Growth and milk production performance of Abergelle goats under the community-based breeding program in northern Ethiopia

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Received: 13 July, 2023 **Accepted**: 16 Februaryl, 2024 **Published**: 15 May, 2024

ABSTRACT

Community-based goat breeding program (CBBP) is becoming an alternative genetic improvement approach for low input production system and being implemented nationwide in Ethiopia. A community-based breeding program was implemented in Abergelle goat breed for six years (2014-2019) at Bilaque village in Ziquala district, Wag-himra zone of North Eastern Ethiopia. The objective of the study was to evaluate the growth and milk production performance of Abergelle goats under community-based genetic improvement program. Best bucks were selected on a yearly basis based on their estimated breeding value and unselected bucks were culled out from the population through castration and sale. Body weight of kids and does milk yield data were collected from flock in the community-based breeding program. A general linear model procedure of SAS was used for data analysis. Birth type, year of birth, and parity had significant ($p<0.05$) effects on the pre-weaning growth performance of Abergelle goats. The mean yearling weight of kids had slightly increased from 12.8±0.11 to 13.7±0.12 kg during the course of four round selections. Daily milk yield was significantly ($p<0.05$) affected by the season of lactation and years. Average daily milk yield has increased from 300.31±7.41 ml to 352.62±14.33 ml during the selection years. Death (22%), sale (44%), share (5.5%), and slaughtering (8%) were the major off-take reasons in the flock. The study gave some insight into the possibility of improvement of growth and milk production traits through strategic design and implementation of community-based selective breeding approaches. This approach can suit the existing management level and breeding practices of farmers and it can allow the use of elite bucks and the removal of inferior ones from the population.

Keywords: Abergelle goat; Body weight; Community-based; Milk yield; Selection
DOI: https://dx.doi.org/10.4314/ejst.v17i1.1

INTRODUCTION

Goats comprise 5.32% of the total tropical livestock units of Ethiopia, contribute an estimated 12 to 14% of annual meat products, 10.5% of milk production, 47% of the agricultural GDP, 30% of all domestic meat consumption (Behnke, 2010), and 6% of all animals exported (Solomon Abegaz *et al*., 2014). Together with sheep, goats contribute about 90% of the live animal and 92% of the total skin export trade value (SolomonAbegaz *et al*., 2014). Abergelle goat is one of the Ethiopian goat breeds which is under the rift valley family and has an estimated population of over 300,000 (Farm Africa, 1996). It is found 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).

Goat together with other livestock species contributes about 75% of the cash income sources of smallholder farmers in the mid and lowland areas of Waghemira. The average flock size was 27 heads per household (Alubel Alemu, 2015). Under the traditional management condition, the breed is characterized by its lower body weight, longer kidding interval, and lower litter size with better meat quality and temperament in comparison to other indigenous goat breeds of Ethiopia (Alubel Alemu, 2015). As a result, a community-based selective breeding program has been developed and implemented for the improvement of the growth and production performance of the breed. The approach is truly participatory, which considers the active involvement of communities in the design, implementation, and ownership of the scheme/system. This innovative approach clearly takes account of farmers' needs, views, decisions, active participation, genetic choices, and overall execution of the system instead of building central breeding facilities. This study was designed with the objectives of devising and implementing a selective breeding scheme to improve body weight and milk production performance of Abergelle goats kept under smallholder management system.

MATERIALS AND METHODS

Description of the study area

The program was implemented at Bilaqu village of Ziquala district, located at 12º48′41.39″N and 38º43′22.02″E 775 km Northeast of Addis Ababa, Ethiopia. The district has rugged topography characterized by mountains, steep escarpments and deeply incised valleys. Mixed crop-livestock system with high priority of livestock

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production is the major farming practice in the area. The mean annual rainfall of the area was 250-650 mm with very short and an erratic distribution from early July to late August. The mean annual temperature was 25-39 °C and an altitude of 1308 m.a.s.l. Based on the above agro-meteorological data and feed availability, the area was considered wet from June to November and the remaining months as dry indicating the birth season of kids.

