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On Farm Performance Evaluation of Abera Sheep Under Abera Community-Based Breeding Program in Hula and Dara Districts, Sidama Regional State, Ethiopia

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Abstract:
Community-based breeding programs (CBBP) have been viewed as appealing breeding schemes that have significantly contributed to improving the performance of small ruminants in many developing countries. The current study aims to assess the productive and reproductive performance of sheep owned by CBBP households in the Dara and Hula districts of the Sidama region using performance records retained over an eight-year period since 2013. A total of 3552 birth records, 3263 weaning age (90-day) records, 2845 180-day records, and 1786 yearling age (360-day) records were analyzed using the general linear model under Statistical Analysis System (SAS) procedures. The model considered fixed effects like lamb sex, birth type, dam parity, birth year, birth seasons, and breeder cooperatives. Sheep body weight at birth, 90 days, 180 days, and 360 days, as well as pre-weaning daily weight gain and post-weaning daily weight gain, were 3.14±0.01 kg, 15.13±0.06 kg, 20.8±0.05 kg, and 28.89 kg, 135.3±0.5 g, and 63.64 g, respectively. Body weight at birth and at 90 days was significantly influenced by all fixed effects except birth seasons. All considered fixed effects have significantly ($p<0.05$) affected body growth at 180 days, pre-weaning daily gain, and post-weaning daily weight gain. A mean litter size of 1.19 was recorded in the present study, which was significantly ($p<0.05$) different across years but not across breeder cooperatives. The results of the current study indicated considerable improvements in the growth traits of sheep since the breeding program was implemented. The consequences of significant fixed effects should be properly incorporated during breeding ram selection, especially at 180 days. The inclusion selection index, along with growth traits under selection and improvements in management, can be an important intervention strategy to improve the prolificacy of sheep.

Keywords: Abera sheep, CBBP, growth traits, on farm

INTRODUCTION

Sheep are the most important livestock species in Ethiopia and other developing countries. Ethiopia has a large sheep population, estimated at 42.9 million (CSA, 2021), which is raised from arid pastoral areas to a cool alpine climate. Previous comprehensive characterization work recognized fourteen sheep groups (Ayalew et al., 2004), whereas Solomon (2008) recognized nine distinct breeds of sheep through his molecular characterization. These sheep have made immense contributions to small-holder farmers in Ethiopia across the country. They provide food items such as meat and milk as well as non-food items like skin and wool. They are also significant sources of monetary income (savings) and serve as a form of protection against extreme events like crop failure. They also contribute significantly to the country's income by generating foreign currency (Gebremedhin et al., 2006). Hence, sheep have a variety of socioeconomic and cultural functions for their producers (Tibbo, 2006). Despite Ethiopia's vast sheep population and diverse genetic resources, productivity has remained considerably below expectations due to a variety of constraints (Tibbo, 2006). Lack of technical capacity, feed scarcity, poor feed quality, disease, inadequate infrastructure development, and weak market linkage were some of the challenges that hampered sheep productivity (Gizaw et al., 2013). Low performance was also due to a lack of a well-planned breeding program that inadequately took into consideration the interests of targeted producers. Crossbreeding programs intended to improve the performance of indigenous sheep by crossing them with exotic rams at different times hardly impressed the targeted producers and consequently failed to be sustainable. Centralized nucleus breeding programs, typically controlled by the government, were unable to address long-term production issues and thus failed due to a lack of active participation by targeted producers.

The community-based breeding program has therefore emerged as an attractive option and resulted in impressive progress (Haile et al., 2018) since the interest of target producers was identified and incorporated into the improvement efforts. As part of CBBPs in Ethiopia, a community-based breeding program has been implemented for the indigenous sheep population, now known as the Abera sheep. Abera sheep are known for meat production in the region and are characterized by long, fat tails with straight tips and short, smooth hairs with straight head profiles (Melesse et al., 2013). The aforementioned breeding program was initiated to make better use of indigenous genetic resources and increase the income of sheep producers by applying a selection-based intervention strategy to targeted growth traits. There have been eight breeder cooperatives established under the Abera CBBP. As per the policy of the breeding program, performance data collection on animals is routinely conducted. Monitoring the current growth performance of sheep under a community-based breeding program is important to know the animals' performance, which could be used to design further improvement directions and add improvement inputs. Therefore, the current study was aimed at the performance evaluation of Abera sheep using current performance records under the Abera community-based breeding program.

