetic correlation of TMWT with other growth traits, ranging from 0.71 to 0.87. This suggests that while there may be some genetic influence on the relationship between BWT and TMWT, it is not particularly strong. Conversely, there were higher positive genetic correlations observed among the later growth stages (TMWT-SMWT, SMWT-NMWT, NMWT-YWT, and SMWT-YWT), with correlation coefficients ranging from 0.74 to 0.89. This indicates that genetic factors influencing one growth trait tend to also influence the others positively, highlighting the concept of pleiotropy where one gene affects multiple traits.

The result of this study early selection based solely on BWT may not be effective in breeding programs aimed at improving the growth of Abergelle goats. Instead, considering the genetic correlations among various growth traits can inform more efficient selection schemes to enhance overall productivity.

IV. CONCLUSION

Promising results of selection were observed from the scale-up goat community-based breeding program. The non-genetic factors like village, birth type, season of birth, parity,

kidding year, and sex had a significant influence on most of the growth and milk production performance traits of Abergelle goats. In the current study, low to high heritability estimates for most of the growth and milk production traits were found. Moderate to high positive phenotypic and genetic correlations among growth traits during the later growth stages suggest the selection for one trait would result in improvement in the other traits and thus could be advantageous for the selection of goats at an early age except for birth weight which has a low correlation with other growth traits. The genetic trend for growth, and milk production traits found in this study are promising. However, genetic progress is not consistent and even the rate of improvement is lower than other breeds which calls for optimization of the program in the future.

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