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Selection Response on Growth and Milk Production Performance of Abergelle Goat Managed Under Station Condition in Wag-Himra, Ethiopia

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Abstract: *Background and Objective*: Aberegelle goat was small in body size and highly resistant to the harsh environment in the low land of Wag-himra. The objective of the study was to conserve the indigenous Abergelle goat and improve growth and milk production traits through selective breeding. *Materials and Methods*: The selection of bucks was done once a year using indexed estimated breeding value of yearling weight and their respective dam milk yield performances. A total of 469 for body weight and 345 for milk yield records were used for performance evaluation Top-ranked bucks selected from the flock were used as replacements at the nucleus while the surplus bucks were disseminated to nearby villages. The general linear model procedure of SAS software (version 9.0) was employed to evaluate the body weight and milk yield of the breed during the last five years (2016-2020). *Results*: The overall birth-, three-month-, six-month-, nine-month- and yearling weights were 1.98, 6.5, 8.6, 11.4, and 13.8 kg, respectively. The overall lactation milk yield, average daily milk yield, and lactation length were 17.64 kg, 0.30 kg, and 8.45 weeks, respectively. Within the last five consecutive selections years' birth weight has increased from 1.64±0.04 to 2.3±0.02 kg, weaning weight from 5.6±0.25 to 7.5±0.15kg, and yearling weight from 13±0.43 to 15.2±0.27kg. *Conclusion*: Wet season birth was important for increasing milk production and lactation length. Nucleus flocks in the station the growth traits and milk traits can be improved by selection and selection at the station once a year. The Selection of breeding bucks should be at the age of six months and nine months before the breeding bucks went market for sale.

Keywords: Abergelle Goat, Breeding, Milk Production, Dissemination, Partial Open, Selection

1. Introduction

Goats are a widely raised farm animal species that play a crucial role in the livelihoods of billions of smallholder farmers, pastoralists, and agro-pastoralists worldwide. They serve various purposes and provide numerous benefits [2, 10]. In developing countries; goats make a very valuable contribution, especially to the poor in rural areas.

According to FAO [11] 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. Though the flock size 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. In addition, goats have a higher multiplication rate; lower capital investment, greater job creation opportunities for jobless youths and unique adaptation to harsh environment [2, 6]. They are also important protein sources in the diets of the poor and help to provide extra income and support. Goats Domestic meat consumption is made up of 30% of the meat produced, while the majority of the income from meat production comes from exporting live animals and skins [22] More specifically, in the lowland areas of Wag-himra, around 70% of the household liquid cash income is generated from the livestock sector especially from goats.

Goat production in Ethiopia is characterized by minimum profit due to several factors, including under-exploitation of indigenous genetic resources, poor or seasonal fluctuations of feed resources, periodic droughts, extensive dry seasons, and severe feed shortages resulting in undernourishment and low productivity among the animals. The average carcass weight produced from yearling goat in Ethiopia is only 8.5 kg [21]. Different authors [1, 3-5, 16] reviewed and documented that the present production levels of indigenous goats with existing breeding strategies and practices are far below their potential.

Aberegelle goat breed is among the rift valley families of goats in the country, widely distributed in the low land areas of Wag-himra, and Raya areas in North Wollo and around East Bellessa in Gondar. In these areas goats are kept for multifunctional roles but mainly to generate cash income, meat and milk consumption [2]. Farmers in the low land of wag- himra engaged the breed for meat and milk production. The breed population size in 2017 was reported at 432,840 only in wag-himra zone without considering the whole breeding tracts of the breed [13, 14].

The livestock breed of all species in the country is produced without clear demarcations of breeding and reproduction resulting in population admixture. This admixture adversely affected the performance of the breeds not expressing their optimum potential in a given environment. To overcome this problem, maintenance and conservation of pure breeding stock at station condition is the first and most important component. It will help to maintain elite nucleus flocks of the desired breed and improving its productivity through selection. In addition, the nucleus will serve as an improved sire source for the nearby community breeding villages and individual smallholders. So, the study was required to establish a nucleus flock for pure Abergelle goats with the following objectives.

1) To evaluate the performance of growth and milk production traits of Abergelle goat breed at station condition
2) To disseminate improved bucks to nearby [CBBP] community based breeding program villages which serve as a source of improved breeding population.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Sekota Zuria district at Aybra main breeding and feeding trial site for the last five years from 2016-2022, which is located at $12^{0.}$ 41′ 11.92′′N and 39^{0}.00′58′′E in Wag- himra administration zone of the Amhara region. The study area was 17Km far from Sekota town, 447km from the Bahir Dar and 737km from Addis Ababa, the capital city of Ethiopia. The district has rugged topography characterized by mountains, steep escarpments and deeply incised valleys.