MATERIALS AND METHODS

Description of the Study Area and Breeding Program

The study was carried out in the Hula and Dara districts, Sidama regional state, where the Abera community-based breeding program has been implemented. Hula district, one of the study areas, is bordered on the south by the Oromia Region; Dara district on the west; Aleta Wendo district on the northwest; Bursa district on the north; and Bona Zuria on the east. Hula district's longitudinal and latitudinal coordinates are 38° 46'–38° 78' E and 6° 40'–6° 75' N, with a mean altitude of 2809 masl. The district's mean minimum and maximum temperatures were 6.2 °C and 19.1 °C, respectively, with an average annual rainfall of 1425 mm. The other study area, Dara, is found in the eastern parts of southern Ethiopia, 85 km away from Hawassa, the capital city of the Southern Nation nationalities and people's region and Sidama Regional State. The longitudinal and latitudinal positions of the district ranged between $38^o38'$–$38^o51'$ E and $6^o36'$–$6^o54'$ N, respectively, with an altitudinal range of 1200–2900 masl. The mean minimum and maximum temperatures of the district were reported to be 19 oC and 28 ^{o}c, respectively. A mixed crop-livestock farming system is mostly practiced in both districts, where each component complements the other. Farmers in both study districts grow maize, barley, wheat, potatoes, and other crops. Enset is a popular food crop that is commonly used by all households.

Natural pasture, *inset*, and agricultural leftovers are the main feed sources in the study area. Farmers keep sheep and other livestock species during the day on pasture land, around homesteads, and on farmland after crop harvest. In line with the common consensus of community-based breeding program policy, sheep producers practice a controlled mating system. Selective breeding programs based on paternal lines have been used since the implementation of CBBP in 2013. Sheep usually graze on natural pastures during the day on grazing land and around the home. Crop residue is also used as a source of feed after harvest. In line with the common consensus of community-based breeding program policy, sheep producers practice a controlled mating system. Selective breeding programs based on paternal lines have been used since the implementation of CBBP in 2013. Ram selection usually takes place twice a year with a selection intensity of 10%–15%. Selections of breeding rams were conducted based on the estimated breeding value (EBV) of the animals, which is done at six months of age. Then, selected breeding rams were shared based on ram-utilizing groups, with a ratio of one ram to twenty to twenty-five ewes.

Data Collection and Management

Eight-year performance data retained for sheep owned by CBBP participants was obtained from the Southern Agricultural Research Institute. Growth records of sheep were taken at birth, 90 days, 180 days, and 360 days by trained enumerators for each breeder cooperative. Body weight records were taken shortly after birth, at 90 days, 180 days, and 360 days, and necessary weight corrections were made before real analysis. The sex of the lamb, birth type, birth year, and seasons across breeder cooperatives were recorded. Pre-weaning (0 to 90 days) and post-weaning (90 to 180 days) were also estimated. Animals were hanged in a sac connected to a spring balance with a capacity of 50 kg, and their weight was measured. Individual ear tags were used to identify the animals.

Data Management and Analysis

The Mixed Procedure in SAS, version 9 was used to analyze growth traits. Preliminary analysis was used to identify the fixed effects having a significant impact on growth traits. The significant effects included in the model were sex (male, female); parity (1, 2, 3, 4, 5, 6); birth type (single, twin, triple); year (2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020); birth season-main rainy season (June-September), dry season (October-May); breeder cooperatives (Abera Atela, Abera Gelede, Abera Doko, Abera Doda, Abera Bongodo, Bochesa Gobe). The Tukey-Kramer test was used to compare the least square means of having more than two levels.

The statistical model used was: $Y_{ijklmon} = + A_i + D_j + G_k + T_o + R_m + H_o + e_{ijklmon}$

Where $Y_{ijklmon}$: growth trait response variable; overall mean A_i denotes the fixed effect of lamb sex; D_j denotes the fixed effect of dam parity; and G_k denotes the fixed effect of birth type; T_o represents the fixed effect of birth year; R_m represents the fixed effect of birth seasons; H_o represents the fixed effect of breeder cooperatives, and eijklmon represents random error.