Village and goat-keeper selection

After developing the mega project entitled, "Harnessing genetic diversity of indigenous goats in Africa" by ILRI/Beca in 2013, the program was implemented at Bilaqu village; selected based on goat production potential, separate flock herding practice, accessibility of road and feed resources under irrigation and the willingness of the farmers to participate in the program. About 33 goat keepers were selected and a continuous discussion on the principle and implication of community-based goat improvement program was followed by further baseline surveys like general household characteristics, the purpose of keeping goats, livestock ownership, flock structure, trait selection criteria of farmers, performance of goats, management and breeding practices and goat production constraints. General information on the farming systems of the study area and the breeding objectives were obtained from a survey report conducted at Saziba village of Abergele district (Solomon Abegaz, 2014). Based on the report, growth and milk production traits were taken as priority traits of interest for goat improvement according to their respective order (Table 1). Reports of the district office of agriculture and rural development were also considered as secondary information sources during site selection.

Table 1. List of preferred traits by farmers (own flock ranking method for females and group animal ranking for males), adopted from (Abegaz *et al*., 2013)

Female		**Male**	
Traits	**Percentage (%)**	**Traits**	**Percentage (%)**
Milk yield	20.4	Body size	21.0
Drought resistance	14.9	Color	23.8
Body size	14.2	Body conformation	10.1
Kid growth	11.8	Height	9.1
Twin birth	10.2	Fast growth	8.0
Kidding interval	9.5	Other cumulative traits	27.9
Other cumulative traits	18.9		

Animal management and recording

All animals in the villages were labeled using plastic ear tags. In addition, local names were provided for each goat which helped to fully recover the information during the loss of ear tags. Pedigree and performance data were collected by trained enumerators from the participating villages. Baseline information collected includes parity of the doe's using farmer recall method, age of the doe's based on their dentition and farmers information, total flock number with each age class category of the households, date of birth, milk yield of the dam, birth weight and subsequent weights of kids. The enumerators made rounds of visits to the villages every morning to record kids born and identify them by ear tags, milk data measurement, and weigh the newborn. The kids were also weighed at three, six, nine and twelve months of age. Milk yield data were also recorded up to twelve weeks at a week interval.

Estimation of breeding value (EBV) and selection

During program implementation, the overall procedure was considered the protocol designed for setting up community-based sheep breeding programs in Ethiopia (Aynalem Haile *et al*., 2018). A one-tier breeding structure was adopted and all first birth kids of the population born from unselected previous village sires were evaluated and selected as first round breeding population. The growth performance of individuals and milk production performance of their respective dams were recorded. Index selection method was implemented for the first two round selections (on yearling weight of male kids and their dam's average daily milk yield) whereas for the recent three-round selections, the breeding value of candidate bucks was estimated by computing correction factors for the non-genetic/fixed factors like season, birth type, parity. Yearling bucks from all flocks in the project villages were evaluated together as cohorts and to be subjected to further approval by farmers from phenotypic criteria like color, body conformation extra and the selection process was conducted based on the selection criteria which have been defined earlier by Solomon Abegaz *et al. (*2014).

Buck usage modality and mating

The selected bucks were assigned to buck groups with a 1:15 buck: doe ratio following an own flock mating plan due to larger flock sizes at each household by considering the previous mating history of bucks to avoid inbreeding (Mueller *et al.*, 2015). Unselected bucks were culled out through castration and sale before the

mating season approached. In cases of small flock numbers faced during the selection process, a group mating system was used. Bucks were rotated among the individual members based on mapped rotation modality by considering the grazing corridor of flocks, settlement and previous mating history. After completion of a single breeding season, bucks were rotated to other farmers by considering the preset conditions, and finally at the end of the service period they got fattened and sold. The income from the sale of these culled bucks was used as a revolving fund and income generation for the established cooperative.

Data analysis

Descriptive statistics and Microsoft excel program were used to perform simple population characteristics and graphical presentation of data. Productive performance data were analyzed using the GLM procedures of SAS version 9.0 (SAS, 2002). Birth type of kid, sex, season of birth, parity of dam, and year of birth were fitted as fixed effects for body weight variables whereas season of doe kidding, parity of dam, and year of kidding were fitted as fixed effects for milk production traits. The least-square mean with the respective standard error was separated using the Tukey-Kramer test. For growth traits:

$$Y_{ijklmn} = \mu + Bt_i + S_j + Sb_k + P_l + Y_m + e_{ijklmn}$$

Where Y_{ijklmn} = the observed growth performance of goats, μ = overall mean, Bt_i = effect of i^{th} birth type (single and multiple), S_j= effect of j^{th} sex, Sb_k= effect of k^{th} birth season (wet and dry), P_L = effect of L^{th} parity (first to ninth), Y_m= effect of the m^{th} year (2013-2018) and e_{ijklmn} = random residual error.