The farming practice of the area is mixed crop-livestock production. The annual rain fall of the area was 650mm with very short and erratic distribution. The maximum and minimum temperature of the area is 26.6°C and 31.6°C respectively with an altitude of 1933 m.a.s.l. The major summer season in the study location begins in late June to half of -July and lasted in late August.

2.2. Animal Management and Data Recording

Founder doe's and sires of the station were bought from the local markets of the breeding tracts of pure Abergelle goat breed with the assumption of zero breed dilution in late 2015. These animals were purposively selected for earlier parities (1-3) by farmer's recall method in addition to information of being not pregnant at the time of buying. During the beginning of the nucleus breeding program, a total of 100 does and five bucks (1:20 mating ratio) were arranged into five breeding groups. The bucks served in one breeding group were purposively rotated to other breeding groups in the next mating to control inbreeding. After being rotated to all the breeding groups, bucks were either distributed to the established nearby CBBP village or culled out from the flock based on their performance. The nucleus was totally linked with one CBBP village where the continuous distribution of improved bucks was made every year.

Adult animals were managed semi-intensively where arranged into grazing land during the daytime and supplemented with 200g commercial concentrate and cowpea hay in the morning and evening during feed shortage season while in the feed available season animals are managed at grazing lands. Kids were suckled their dams up to three months of age and then separated from their mother to join the younger stock group. All groups of animals received programmed vaccinations and treatment against major diseases in the area. Data was recorded by an enumerator who trained for data collection and flock follow-up. Herding system was strict to control inbreeding and the season of mating.

2.3. Description of the Nucleus Breeding Program and Its Structure

The breeding program was implemented based on the identified breeding objective traits of the breed in the area. Growth and milk production performance improvement was the target breeding objective traits of the Abergelle goat breed identified by [1, 6]. Growth performance was evaluated based on weight at different age group selection criteria's (birth weight up to yearling weight) while milk yield was evaluated based on total milk yield, average daily milk yield and lactation length criteria's. Kids born without known sire and dam especially during the beginning year 2015 and selection of breeding bucks and unselected bucks were removed from the performance evaluation during data analysis.

Selection of bucks was conducted at yearling age by combining individual's yearling weight and their respective dam milk production performance. The selection index was constructed based on the adjusted deviation of selected means from population mean with a 60% share for growth performance and 40% for milk production performance based on a quick survey data from CBBP villages. The adjusted growth and milk production performances deviation were then multiplied by heritability values of 0.3 and 0.25 a from meta-analysis study by [17-19] respectively. Bucks were then selected by their indexed estimated breeding values from growth and milk production performances by partitioning for various fixed effects. EBV trend was unable to present here due to shorter generation of the program, very few and non-consistent selection candidates over years and very small produced progenies that were not sufficient for comparisons. Birth type, season, year and parity were identified sources of variation for both growth and milk production performance traits during the course of selection. The selected sires in the nucleus are either used for replacements or directly distributed to [CBBP] village.

2.4. Statistical Analysis

Productive performances (continuous type) data for growth and milk production were analyzed using the general linear model [GLM] procedures of SAS software version 9.0. The least-squares means of traits was done using the Tukey HSD test for statistically significant effects at 0.05 alpha level based on the general linear model [GLM] analysis result. Indexed estimated breeding value was performed using the Excel 2007 for Microsoft Office. Body weight variables were fitted with birth type, sex, and season of birth, parity, and year as fixed factors, whereas milk production features were fitted with season of birth, parity, and year as fixed factors. The association of body weight of kids at different ages was evaluated using Pearson correlation analysis. Two separate models were utilized for growth and milk production performance evaluation.

2.5. For Growth Performance

$$Y_{ijklm} = \mu + B_i + S_j + Z_k + P_l + Y_m + e_{ijklm}$$

Where: Y_{ijklm} = the observed growth performance of goat by weight mainly at birth weight, weaning weight

Weight of a yearling

μ = Global Mean

Bi = is the result of the type of birth (single vs. twin).

Sj = Is the Jth Sex's (Male and Female) Effect

Zk = is the result of the kth birth season (dry from January to the first of June and wet from late June to the end of December).

The impact of the 1 through 6th parity is shown by Pl.