RESULT AND DISCUSSION

Growth Performance of Abera Sheep

The growth performance of Abera sheep under a community-based breeding program is presented in Table 1. The overall mean body weight of Abera sheep at birth in the present study was heavier by 0.34 kg than the corresponding value for the same sheep breed (Marufa et al., 2017). Similarly, a lower corresponding value was reported for Gumuz sheep (2.79 kg; Abegaz, 2007); Arsi-Bale sheep (2.89 kg; Legesse, 2008); Washera sheep (2.7 kg; Taye et al., 2010); indigenous sheep in the Fentale area (2.84 kg; Worku et al., 2019); sheep reared around the Jimma zone (2.45 kg; Berhanu and Aynalem, 2009); and 2.3 kg for Alaba sheep (Gemiyu, 2009). In contrast to the result of the present report, a heavier birth weight of 3.71 kg was found for Rutana desert sheep (Dagnew et al., 2018). Birth weights of Afar (2.7 kg) and Horro (2.34 kg) sheep managed at the station were found to be lower than reported in the present study, as respectively reported by Yacob (2008) and Tibbo (2006). The heavier weaning weight of sheep is a good indicator of sheep productivity and ewes' ability to gestate lambs. The overall mean of 15.13 kg of weaning weight recorded in the present study was heavier than previous reports for Sekota sheep (Yeheyis et al., 2012), Gumuz sheep (Abegaz, 2007), and local sheep around the Fentale district (Worku et al., 2019); who recorded 11.9 kg, 12.6 kg, and 7.95 kg, respectively. The weaning weight of sheep investigated at the station level reported by previous studies (Tibbo, 2006; Yacob, 2008) found for Afar (11.5 kg), Menz (9.1 kg), Horro (9.9 kg), and Black-Headed Somali sheep (11.3 kg) was lighter compared with the present report. Heavier weaning weight (15.55 kg) was, however, reported for Bonga sheep under a community-based breeding program (Mestafe, 2015). The pre-weaning body weight difference among many sheep breeds could have resulted from differences in management systems, feed resource availability, and genetic potential of the breed. In addition to this, performance improvement programs such as selective breeding programs could have resulted in better growth performance for sheep breeds under these intervention activities.

The post-weaning growth rate of Abera sheep in the present study is presented in Table 1. In the current study, the overall least-square means of sheep at six-month age (180 days) and yearling age were 20.80 kg and 28.08 kg, respectively. Previous reports (Berhanu and Aynalem, 2009; Marufa et al., 2017; Dagnew et al., 2018; Asmare et al., 2021) found lower six-month weight for the same population (18.5 kg), for indigenous sheep of southwest Ethiopia (18.8 kg), Gumuz sheep (15.77 kg), and Washera sheep (13.94 kg). Dagnew et al. (2018) reported a nearly comparable six-month weight of Rutana desert sheep. However, the corresponding value of Bonga sheep (22.2 kg) reported by Mestafe (2015) was heavier than that reported in the current study. The yearling weight of Abera sheep recorded in the present study was heavier than reports by Asmare et al. (2021) for Gumuz sheep (20.37 kg) and Washera sheep (21.8 k), Horro Highland sheep (Tagaynesh, 2014), Begait sheep (Bahran, 2014), and Hararrghe highland sheep (Negussie, 2015). The yearling weight of Rutana desert sheep (27.6 kg) reported by Dagnew et al. (2018) was nearly comparable with the corresponding value in the present study.

Fixed Effects Affecting the Growth Performance of Abera Sheep

Birth Year:

The year of birth was among source of variation during the pre-weaning and post-weaning periods. Heavier pre-weaning average daily weight gain was observed during 2015, whereas heavier post-weaning average daily weight gain was observed during 2015, 2016, and 2018. The observed difference in the growth rate of Abera sheep across the years could be associated with a difference in the availability of feed resources and other management issues.

Growth performance of sheep can be greatly improved by improvement and genetics. However, many non-genetic factors influence sheep growth performance (Berhanu and Aynalem, 2009), implying that these effects should be considered for the planned improvement intervention. The least-square means of fixed effects influencing the growth performance of Abera sheep are presented in Table 1. Lamb sex highly influenced growth traits at all ages significantly ($p < 0.001$).

Male lambs were heavier than females by an average mean value of 0.09 kg, 0.56 kg, 0.66 kg, and 1.95 kg, respectively, at birth, 90 days, 180 days, and yearling age.

Table 1: Least square mean ± standard error of fixed factors affecting growth performance (kg) of Abera sheep at birth, weaning age, six-month weight and yearling age.

