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Research Article
Evaluation of Phenotypic and Morphometric Characteristics in Community Based Breeding Program of Gumer Sheep

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Abstract
Background and Objective: Community-Based Breeding Programs (CBBP) have been adopted to improve Gumer sheep. This study was undertaken to evaluate growth rate, prolificacy performance, characterizing morphological traits and to establish weight estimating regression models. **Material and Methods:** Data on 988, 854, 708 and 404 for birth, weaning, 6 months and yearling weights, respectively for growth rate traits and 678 for prolificacy traits were used for evaluation across the years of 2015-2020. Similarly, 85 males and 200 females were used for morphometric measurements viz, body length, height at withers, heart girth, horn length, tail length, scrotal circumference, tail circumference and ear length. The effect of non-genetic factors like a year of birth, sex, litter size, birth season, CBBP type and coat colour were analyzed by using general linear model procedures of the Statistical Analysis System (SAS). Correlation between morphometric measurements and stepwise regression procedures to determine the best fitting regression equation for the prediction of live body weights for male and female sheep. **Result:** The overall least square means for birth, weaning, 6 months and yearling weights of Gumer sheep were 2.09$\pm$0.02, 11.63$\pm$0.20, 15.76$\pm$0.42 and 21.14$\pm$0.64 kg, respectively. A high and significant correlation between body weight and morphometric measurements suggest that either of the variables provide a good estimation of live weight. The regression models for both male and female were $Y = -42.29+0.46HG+0.53\ BL$ with $R^2_{adj} = 0.87$ and $Y = -16.11+0.40\ HG$ with $R^2_{adj} = 0.50$, respectively. **Conclusion:** The body weight and prolificacy traits of Gumer sheep were in increasing trend and had high within variation which leads to further improvement for those traits through CBBP.

Key words: Growth rate, Gumer sheep, morphometric measurements, prediction, prolificacy, regression, sheep community-based breeding program

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa. According to the Ethiopian Central Statistical Agency (CSA) in 2021 the total Ethiopian sheep population was estimated as 42.9 million to breed 99.52, 0.41 and 0.08% are indigenous, hybrid and exotic, respectively. At the national level, small ruminant accounts for about 90% of the meat and 92% of skin and hide export trade value. They also serve as a means of risk mitigation during crop failures, property security, monetary saving and investment and other socio-economic and cultural functions. Sheep population of Southern Nation Nationalities and People Region (SNNPR) of Ethiopia cover 10.63% of the national population which is characterized by multicultural diversity along with its great variation in climate and topography representing a good reservoir of sheep genotypes[1].

The information of animal genetic resources is essential to the design of strategies for their sustainable management and breed improvement program[2]. Characterizations of animal genetic resources include identification of quantitative and qualitative description, documentation of breed populations and the natural habitats and production. Body measurements are perfect indicators to make a definition for each breed and to make rational decisions for the improvement and the development of effective breeding programmes[3]. Recent concerns on the loss of diversity of indigenous small ruminants have led to renewed initiatives and efforts to use, conserve and improve small ruminant genetic resources sustainably[4].

The natural habitat of Gumer sheep is found in Gurage and Silte zones highland areas of SNNPR. The total sheep populations in these areas were 360,291 and 382,495 for Gurage and Silte zones, respectively. Gumer district is among the most populous area of Gumer sheep, a result of the developed Community-Based Breeding Program (CBBP) in the area and has been led to call the name of the population as Gumer sheep. The CBBP of Gumer sheep is aimed to initiate systematic breeding at the community level, including an organized animal identification and recording of performance and pedigree data.

This study aimed to evaluate growth rate traits, determination of prolificacy performance, characterizing morphological traits and to establish weight estimating regression models in the Gumer district for CBBP of Gumer sheep.

MATERIALS AND METHODS

Description of the study area: The study was conducted in the Gumer district, which is geographically located in Gurage Zone SNNPR, Ethiopia. The study was carried out at the South Agricultural Research Institute of Worabe Agricultural Research Center from 2015-2020. The geographic coordination of the district is 7°55'N 38°05'E with an altitude range of 2500-3000 m above sea level. According to the world metrology organization, the maximum and minimum temperature of the district is 26 and 12°C with an average of 19°C and the average annual rainfall is 1226 mm. According to personal observation and discussion with elder people in the area, the rainy season ranges from May to November and the dry season extend from December to April. The production system in this area is mixed crop-livestock and suitable for cereal production due to suitable weather conditions.