The effect of the mth year (2016–2020) is denoted by Ym. is random residual error, or eijklm

In terms of performance qualities for milk production,

$$Yijk = + Si + Pj + Yk + eijkl$$

Where: Yijkl = overall mean + observed milk yield

Si = is its birth season (dry or rainy) having an impact?

The result of j^{th} parity (1-6) is Pj=

The result of k^{th} y is Y_k=.year (2016-2020)

e_{ijkl} = is random residual error

3. Results

Selection Progress on Growth Performance of Goats

The overall least-square mean of birth, three-month, six-month, nine-month, and yearling weights of kid's were 1.99±0.02, 6.54±0.08, 8.55±0.09, 11.14±0.12, and 13.74±0.14kg, respectively kg as presented in Table 1.

The fixed effects birth type, sex, season and year of birth had a significant effect on birth weight. Kids born single had higher birth weights than those born as twins. This difference could be directly linked to the absence of competition from the mother side for food in singletons. Male Compared to females and kids born during the dry season and those born during the wet season had significantly greater birth weights. This may result from the metabolic activity of males during embryonic development in the uterus being dams is high and during wet season follicular growth of does could be supported by available forage, respectively.

Year exerted a significant positive effect on the birth up to six-month weights of kids in the nucleus. The positive effect of the year could be connected with the selection of better performing parents for the next generation, control of inbreeding and the feeding management in the flock with substantial supplementation during feed shortage seasons. However, the growth performance values of this study at all growth stages were lower in comparison with reports of other studies for the same breed under CBBP and farmer's management conditions. For instance, reported [5] 7.2, 10.1, 13.0 and 15.9kg for, weaning, six, nine-months and yearling weight kids, and reported, 6.84, 9.13, 14.25 Kg weaning weight, six month and yearling weight respectively at farmers management condition. This could be that because founder animals of the nucleus were moved to an agro-ecologically different area that has variation from the originated locality of the breed. In addition, the flocks in the nucleus are managed in a confined system due to the shortage of grazing lands for them and even the available grazing land was degraded that barely hosts browsing shrubs that would treat them against their physiological and biological requirements.

This phenomenon was confirmed by previous studies for the same breed that even under proper concentrate supplementation, yearling bucks didn't respond to body weight due to confinement that was against their feeding behavior. Goats by their nature are selective browsers in grazing lands and not respond for confined feeding especially on low available shrub lands.

Table 1. *Least square means (±SE) of live weight at different age (kg) of Abergelle goat breeds managed at station condition.*

Variables	N	BWT	N	TMWT	N	SMWT	N	NMWT	N	YWT
		LSM±SE		LSM±SE		LSM±SE		LSM±SE		LSM±SE
Overall	469	1.99±0.02	453	6.54±0.08	431	8.55±0.09	416	11.14±0.11	385	13.74±0.14
CV%		18.55		22.89		19.38		20.28		18.81
Sex		*		Ns		Ns		Ns		Ns
Male	228	1.79±0.03^{a}	221	6.61±0.11	206	8.94±0.12	198	11.63±0.16	180	14.45±0.21
Female	241	1.71 ±0.03^{b}	232	6.50±0.10	225	8.93±0.12	218	11.38±0.16	205	14.04±0.19
Birth type		***		*		**		Ns		Ns
Single	403	1.89±0.02^{a}	388	6.33±0.09	367	8.90±0.09^{b}	356	11.32±0.12	332	14.06±0.15
Twin	66	1.61±0.06^{b}	65	6.78±0.18	64	9.27±0.20^{a}	60	11.68±0.30	53	14.44±0.35
Season		*		ns		**		**		***
Wet	366	1.82±0.03^{a}	354	6.63±0.09	339	8.60±0.09^{b}	328	10.96±0.11^{b}	306	13.29±0.14
Dry	103	1.68±0.05^{b}	99	6.48±0.16	92	9.28±0.21^{a}	88	12.04±0.32^{a}	79	15.20±0.34
Year		***		***		***		Ns		Ns
2016	51	1.23±0.04^{e}	49	5.53±0.21^{d}	49	7.67±0.22^{c}	47	11.51±0.34	45	14.08±0.33
2017	69	1.58±0.06^{d}	67	6.38±0.17^{bc}	61	9.20±0.19^{ab}	58	11.06±0.19	53	13.75±0.25
2018	44	1.94±0.08^{b}	44	7.06±0.17^{ab}	42	9.37±0.22^{a}	40	11.62±0.21	38	14.24±0.32
2019	157	1.83±0.03^{c}	156	6.11±0.11^{cd}	144	9.43±0.18^{a}	136	11.42±0.22	113	14.25±0.27
2020	148	2.16±0.03^{a}	137	7.70±0.15^{a}	135	8.66±0.10^{b}	135	11.91±0.22	135	14.92±0.27
Parity		Ns		Ns		Ns		Ns		Ns
1	108	1.77±0.05	105	6.64±0.18	101	9.01±0.21	93	11.84±0.25	84	14.80±0.32
2	86	1.78±0.05	84	6.55±0.16	79	8.91±0.19	79	11.71±0.28	73	14.67±0.33
3	78	1.81±0.06	73	6.36±0.19	68	8.67±0.21	66	11.17±0.26	60	14.01±0.31
4	73	1.78±0.06	72	6.54±0.19	70	8.90±0.19	68	11.39±0.28	64	14.28±0.36
5	68	1.69±0.06	65	6.42±0.19	61	8.92±0.23	59	11.15±0.28	56	13.76±0.32
≥6	56	1.66±0.06	54	6.82±0.26	52	9.21±0.24	511	11.76±0.32	48	13.96±0.38