Variable	N	BW (kg)	N	WW (kg)	SMW	YW
Overall	3552	3.14±0.01	3263	15.13±0.06	20.80±0.05	28.89
R^2	3552	0.48	3263	0.06	17.80	14.41
CV%	3552	9.87	3263	20.8	11.57	8.28
Year		0.001		0.001	<0.0001	0.001
2013	157	2.72^{f}±0.02	157	14.85^{bc}±0.14	20.80^{abcd}±0.16	27.76^{c}±0.28
2014	209	2.85^{e}±0.02	209	15.74^{a}±0.14	21.24^{abc}±0.15	28.80^{bc}±0.19
2015	571	2.84^{e}±0.01	560	15.19^{ab}±0.08	21.41^{a}±0.11	29.25^{a}±0.11
2016	494	3.12^{d}±0.02	486	15.55^{a}±0.31	21.31^{ab}±0.11	29.13^{a}±0.13
2017	372	3.26^{bc}±0.02	358	14.70^{bc}±0.11	20.17^{cd}±0.15	29.51^{a}±0.21
2018	729	3.35^{a}±0.02	702	14.79^{bc}±0.10	20.29^{bcd}±0.1	28.85^{ab}±0.13
2019	750	3.29^{ab}±0.02	718	15.23^{ab}±0.07	20.33^{abcd}±0.11	28.76^{ab}±0.28
2020	270	3.21^{c}±0.03	73	14.51^{c}±0.23	20.06^{d}±0.65	
Sex		0.001		0.001	<0.0001	<0.0001
Male	2092	3.18±0.010	1330	15.36±0.09	21.02±0.06	29.22±0.08
Female	1460	3.09±0.011	1933	14.80±0.05	20.36±0.08	27.77±0.08
Litter size		0.001		0.001	<0.0001	NS
Single	2411	3.23^{a}±0.009	2242	15.35^{a}±0.08	20.87^{a}±0.06	28.92^{a}±0.08
Twin	1126	2.96^{b}±0.011	1008	14.66^{b}±0.06	20.56^{a}±0.09	28.84^{a}±0.1
Triple	15	2.59^{c}±0.13	13	12.78^{c}±0.98	18.82^{b}±1.27	28.0^{a}±0.7
Parity		0.01		NS	0.0008	NS
1	1796	3.08^{d}±0.01	1715	15.13±0.1	20.67^{ab}±0.05	28.88±0.10
2	770	3.14^{cd}±0.02	692	15.24±0.07	21.05^{a}±0.08	28.73±0.17
3	550	3.22^{bc}±0.02	441	15.11±0.10	20.82^{a}±0.11	28.74±0.24
4	272	3.26^{ab}±0.01	255	14.95±0.12	20.95^{a}±0.13	29.60±0.31
5	119	3.31^{a}±0.04	103	15.17±0.22	19.95^{bc}±0.18	29.84±0.59
6	45	3.35^{a}±0.06	39	14.86±0.33	19.80^{c}±0.29	29.29±0.94
Seasons		NS		NS	<0.0001	28.67±.09
DS	1395	3.12±0.01	1349	15.18±0.08	21.08^{a}±0.1	28.81±0.12
SRS	1021	3.16±0.01	812	15.21±0.06	20.67^{b}±0.1	28.41±0.10
MRS	1136	3.14±0.01	1103	14.99±0.05	20.48^{b}±0.1	
BC		0.001		0.001	<0.0001	
A Atela	825	3.26^{a}±0.01	774	15.41^{b}±0.06	21.15^{b}±0.08	Na
A Gelede	901	3.26^{a}±0.02	828	14.96^{bc}±0.06	20.69^{c}±0.10	Na
A Bongodo	590	3.15^{b}±0.01	547	16.06^{a}±0.05	21.95^{a}±0.10	Na
B Gobe	356	3.03^{c}±0.02	326	14.96^{b}c±0.10	20.33^{d}±0.14	Na
A Doko	406	2.95^{d}±0.02	384	14.96^{c}±0.11	21.07^{b}±0.14	Na
A Doda	474	2.95^{d}±0.02	404	14.24^{d}±0.38	18.40^{e}±0.17	Na

BW: Birth weight; WW: Weaning weight; SMW: Six-month weight; YW: Yearling weight; SRS: Short rainy seasons; MRS: Main rainy season; A: Abera. Column mean with same letter are not significantly different, LSM – least square mean; BC- Breeder cooperatives; SE – standard error; NS: Non-significant.