Breeding program and animal management: All CBBPs (Abeke, Denber, Enjefo and on-station) were established in 2014. Gumer sheep is not a seasonal breed, lambing is observed all year round. The founder stocks of sheep were tagged for identification with a plastic ear tag and the lambs were tagged before weaning. The ear tag contained information on the code of the CBBP, the Identification Number (ID) of the animal and year of birth or registration. The data recorded for each lamb included their sex, Birth Weight (BWT), Weaning Weight (WWT), Six Months Weight (SMWT), Yearling Weight (YWT), coat colour pattern, animal ID, sire ID, dam ID, birth date, birth type, parity, CBBP name and owners name. The selection of male lambs was carried out separately within each CBBP based on their Estimated Breeding Value (EBV) at SMWT. Lambs with undesirable traits like white and black coat colour were culled regardless of their EBV. The maternal selection for Gumer sheep CBBP was not undertaken due to the small flock size per household. The total flock size for Gumer CBBP participants of 153 members was 520 sheep. This indicates that the average flock size for each household of the area was 3.42. The reason for the lower flock size is the selling of their sheep due to shortage of grazing land and fear of predators like a hyena. Flocks were kept in animal a house which is shared with kitchen during night and midday. The houses were made of wooden walls and covered by mud with straw corrugated with grass or corrugated iron. The major feed resources were pasture, crop residues and kitchen leftovers.

Data collection: Bodyweight (BW) data used for this study were BWT, WWT, SMWT and YWT. Similarly, Average Daily

Gains (ADGs) like ADG from birth to weaning weight (ADG_1), ADG from weaning to 6 month (ADG_2) and ADG from 6 month to yearling (ADG_3) were collected. ADG was calculated as:

$$ADG = \frac{W_{t2} - W_{t1}}{t_2 - t_1}$$

Where:

W_{t1} = BW at t_1 age in days

W_{t2} = BW at t_2 ages in days

When referring to WWT, SMWT and YWT, these are age-corrected traits such that, for example:

$$WWT = \frac{(wwt - BWT) \times 90}{Age} + BWT$$

where, wwt is the three months weight recorded at approximately three months and age is the recording date minus birth date in days. SMWT and YWT are calculated similarly.

The total BW data used for this study were 988, 854, 708 and 404 for BWT, WWT, SMWT and YWT, respectively. Data sizes for ADGs used for the current study were 853, 711 and 572 for ADG_1, ADG_2 and ADG_3, respectively whereas 678 data of ewe were used for prolificacy traits evaluation. A suspended weighing scale 50 kg capacity with an accuracy of 100 g was used to record BW. Linear Body Measurement (LBM) data were collected from mature 85 male and 200 female sheep by using the purposive sampling technique. These LBMs BW, Body Length (BL), Height at Wither (HW), Heart Girth (HG), Horn Length (HL), Tail Length (TL), Scrotal Circumference (SC), Tail Circumference (TC) and Ear Length (EL).

Data analysis: The effect of non-genetic factors like a year of birth (6 levels: 2015-2020), sex (2 levels), litter size (3 levels: single, twin and triple), birth season (2 levels: dry and wet), animal coat colour (8 levels) and CBBP (4 levels) were analyzed by using general linear model procedures of the Statistical Analysis System (SAS). Both BW and ADGs at different ages were considered as response factors and subjected to the adjusted Tukey-Kramer method when significant in SAS. Similarly, the non-genetic factors for prolificacy traits included lambing year (6 levels: 2015-2020), CBBP (4 levels) and lambing season (2 levels). The correlation between LBM traits was estimated as the ratio of the estimates of the covariance between traits one and two to the product of the square roots of the estimates of variance for traits one and two[5]. A stepwise regression procedure was used to determine the best fitting regression equations for the prediction of the live body weight of both sexes. Regression equations were calculated and the highest adjusted coefficient of determination (R^2_{adj}) was used to establish the accuracy of the equations. The following regression model was used for estimation BW from LBM:

$$Y = \alpha + \beta_i X_i + e$$

Where:

Y = Mature BW

α = Intercept

X_i = Variables (BL, HG, HW, SC, TL, HL, TC and EL)