Statistical model for milk traits:

$$Y_{ijkl} = \mu + S_i + P_j + Y_k + e_{ijkl}$$

Where Y_{ijkl}= the observed milk yield, μ= overall mean, S_i= effect of i^{th} birth season (wet and dry), P_j= is the effect of j^{th} parity, Y_k= effect of k^{th} year and e_{ijkl} = random residual error.

RESULTS AND DISCUSSION

Population structure and off take rates

The flock structure is presented in Figure 1. The current study confirmed that from the monitored goat population during the baseline data recorded in the village, about 51.7% of the population was breeding females, 40.2% weaned kids, 2.1% kids, 5.2% bucks and about 0.6% castrated bucks. The flock composition was normal with more breeding females followed by weaned kids. The total proportion of doe's from the population in this study was slightly lower than the report of Belay Deribe & Mengistie Taye (2013 and Solomon Abegaz (2014), who reported 56.6% and 51.8%, respectively in the same breed. The lower proportion of breeding females in this study might be due to the difference in aim of goat production. In addition, the small proportion of kids could be associated with the low litter size of Abergele goats and seasonality of kidding. Death (22%), sale (44%), share (5.5%), and slaughtering (8%) were the major off-take reasons in the flock. The result also revealed that sale was the highest proportion for goat disposal. Indeed, it is expected as their livelihood is mainly based on goat production. Kids with their dams and weaning male kids were leaving the flock with the highest proportion that might be directly linked with the reason that goat keepers mostly took either male kids or old doe's to the market.

Body weight at different ages

The body weight of kids at all ages (birth, weaning, six month, nine month and yearling weight) is shown in Table 2. Selection year had a significant influence on the body weight of goats. Nevertheless, the body weight changes across selection years were very slight. This might be due to very fragile, feed scarce and prolonged drought prone area, which lets the animal for survival instead of producing more. The birth weight of kids in the present study was lower than some other Ethiopian indigenous goats for instance, Bati goats (2.71±0.04 kg) and Borana goats (2.36±0.05 kg) under traditional management system (Hulunim Gatew *et al*., 2019). This result is comparable with weights at birth (1.91 kg), weaning (6.84), at six-month (9.13), and yearling weight (14.25 kg) of the same breed under traditional management conditions (Belay Deribe and Mengistie Taye, 2013). However, Zeleke Mekuriaw (2007) reported a higher value of birth weight (3.19 kg) for Somali goats in extensive management system as compared with the result found in the present study. Six month and yearling weights of Abergelle goats were larger than the mid Rift Valley goats (7.87±1.62 and 12.85±2.55 kg) (Tesfaye Kebede *et al.*, 2008).