In agreement with the present result, many studies (Tibbo, 2006; Taye et al., 2010; Marufa et al., 2017; Dagnew et al., 2018) have widely reported the body weight superiority of males over female counterparts. This difference in body weight between sexes at a given time could be associated with the action of sex hormones that favor more growth in males when compared with females. Single-born lambs were significantly heavier than multiples (twin and triple) at birth and weaning age, whereas triples had a lower body at sixth-month age. On the other hand, the present result observed no significant ($p > 0.05$) variation in birth type at yearling age. More space in the dam's uterus and a lack of competition during pregnancy would have facilitated a higher birth weight for a single lamb at birth.

Litter Size:

The number of lambs born per birth was observed as a significant ($p<0.001$) source of variation at all ages except for yearling age, where observed body weight was not significantly ($p > 0.05$) different. At birth, weaning, and six months of age, single-born lambs achieve significantly heavier body weight than multiple-birth lambs. Similarly, the body weight of twin births was significantly heavier than that of triple births at birth and weaning age. More space in the dam's uterus and a lack of competition during pregnancy would have facilitated a higher birth weight for a single lamb at birth. The absence of competition for milk utilization for lambs born as singles could have facilitated a better growth rate before weaning age. Many previous studies have widely documented heavier body weight and better growth in single-born lambs over multiple-born counterparts (Abegaz et al., 2011; Zeleke *et al.*, 2017; Dagnew *et al.*, 2018). Better feeding management of dams during pregnancy could thus partially improve body weight at birth and later age because lambs with a higher birth weight typically have better growth performance throughout their lives (Kosgey, 2004).

Dam Parity:

Dam parity was observed as a significant source of variation in body weight at birth and at 180 days. However, no significant parity effect was observed at 90 days or yearling age (360 days). The lamb of an older dam (four to six) had a heavier birth weight compared with the younger dam. This is associated with older dams developing more useful physiological processes than younger dams, which is consistent with previous research (Sodiq, 2012). The significant effects of parity at 180 days were slightly increasing up to parity four and starting to decline. This implies that lambs of lower parities had lower body weight performance, which might be associated with the reproductive physiological process not being well developed in a younger dam when compared with an older one.

Year Effect:

The growth performance of Abera sheep was significantly ($p<0.001$) different across years (2013–2020). The least-square mean of birth weight observed during 2018 was significantly ($p<0.01$) heavier (3.35±0.017 kg) than the lowest least-square mean observed during 2013—when Abera CBBP was implemented. Observed body birth weight performance differences across years could be associated with selective breeding programs which increase the overall performance of sheep.

Birth Seasons:

The present study observed no significant difference in seasons at birth and at 90 days. The current result was in agreement with a previous study (Ashebir *et al.*, 2019) that did not observe significant effects of the birth season at 90 days for a study conducted for sheep reared in the Fentale district of Oromia regional state. However, the current result was contrary to a previous study (Legesse, 2008), which observed significant effects of the season at birth.

The Daily Growth Rate of Abera Sheep

The least-squares mean (standard error) of fixed effects having significant effects between 0 and 90 days and 90 and 180 days were presented in Table 2. The observed pre-weaning average daily weight gain (135.31±0.50) g/day in the present study was heavier by 29.32 g/day for the same sheep population (Marufa *et al.*, 2017). The pre-weaning daily weight gain of Washera sheep (107.1 g/day) was also lower than the corresponding value in the present study (Taye *et al.*, 2010). The post-weaning average daily weight gain of Abera sheep was observed to be 63.64±0.49 g/day. The present study showed Abera sheep gained more daily weight during the pre-weaning age than after weaning, which indicated strong maternal dependence of lambs on their dams during pre-weaning periods. Weaning shock could also be a significant factor causing lower daily weight gain during post-weaning periods. The result of the present study was somewhat heavier than the corresponding value for Rutana sheep (59.01 g/day), as reported by Dagnew *et al.* (2018).

Lamb Sex:

Lamb sex had a significant effect on both pre-weaning and post-weaning daily weight gain (g/day) of Abera sheep. The male lambs were significantly heavier than their female counterparts by 4.41 g/day and 2.52 g/day, respectively, during pre-weaning and post-weaning periods. The result of the pre-weaning average daily weight of male superiority over females was in agreement with previous studies (Marufa *et al.*, 2017; Dagnew *et al.*, 2018). The possible reason for male superiority over females could be associated with a difference in testosterone secretion between males and females. Previous studies (Marufa *et al.*, 2017) did not observe a significant average daily weight gain difference between male and female lambs during post-weaning periods, which was contrary to the result of the present study.