β_i = Regression coefficients of the variables

X_i and e = Residual random error

RESULTS

Growth rate traits: The overall least square Mean±SE for BWT, WWT, SMWT and YWT of Gumer sheep were 2.09±0.02, 11.63±0.20, 15.76±0.42 and 21.14±0.64 (kg), respectively (Table 1). The effect of birth year, CBBP and litter size was significant ($p<0.0001$) for BW traits (Table 1). Whereas birth season except for WWT, sex except for BWT and coat colour pattern fixed effects were not significantly affected BW of Gumer sheep. Similarly, the overall least-square Mean±SE for ADG_1, ADG_2 and ADG_3 were 105.31±2.21, 47.71±5.16 and 20.82±4.48 g/day, respectively (Table 2). The effect of birth year and CBBP of animals was significant ($p<0.0001$) for all ADGs. Gumer sheep ADGs were not significantly affected by sex, litter sizes except for ADG_1 and the coat colour pattern of the animal (Table 2).

Prolificacy trait of Gumer sheep: The overall least square Mean±SE for litter size of Gumer sheep was 1.65±0.02 lambs and the Coefficient of Variation (CV) was 31.24% (Table 3). The percentages of twins and triplets were 70.34%. This trait was statistically significant ($p<0.0001$) variation across different CBBPs but non-significant across lambing year and season. The lower litter size performance was recorded from the on-station of Gumer site which is related to poor management in the station. Flushing the ewe at least three weeks pre-mating is important to increase litter size which was not implemented at this sheep station. The overall prolificacy of this sheep population was higher than any other indigenous and some exotic sheep breeds.

Linear body measurements of Gumer sheep: Mature BW for male and female of Gumer sheep was 29.13±0.971 and

Table 1: Least square Mean±SE for different body weight traits as affected by different fixed effects of Gumer sheep

Fixed effects	N	BWT	N	WWT	N	SMWT	N	YWT
Overall	988	2.09±0.02	854	11.63±0.20	708	15.76±0.42	404	21.14±0.64
CV (%)		15.87		20.92		13.61		20.04
Range (kg)		1- 3.9		5.5-33.5		9-28.4		14-46
Birth year		p = 0.0004		p<0.0001		p<0.0001		p = 0.9857
2015	36	2.13±0.06^{abc}	17	14.47±0.63^{a}	-	-	-	-
2016	109	2.20±0.04^{a}	88	11.46±0.32^{b}	53	15.21±0.37^{bc}	34	20.88±0.97
2017	144	2.00±0.03^{c}	136	10.93±0.27^{b}	134	14.73±0.27^{c}	114	21.00±0.71
2018	131	2.06±0.04^{bc}	118	10.26±0.27^{c}	108	15.89±0.28^{b}	85	21.31±0.69
2019	358	2.11±0.02^{ab}	337	11.34±0.21^{b}	295	15.89±0.21^{b}	161	21.07±0.61
2020	210	2.06±0.0^{bc}	144	11.33±0.25^{b}	118	16.70±0.25^{a}	7	21.46±1.75
CBBP		p<0.0001		p<0.0001		p<0.0001		p<0.0001
Abeke	284	1.97±0.03^{bc}	281	11.84±0.24^{b}	243	15.75±0.43^{b}	135	22.63±0.71^{a}
Denber	136	2.02±0.04^{b}	133	11.51±0.29^{b}	130	14.17±0.46^{c}	72	20.33±0.83^{b}
Enjefo	321	1.93±0.03^{c}	233	14.35±0.23^{a}	165	21.00±0.43^{a}	65	23.58±0.81^{a}
On-station	247	2.45±0.04^{a}	193	8.82±0.29^{c}	170	12.17±0.46^{d}	129	18.04±0.78^{c}
Birth season		p = 0.2152		p = 0.0004		p = 0.2737		p = 0.1234
Dry	422	2.11±0.02	381	11.94±0.23	315	15.86±0.43	155	21.52±0.71
Wet	566	2.10±0.03	459	11.34±0.20	393	15.67±0.42	246	20.77±0.65
Sex		p = 0.0032		p = 0.7486		p = 0.5951		p = 0.6657
Male	494	2.13±0.03	427	11.60±0.22	366	15.81±0.42	214	21.24±0.65
Female	494	2.06±0.03	413	11.66±0.21	342	15.72±0.43	187	21.04±0.70
Litter size		p<0.0001		p<0.0001		p<0.0001		p = 0.1912
Single	293	2.35±0.03^{a}	253	12.82±0.23^{a}	218	16.70±0.43^{a}	154	21.83±0.65
Twin	640	2.07±0.02^{b}	536	11.70±0.19^{b}	443	15.95±0.41^{b}	225	21.68±0.62
Triple	55	1.86±0.04^{c}	51	10.37±0.37^{c}	47	14.64±0.52^{c}	22	19.92±1.09
Coat colour		p = 0.0559		p = 0.9915		p = 0.9256		p = 0.5069
Brown black with white	278	2.19±0.06	236	11.64±0.55	207	15.96±0.68	124	21.53±0.60
Pied gray and white	12	2.24±0.09	10	11.55±0.77	5	15.81±1.06	3	20.20±2.52
Pied black and white	132	2.05±0.03	118	11.67±0.26	101	15.82±0.43	51	21.47±0.78
Plain brown black	428	2.13±0.05	356	11.86±0.40	204	16.054±0.53	180	21.52±1.30
Plain gray	43	2.15±0.05	33	11.68±0.45	25	15.48±0.59	13	20.89±1.34
Plain red	16	2.16±0.09	16	12.09±0.62	10	15.37±0.81	3	22.05±2.56
Plain white	45	2.06±0.05	37	11.66±0.42	25	16.03±0.59	7	24.75±1.75
Pied white and brown	34	1.98±0.10	34	11.40±0.74	31	16.30±0.78	20	19.91±2.22