Where BWT=birth weight, TMWT=three month weight, SMWT=six month weight, NMWT=nine month weight, YWT= yearling weight, LSM= least squar/e means and SE= standard error, "*"= p<0.005, "**"=p<0.001, "***"=p<0.0001, Ns= NO significance difference b/n means

Table 2. *Least square means± SE of lactation milk yield (kg) and lactation length (weeks) influenced by different factors.*

Variables	N	LMY (kg)	N	ADMY (kg)	N	LL (week)
		LSM±SE		LMS±SE		LSM±SE
Overall	345	31.28±1.04	345	0.39±0.09	345	8.45±0.25
CV%		36.70		30.44		27.86
Season		***		**		***
Wet	271	27.31±1.21^{a}	271	0.35±0.01^{a}	271	7.63±0.20^{a}
Dry	74	18.68±1.88^{b}	74	0.34±0.02^{b}	74	5.66±0.26^{b}
Year		***		*		**
2016	35	39.74±2.19^{a}	35	0.43.4±0.01^{a}	35	9.06±0.28^{a}
2017	23	11.61±0.9^{b}	23	0.20±0.02^{c}	23	8.09±0.90^{a}
2018	169	42.09±1.23^{a}	169	0.48±0.01^{a}	169	8.93±0.21^{a}
2019	60	7.93±0.53^{c}	60	0.33±0.01^{b}	60	2.86±0.03^{b}
2020	58	12.09±0.66^{b}	58	0.30±0.01^{b}	58	4.29±0.04^{b}
Parity		**		**		Ns
1	60	15.66±0.18^{c}	60	0.30±0.02^{bc}	60	6.05±0.36
2	91	24.62±0.21^{ab}	91	0.35±0.02^{bc}	91	7.29±0.37
3	63	21.75±0.22^{bc}	63	0.33±0.03^{b}	63	6.91±0.45
4	45	25.57±0.29^{ab}	45	0.37±0.02^{ab}	45	6.95±0.48
5	48	21.56±0.28^{b}	48	0.37±0.03^{ab}	48	5.92±0.44
≥ 6	38	27.00±0.32^{a}	38	0.38±0.03^{a}	38	6.75±0.49

Where LMY= Lactation milk yield; ADMY= Average daily milk yield; LL= lactation length; LSM= least square means; SE= standard error; "*" p=<0.005; "**" p=<0.001; "***" p=0.0001= litter shows if they are different a, b, c, d if they are the same a, a, a no significant difference b/n means

4. Discussion

The birth weight result found in this study was in line with the values reported [9, 12] for the same breed by in farmer management practice, 1.91kg in CBBP conditions of Saziba village, 2.0kg [7]. The heavier the birth weight at later parities but not statistically significant could be result of the physiological imprint in the uterus during the first pregnancy [15] will facilitate relatively greater fetus growth in subsequent pregnancies. Birth weight had lower association with other weight groups The weaning, six months and the yearling The doe's parity did not have a significant impact on weight, although does with earlier and greater parities were more likely to have babies with higher birth weights. Growth rates in first-parity did was lower than those in older does who had reached physiological maturity. It concurred with the findings of a few previous researches and in line with the study of [8]. Birth weight improvement had a positive but smaller association with weaning weight than other weight groups but birth weight had no significant correlations with post-weaning weights as a result birth weight improvement was not more important in any other growth traits except weaning weight. Birth weight had no positive correlation with three-month, six-month, nine-month and yearling weight, but the weaning weight with six-month weight, weaning weight with nine-month weight and weaning weight with yearling weight had a positive correlation and also six-month weight with nine-month weight and nine-month weight with yearling weight had positive association. This implies that selection would be possible to be undertaken during earlier age's that improving the availability of selected bucks at both station and community based breeding program [CBBP] village throughout the year.