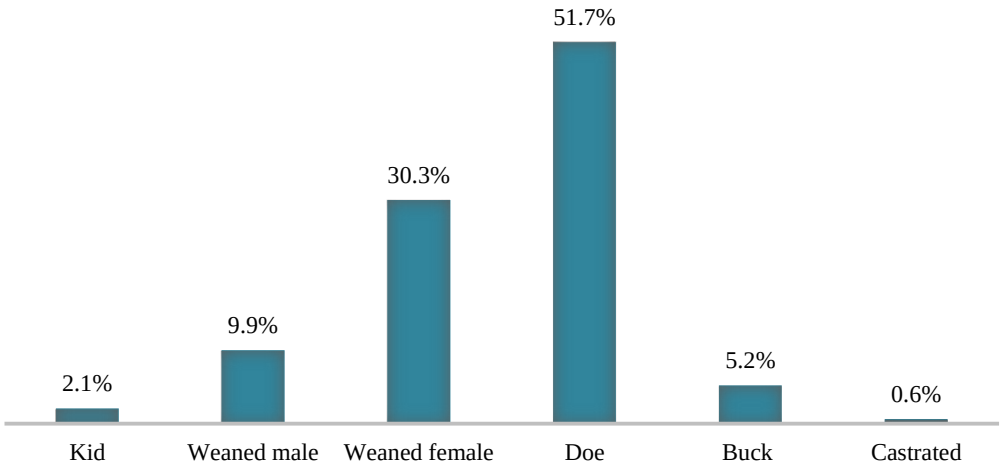

Figure 1. Population structure by age category

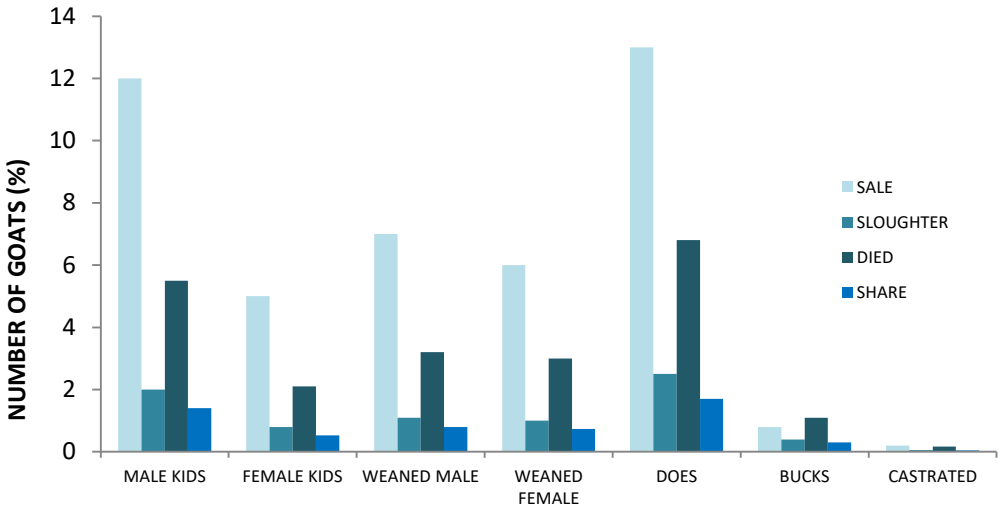

Figure 2. Goat off-take reasons by age category at CBBP village

Sex of kids did not have pronounced effect on the body weight across different ages. The result of the present study is in line with the result of Hulunim Gatew *et al.* (2019), who reported non-significant ($p > 0.05$) difference between males and females for their daily weight gain for both Borana and Short-eared Somali goats. However, the same author also reported that the sex of kids affected weight significantly ($p < 0.05$), i.e., the total pre-weaning daily weight gain of male Bati goats was higher (86.82 ± 3.05 g/day) as compared to their female counterparts (78.17 ± 3.37 g/day). Zeleke Tesema *et al.* (2021) also reported a greater live weight of male kids than their female counterparts at all ages. In the present study, single birth kids weighed significantly more ($p< 0.05$) at birth with insignificant body weight changes for the remaining ages. In contrast, other scholars (Belay Deribe and Mengistie Taye, 2013; Zeleke Tesema *et al.*, 2021) reported that the weight of single- born kinds were higher than multiple-born kids. Kids that were born during the wet season gave significantly ($p< 0.05$) more body weight changes across all ages except the nine-month. The reason might be better feed supply during the wet season than the dry one.

Milk production performance

In the lowlands of Ethiopia, where an estimated 75% of the nation's goats are found, goat milk is an important part of the diet of pastoralists. According to Tsedeke (2007), 16.7% of Ethiopia's milk consumption comes from goat production. From this perspective, milk production performance average daily milk yield (ADMY) during the selection period was significantly different ($p<0.05$) between years (Table 3). In addition, the phenotypic milk production trend across years is presented in **Error! Reference source not found.** and this shows a positive trend. Lactation length, average daily milk yield and total milk yield were all significantly affected by the season and year of birth. The overall average lactation length was 73.5 days, total lactation milk yield was 25.63±0.29 kg and average daily milk yield was 358.04±2.97 g. This is slightly higher than a report by Mohammed Bedhane *et al*. (2012) for Arsi-Bale goats, which was 86 days, 17.73 kg and 208.72 g for lactation length, total milk yield and average daily milk yields, respectively. On the other hand, the average daily milk yield in this study was lower than the one reported by Dereje Tadesse *et al.* 2015) for Afar goat (450 g/day). In

general, the milk yield of indigenous goats in Ethiopia under smallholder management system ranges from 0.29 kg/day for Arsi Bale goats to 0.55 kg/day for Begait goats (Zeleke Tesema and Kefyalew Alemayehu, 2018) and the current result was found within this range.