BWT: Birth weight, WWT: Weaning weight, SMWT: Six-month weight, YWT: Yearling weight, CBBP: Community-based breeding program and Mean with different letters in column within fixed effects are significantly different

26.11±0.454 kg, respectively and statistically significant between sexes of sheep (Table 4). Similarly, both EL and HL were significantly different for male and female sheep. Most ewes are prolific and have a large frame which may be the reason for related and non-significant traits like BL, HG and HW between male and female sheep. Also, farmers share their food for their prolific ewes than breeding sires result in related body size for both sexes of sheep.

Correlation between body weight and linear body measurements: The BW had the highest correlation with BL (0.892) followed by HG (0.861) and HW (0.792) for male sheep (Table 5). The EL of male sheep had a non-significant association with BW. The BL of male sheep had the highest correlation with HW (0.777) and HG (0.768) but no association with EL. Similarly, BW of female sheep had highly correlated with HG (0.602) followed by BL (0.296) and EL (0.289) but HW and TL had a non-significant correlation (Table 5). Unexpectedly TL of female sheep was negatively correlated with BL and HG.

Prediction of body weight estimation equation: The best regression model for live weight estimation to be used by farmers without the use of a weighing scale for the Gumer sheep population was determined separately by sex. It indicated that BW is estimated by morphometric measurements which included HG and BL for male sheep but HG alone was an important trait for female sheep. The model for BW estimation for male sheep was $Y = -42.29+0.46\ HG+0.53\ BL$ with $R^2_{adj} = 0.87$ and for female sheep $Y = -16.11+0.40\ HG$ with $R^2_{adj} = 0.50$. The accuracy was expected because HG was linked to the chest and abdominal area which dominate the volume of BW than the chest to the base of the tail known as BL.

Table 2: Least square Mean±SE for different ADG traits as affected by different fixed effects of Gumer sheep