Birth Type:

Birth types had significant effects ($p<0.05$) on the body weight gain of Abera sheep. Single and twin births had a heavier growth rate (g/day) during 0 to 90 days than triplet births—triplets had a lower daily weight gain. From 90 days to 180 days, single-born lambs had a higher daily weight gain than their multiple-born counterparts. The superiority of single-born lambs during post-weaning periods could be associated with their previous better condition during pre-weaning periods. The previous studies, in agreement with the present study, observed significant effects of birth types on the growth rates of sheep reared in different locations (Tibbo, 2006; Cloete *et al.*, 2007; Taye *et al.*, 2010; Marufa *et al.*, 2017; Dagnew *et al.*, 2018).

Birth Seasons:

The daily weight gain (g/day) of Abera sheep differed significantly ($p< 0.05$) from 0 to 90 days and from 90 days to 180 days**.** From ninety days to 180 days, the average daily weight gain of Abera sheep was higher for lambs born during the dry season than for those born during the short and main rainy seasons. The higher body growth rate of lambs born during dry seasons could be associated with ample feed resource availability during the main rainy seasons when lambs born during dry seasons achieve their 180-day age.

Breeder Cooperatives:

The average body growth rates of Abera sheep were significantly ($p<0.01$) different across the breeder cooperatives. Sheep in Abera Bongodo cooperatives had a higher average daily weight gain (g/day) from 0 to 90 days, followed by sheep in Abera Atela breeder cooperatives, whereas the lowest 0 to 90-day daily weight gain was observed for sheep owned by Abera Doda cooperatives. Sheep in the Abera Doko cooperative gained more weight from 90 to 180 days, followed by sheep in the Abera Bongodo and Abera Gelede breeder cooperatives. The difference in feed resources and management conditions could be the most possible reasons for the difference in the body growth rate of Abera sheep across breeder cooperatives.

Table 2: Least square mean ± standard error (g/day) of fixed effects affecting body growth rate of Abera sheep from 0 to days and 90 days to 180 days.

Fixed effects	**Pre-weaning daily weight gain**		**Post weaning daily weight gain**	
	[1]N	[2]LSM±SE (g/day)	N	LSM±SE (g/day)
Overall	2838	135.31±0.50	2692	63.64±0.49
R^2	2838	18.46	2692	7.92
CV%	2838	14.16	2692	38.95
Sex		**		*
Male	1716	137.04±0.63	1634	64.50±0.61
Female	1122	132.63±0.79	1058	61.98±0.77
Litter size		**		*
Singleton	1956	136.77^{a}±0.57	1855	81.81^{a}±0.58
Twin	871	132.55^{a}±0.74	829	65.53^{b}±0.91
Triplet	11	121.69^{b}±11.94	8	62.71^{b}±6.59
Seasons of lambing		*		**
Dry season	1118	136.98^{a}±0.77	1069	67.19^{a}±0.77
Short rainy season	689	134.59^{a}±0.95	653	61.07^{b}±0.98
Main rainy season	1031	133.82^{b}±0.65	970	61.45^{b}±0.85
Year of lambing		**		**
2013	157	142.95^{ab}±1.61	157	66.37^{a}±1.69
2014	209	142.91^{ab}±1.1	209	61.64^{ab}±1.31
2015	551	145.28^{a}±0.72	552	69.14^{a}±1.08
2016	452	134.11^{c}±7.21	457	67.92^{a}±1.16
2017	321	125.67^{d}±1.25	317	58.85^{ab}±1.34
2018	642	121.96^{d}±1.37	499	63.11^{a}±1.19
2019	498	138.56^{bc}±0.97	494	56.84^{ab}±0.98
2020	8	143.74^{ab}±3.06	7	50.42^{b}±8.41
Dam parity		*		*
1	1520	136.33^{a}±0.52	1443	62.72^{b}±0.66
2	606	136.89^{a}±0.84	581	65.03^{b}±1.04
3	388	132.51^{a}±1.10	372	64.34^{b}±1.26
4	211	131.80^{a}±1.45	198	67.41^{a}±1.75
5	80	136.50^{a}±2.70	74	54.13^{c}±2.54
6	22	124.68^{b}±5.12	24	52.43^{c}±4.70
Breeder cooperatives		**		**
Abera Atela	668	136.28^{b}±0.73	667	62.92^{c}±0.75
Abera Bongodo	462	143.66^{a}±0.63	462	65.75^{b}±1.00
Abera Doda	307	118.13^{d}±1.40	307	54.91^{d}±1.62
Abera Doko	360	130.58^{c}±1.25	360	71.39^{a}±1.89
Abera Gelede	752	130.35^{c}±0.70	751	63.50^{b}±0.92
Bochesa Gobe	289	132.32^{c}±1.10	289	60.50^{c}±1.50