Table 2. Least square means (± SE) of live body weights at different age (kg) of Abergelle goats at Bilaqu village

Variables	**BWT**		**TMWT**		**SMWT**		**NMWT**		**YWT**	
	N	**LSM ± SE**	**N**	**LSM ± SE**	**N**	**LSM ± SE**	**N**	**LSM ± SE**	**N**	**LSM ± SE**
Over all	1607	2.09±0.01	1370	6.99±0.03	1306	8.61±0.04	1072	11.4±0.12	771	14.1±0.1
CV%		13.5		17.6		16.2		35.5		16.9
Sex		ns		ns		ns		ns		Ns
Male	852	1.92±0.01	723	6.96±0.05	692	8.8±0.05	562	11.7±0.07	368	15.2±0.15
Female	755	1.88±0.01	647	6.92±0.05	614	8.6±0.06	510	11.5±0.25	403	14.7±0.13
Birth type		*		ns		ns		ns		Ns
Single	1542	2.15±0 [a]	1323	7.04±0.03	1262	8.62±0.04	1035	11.7±0.13	753	14.8±0.10
Multiple	67	2.00±0.03[b]	47	6.84±0.18	44	8.78±0.21	37	11.5±0.33	18	15.1±0.79
Birth season		*		*		*		ns		*
Dry	466	1.91±0.01	416	6.74±0.04[b]	380	8.51±0.06[b]	253	11.4±0.5	181	14.5±0.23[a]
Wet	1141	1.95±0.00	954	7.14±0.04[a]	926	8.9±0.05[a]	819	11.8±0.05	590	15.4±0.11[b]
Year		*		*		*		*		***
2014	400	1.94±0.01[b]	350	7.51±0.08[a]	315	9.36±0.10[a]	265	11.1±0.1[b]	241	12.8±0.11[d]
2015	243	1.97±0.01[b]	239	6.74±0.06[b]	221	8.19±0.07[c]	128	13.2±0.97[a]	90	16.9±0.30[a]
2016	239	1.86±0.01[c]	222	6.81±0.05[b]	213	8.26±0.07[c]	175	10.6±0.1[c]	105	15±0.27[b]
2017	266	1.81±0.01[c]	261	6.19±0.06[c]	260	8.60±0.06[b]	226	11.8±0.11[ab]	190	16.3±0.22[a]
2018	312	1.94±0.01[b]	298	7.45±0.08[a]	297	9.12±0.08[a]	278	11.3±0.07[b]	145	13.7±0.12[c]
2019	147	2.06±0.02[a]	-	-						
Parity		*		ns		ns		*		Ns
1	363	1.80±0.01[b]	311	6.6±0.07	292	8.46±0.08	242	11.12±0.1[b]	157	14.11±0.21
2	288	1.86±0.01[b]	240	6.83±0.08	230	8.62±0.09	178	11.34±0.13[a]	130	14.33±0.25
3	256	1.91±0.01[a]	217	6.71±0.09	213	8.46±0.09	175	11.21±0.13[a]	116	14.23±0.25
4	308	1.90±0.01[a]	259	6.78±0.08	247	8.57±0.104	218	11.31±0.12[a]	166	14.72±0.24
5	219	1.93±0.01[a]	195	6.89±0.09	186	8.54±0.11	150	11.03±0.12[b]	116	14.2±0.23
6	117	1.94±0.02[a]	103	6.73±0.13	94	8.44±0.14	74	12.72±1.67[a]	60	14.47±0.38
≥7	40	1.94±0.04[a]	33	7.13±0.23	32	8.51±0.22	26	11.66±0.34[a]	19	15.07±0.71

BWT=birth weight, TMWT=three month weight, SMWT=six month weight, NMWT=nine month weight, YWT= yearling weight, N= total population, LSM= least square means and SE= standard error, *= P <0.05, **= P<0.01, ***= P <0.001, ns= non-significant

Doe's that have given birth during the wet season gave relatively higher daily milk yield. This difference could be due to the better availability of feed in wet season. At the same time, average daily milk yield was significantly increased across years and it can be associated with the response to selection. Higher parity does produced slightly more milk than lower parity does, likely because they had more developed mammary glands due to multiple birthing experiences, despite the statistical insignificance of parity on milk traits. To some extent, inconsistent data was recorded in response to flock mobility which was the most critical problem during the peak periods of lactations as the farmers migrated the flock to distant areas for long seasons.