Fixed effects	N	ADG_1	N	ADG_2	N	ADG_3
Overall	853	105.31±2.21	711	47.71±5.16	572	20.82±4.48
CV (%)		24.90		58.35		93.40
Range (kg)		12-352.80		-7.6-227.30		-33-248.80
Birth year		p<0.0001		p<0.0001		p<0.0001
2015	17	136.58±6.94[a]	-	-	-	-
2016	88	101.84±3.45[b]	53	49.42±4.63[b]	50	22.37±4.12[a]
2017	137	98.94±3.03[b]	136	46.43±3.34[b]	136	28.49±2.99[a]
2018	121	90.02±3.01[c]	109	65.90±3.40[a]	107	26.30±3.00[a]
2019	343	101.53±2.28[b]	293	37.50±2.62[c]	194	29.90±2.61[a]
2020	147	102.94±2.75[b]	120	47.22±3.17[b]	85	7.38±3.23[b]
CBBP		p<0.0001		p<0.0001		p<0.0001
Abeke	281	110.22±2.64[b]	243	38.02±5.40[b]	142	31.89±4.92[a]
Denber	133	105.55±3.19[b]	124	44.88±5.74[b]	129	18.74±4.92[b]
Enjefo	233	138.35±2.59[a]	163	69.97±5.40[a]	162	9.096±4.67[c]
Gumer station	206	67.12±3.14[c]	181	37.96±5.72[b]	139	23.54±5.09[b]
Birth season		p = 0.0002		p = 0.0007		p = 0.0153
Dry	383	108.84±2.53	317	44.06±5.37	203	23.40±4.74
Wet	470	101.78±2.26	394	51.35±5.17	369	18.23±4.46
Sex		p = 0.5535		p = 0.4374		p = 0.2943
Male	434	104.77±2.43	366	48.51±5.23	308	21.85±4.54
Female	419	105.85±2.36	345	46.90±5.30	264	19.79±4.63
Litter size		p<0.0001		p = 0.1268		p = 0.9654
Single	257	116.37±2.51[a]	219	51.020±5.34	181	20.41±4.63
Twin	545	105.87±2.13[b]	445	50.32±5.10	357	20.46±4.40
Triple	51	93.69±4.13[c]	47	41.78±6.43	34	21.58±5.88
Coat colour		p = 0.9934		p = 0.3987		p = 0.9617
Brown black with white	245	105.99±2.32	207	49.79±5.14	165	22.23±4.49
Pied gray and white	10	102.67±8.47	5	64.57±13.16	5	17.22±11.12
Pied black and white	160	105.71±2.91	141	43.70±5.34	104	24.47±4.67
Plain brown black	318	106.50±2.22	268	46.94±5.09	230	21.44±4.45
Plain gray	33	106.72±4.93	24	49.41±7.44	18	16.89±6.94
Plain red	16	109.73±6.89	10	45.15±10.05	7	18.47±9.82
Plain white	37	106.20±4.67	25	43.34±7.41	17	27.47±7.11
Pied white and brown	34	103.93±8.20	31	55.35±9.64	26	19.16±8.82

ADG_1: Average daily gain from birth to weaning, ADG_2: From weaning to 6 months, ADG_3: From 6 months to yearling, CBBP: Community-based breeding program and Mean with different letters in the column within fixed effects are significantly different

Table 3: Least square Mean±SE for litter size trait as affected by different fixed effects of Gumer sheep

Fixed effects	N	LSM±SE
Overall	678	1.65±0.02
CV (%)		31.24
Range (lamb)		1-3
Lambing year	p = 0.2342	
2015	20	1.72±0.12
2016	67	1.58±0.06
2017	101	1.57±0.05
2018	87	1.59±0.05
2019	230	1.65±0.03
2020	173	1.73±0.04
CBBP	p<0.0001	
Abeke	184	1.76±0.04[a]
Denber	78	1.84±0.06[a]
Enjefo	197	1.77±0.04[a]
On-station	219	1.22±0.04[b]
Lambing season	p = 0.9360	
Dry	282	1.65±0.04
Wet	396	1.65±0.03

CBBP: Community based breeding program, CV: Coefficient of variation, N: Number of sample, LSM: Least square mean and SE: Standard error

Table 4: Least square Mean±SE for quantitative variations in morphometric measurements (cm) and body weight (kg) of mature Gumer sheep

LBMs	Male	Female	Overall	p-value
BW	29.13±0.971	26.11±0.454	27.62±0.536	0.006
BL	62.63±1.032	63.85±0.483	63.24±0.569	0.285
HG	78.06±1.388	75.99± 0.649	77.02±0.766	0.179
HW	64.81±0.852	63.92±0.399	64.37±0.470	0.344
TL	35.88±1.171	33.54±0.548	34.71±0.647	0.075
HL	26.84±1.138	3.14±0.532	14.99±0.628	<0.0001
EL	10.031±0.292	11.14±0.137	10.58±0.161	0.009
TC	18.25±0.983	16.44±0.460	17.34±0.542	0.098
SC	25.50±0.200	_	-	-