Milk is the most important product consumed by the community in the study area in Sekota Zuria district and in lowland of wag-himra. Milk data was used as a supportive trait for the selection of best performing breeding bucks that will be parents of the next generation. As shown in Table 2, the overall least square means of the lactation milk yield (LMY), average daily milk yield (ADMY) and lactation length (LL) were 31.28±1.04kg, 0.39±0.09kg and 8.45±0.25 weeks, respectively**.** The LMY, ADMY, and LL were significantly affected by the fixed factors season, year and parity. LMY, ADMY and LL was significantly affected by the season where does produce more milk in wet than dry season and this is due to the availability of forage and an increase in the lactation length in wet season. The performance of produced progenies in the station for milk production traits was low in comparison to the reports of same breed under CBBP condition [20, 5]. This could also connect with the confinement of experimental animals at station like the growth performance traits discussed above. Lactation milk yield, average daily milk yield and lactation length was significantly affected by year however the trend was not consistent. The reason for fluctuation of milk performance traits was due to variations in sampling methods during data collection where the latter two years' milk data was collected based on small test day samples whereas the former three years were based on twelve-week samples. In addition, does are not controlled for birth to selective season that make them forced to give birth out of their original environment. This means, does in the lowland areas of Wag-himra are somehow seasonal breeders during September to December, but forced to give birth throughout the year at station and that might be the reason for lower milk production performance.

5. Conclusion

In this study, growth and milk production performance of Abergelle goat under the established station were evaluated. Body weight of kids showed increased trend in four round selections across years up to six-month weights but not improved for nine-month and yearling weights. The growth performances of progenies produced at station condition however, were smaller in comparison to [CBBP] and farmer's management conditions at all growth stages. Milk yield performance of does showed non-consistent trend over the years in this study and it was also lower than the performances under [CBBP] condition. Strong consideration of the fixed factors like birth type, sex, parity, year and season of kidding remained an important source of variation during estimation of breeding value [EBV]. Total milk production and lactation length increased in wet season which calls synchronization of birth at wet season. Thus, from this evaluation it is recommended that critical economic evaluation of station breeding programs should be undertaken in terms of the cost incurred to maintain nucleus flocks and the return it provides for genetic improvement of the breed as it was low performed compared to CBBP conditions.

List of Abbreviations

CBBP: Community based breeding program
EVB: estimated breeding value

Significance Statement

The siginificancene of the study was to conserve and improve Aberegelle goat in experiment site. The selected and matured male goat used to mate matured female goat to obtained goats that had fast growth rate, better milk yield. The newly born goats were reach marketable age in short period of time. The improvement of those animals were reduce time that goats gave economic benefits to their producers. The major finding of this study were the birth weight, three –month weight, nine-month weight and yearling weight*1.98, 6.5, 11.4, 13.8 kg, respectively. Those results were obtained by using selection, as instrument in genetic improvement of goat in station condition. In the future use largely selection to improve the whole population of goat.*

Authors Contribution

Yeshiwas Abebe walle contribution: initiate the idea data management, data analysis; drafting interpreted the result full write of the paper

Mulatu Alamirew Gobeze: work on revision of the draft of the result and interpretation of the result

Bekahagn Wondim Wondim: follow up on field on station on the work site assigning the data collectors

Wubneh kibert Aklog: data collection sheet preparing data collection follow up on station

Adane Woreta Bahiru: revision on the draft of the manuscript on field follow up the work

Alemu Demilie Demlie: data collection regular follow up and data entry to the computer

Tigabu Limenh Limenh: data collection regular follow up

Conflicts of Interest

We all authors declared that have not conflict of interest. Yeshiwas Abebe Walle, Mulatu Alamirew Gobeze, Bekahagn Wondim Wondim, Wubneh kibert Aklog, Adane Woreta Bahiru[1]. Alemu Demilie Demlie, Tigabu Limenh Limenh have declared and agree the rule of the journal and put the signatures on the declaration. We all are co-authors and first Authors/corresponding Authors of the papers Yeshiwas Abebe Walle. The contributions of the first author of the Authors are from initiation of the paper until final write up.

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