Table 3. Least squares means (± SE) of milk traits of Abergelle goats at Bilaqu village

Variables	**LL**		**TMY**		**ADMY**	
	N	**LSM ± SE**	**N**	**LSM± SE**	**N**	**LSM ± SE**
Over all	803	10.5±0.1	803	25.63±0.29	803	358.04±2.97
CV%		26.9		30.6		20.7
Season		*		*		*
Dry	213	11.0±0.2[b]	218	25.2±0.52[b]	213	323.3±6.27[b]
Wet	590	10.4±0.1[a]	610	26.3±0.34[a]	590	370.6±3.20[a]
Year		*		*		*
2014	190	10.9±0.2[bc]	190	21.9±0.60[c]	190	300.3±7.41[d]
2015	120	10.7±0.2[bc]	120	23.9±0.66[b]	120	328.4±7.34[c]
2016	122	10.9±0.2[bc]	122	28.1±0.64[a]	122	375.1±5.87[b]
2017	116	11.6±0.1[ab]	116	29.3±0.46[a]	116	362.6±5.01[b]
2018	255	9.70±0.2[c]	255	25.6±0.57[b]	255	389.3±3.66[a]
Parity		ns		ns		ns
1	180	10.9±0.21	180	25.2±0.61	180	339.8±6.58
2	138	10.4±0.27	138	25.5±0.70	138	363.1±6.84
3	143	10.9±0.24	143	25.8±0.63	143	347.9±6.13
4	145	10.9±0.22	145	25.1±0.68	145	348.9±6.95
5	111	10.8±0.27	111	26.3±0.83	111	354.6±8.72
≥6	86	10.7±0.60	86	25.7±1.45	86	352.6±14.33

LL=Lactation length, TLMY=Total lactation milk yield, ADMY=Average daily milk yield, N= total population, LSM= least square means and SE= standard error, '*'=p<0.05, and ns=no significant difference

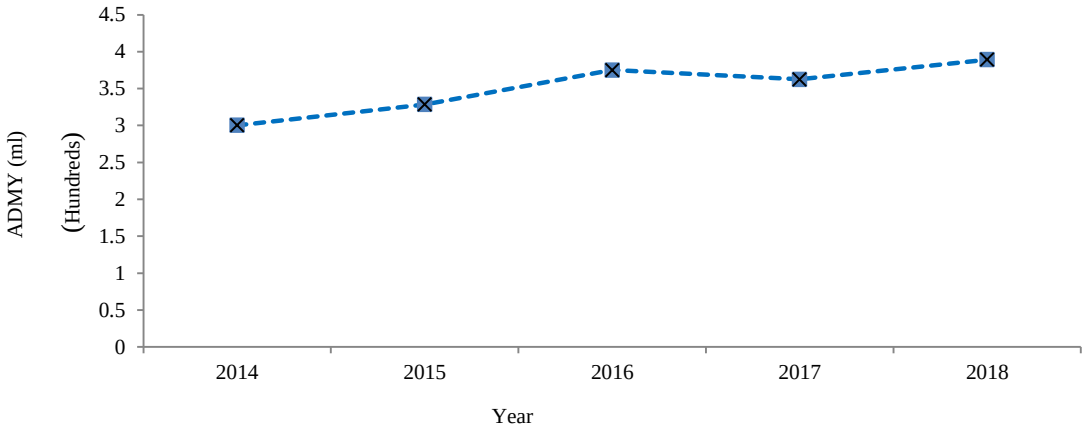

Figure 1. Trends of average daily milk yield across selection years

CONCLUSION

Body weight of kids and milk yield were slightly increased during the selection years. In addition, strategic feed supplement for the breeder stock will be an important management step in order to exploit the real genetic merit of goats as the area is poor in feed availability. Considering fixed factors like birth type, season of birth and parity is important during breeding value estimation and selection as the factors have significant effect on live weight at different ages. The kids born from the dams with parity of ≥3 had better birth and post weaning body weight, thus keeping those doe's as breeder stock could help improve Abergelle goat population. The study gave some insight for its great possibility of improvement of growth and milk production traits through strategic design and implementation of selective breeding approaches.

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