N: number of records, LSM: Least square mean, SE: Standard error, * and ** significant at $p<0.05$ and $p<0.01$, respectively. Means with different superscript are significantly different.

Reproductive Performance

Litter Size:

Sheep prolificacy is an important reproductive trait that determines farm productivity. Although there has been a slight improvement in the prolificacy of Abera sheep over the past year (Table4), the recorded mean litter size (1.19) was lower than corresponding values for many sheep breeds such as Bonga sheep (1.4; Edea, 2008), Gumuz sheep (1.43; Asmare et al., 2021), and Adilo sheep (1.42; Getahun, 2008) under different management conditions. In contrast to this, however, lower mean litter size was reported for Gumuz sheep (1.17; Solomon, 2007), Washera sheep (1.1; Taye, 2010), and Menz sheep (1.13; Mukasa-Mugerwa et al., 2002). The observed mean litter size of sheep in the present study was significantly ($p<0.05$) different across the year but not across breeder cooperatives (Table 3). The lowest mean (1.09) of litter size was observed in 2013, followed by 2014. The mean litter size observed between 2015 and 2020 was not significantly ($p<0.05$) different and higher (Table 3). In 2013, more than 90% of observed births were single, whereas in 2020 the corresponding proportion was nearly 80%, which indicated the improvement in prolificacy as the chi-square test showed (Table 4).

Table 3: Mean litter size of Abera sheep across year and breeder cooperatives.

Year	N	Mean ± SE	Breeder cooperatives	N	Mean ± SE
2013	144	$1.09^{b}\pm0.03$	Abera Atela	703	1.17±0.01
2014	180	$1.15^{ab}\pm0.03$	Abera Bongodo	514	1.22±0.02
2015	478	$1.19^{a}\pm0.02$	Abera Doda	395	1.19±0.02
2016	404	$1.21^{a}\pm0.02$	Abera Doko	340	1.18±0.02
2017	312	$1.19^{a}\pm0.02$	Abera Gelede	738	1.21±0.02
2018	600	$1.19^{a}\pm0.02$	Bochesa Gobe	295	1.17±0.02
2019	644	$1.22^{a}\pm0.02$			
2020	223	$1.20^{a}\pm0.03$			
Overall	2985	1.19±0.01		2985	1.19±0.01
p-value		0.0263			0.1371

SE: standard error. Column means with different letter are significantly different ($p<0.05$)

Table 4: The proportion (%) of single and twin of sheep between 2013 and 2020

Prolificacy	Year								X^2	*p*-value
	2013	2014	2015	2016	2017	2018	2019	2020	15.86	0.026
Single	91	85	80.8	78.7	81.1	81.2	78.1	80.3		
Multiple	9	15	19.2	21.3	18.9	18.8	21.9	19.7		
[1]N	144	180	478	404	312	600	644	123		

N: Number of records

CONCLUSIONS

The present study evaluated the growth and reproductive performance of Abera sheep owned by community-based breeding program participants using retained performance records since 2013. The result showed considerable improvement in growth traits since the breeding program was implemented. Many of the considered fixed effects had a significant influence on growth traits, indicating that these fixed effects should be considered when breeding rams are selected. The selection index should be used to consider the fixed effects significantly affecting growth performance for further selection of breeding rams. Although the proportion of ewes lambing multiples per lambing showed considerable increment over years, the overall mean of sheep prolificacy was found to be low under a community-based breedingprogram. As community-based breeding programs have made considerable contributions to improvement in growth traits, further selection and scaling up should be encouraged. Inclusion of the selection index along with growth traits targeted for improvement can be used as an important strategy to improve sheep prolificacy per lambing.

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