LBMs: Linear body measurements, BW: Body weight, BL: Body length, HG: Heart girth, HW: Height at wither, TL: Tail length, HL: Horn length, EL: Ear length, TC: Tail circumference and SC: Scrotum circumference

Table 5: Correlation between body weight and body measurements for male below diagonal and female above diagonal

	BW	BL	HG	HW	SC	TL	HL	TC	EL
BW		0.296**	0.602***	0.197^{ns}	NA	0.027^{ns}	0.258*	0.279**	0.289*
BL	0.892***		0.331**	0.641***	NA	-0.027^{ns}	0.072^{ns}	0.019^{ns}	0.086^{ns}
HG	0.861***	0.768***		0.134^{ns}	NA	-0.117^{ns}	0.096^{ns}	0.257*	0.053^{ns}
HW	0.792***	0.777***	0.761***		NA	0.130^{ns}	0.140^{ns}	-0.026^{ns}	0.137^{ns}
SC	0.587**	0.641**	0.487^{ns}	0.461^{ns}		NA	NA	NA	NA
TL	0.776***	0.673**	0.668**	0.511*	0.232^{ns}		-0.06^{ns}	0.135^{ns}	0.023^{ns}
HL	0.748***	0.571*	0.653**	0.489^{ns}	0.352^{ns}	0.480^{ns}		0.0004^{ns}	-0.07^{ns}
TC	0.687**	0.529*	0.640***	0.645***	0.028^{ns}	0.811***	0.557*		0.345**
EL	0.165^{ns}	0.350^{ns}	0.104^{ns}	0.339^{ns}	-0.02^{ns}	0.410^{ns}	0.044^{ns}	-0.023^{ns}	

BW: Body weight, BL: Body length, HG: Heart girth, HW: Height at wither, SC: Scrotal circumference, TL: Tail length, HL: Horn length, TC: Tail circumference, EL: Ear length, *p<0.05, **p<0.01, ***p<0.001, NS: Non-significance and NA: Not available

DISCUSSION

The studied BW showed a fluctuating trend over the years of 2015-2020. Numerically the value of BW for BWT and WWT is higher during the initial year of CBBP (Table 1). Whereas, the efficiency of the enumerator was poor during the initial period and the number of observations for the mentioned year was few which lead to difficulty to recorded BW being higher. Possible reasons for the fluctuating trend of BW may be the number of recorded data differences, enumerators record-keeping know how variation through time, a variation in environmental conditions and the availability of forage and feeding over the last 6 years (2015-2020). The performance of Gumer sheep was comparable with other local sheep breeds such as sheep ecotype of Jimma zone, Afar, Washera, Farta, a cross of Wahera and Farta and Atsbi highland sheep breeds reported as 8.98±0.24-14.8±0.22 kg for WWT, 13.7±0.30-23.8±0.16 kg for SMWT and 16.9±0.45-26.9±3.98 kg for YWT[6-8], respectively. Results showed that BWT was significantly higher for on-station but the least for WWT, SMWT and YWT. The main reason for lower BW from on-station was poor animal management like feeding, supplementing during the dry season and health care. Enjefo CBBP had higher WWT, SMWT and YWT among CBBP cooperatives. This performance comparison of the same breed at on-farm and on-station breeding programs indicated that management at the farmers level organized by CBBP was comparatively better. It incurs low cost and better performance than the on-station breeding program. It leads to focus on CBBP as a best breed improvement program in the study area than governmental station site. Bodyweight gain after SMWT was relatively lower than Bonga and Karangploso sheep which were 98.7±2.40 and 93.29±26.73 g/day, respectively[9,10]. Litter size had a significant effect (p< 0.001) on BWT, WWT and SMWT (Table 1). It shows that a uniform trend was exhibited in BW among singles, twins and triplets wherein the BW of single born lambs was higher and triplets lower. The higher body weight in single born lambs may be as a result of the optimum nutrition during both pre and postnatal stages of growth. The superiority of BW of singles over multiple born lambs after weaning was lost due to the decline of maternal effect[8].

Numerically the value is increasing trend for litter size across 6 lambing years (2015-2020) but statistically not significant (Table 3). Even though the selection was based on SMWT EBV of ram lamb that didn't influence the prolificacy trait of Gumer sheep. This may be as a result of twins and triplet dam and sire dominating flock. It had an opportunity to increase for the future when we consider it as a selection criterion. Litter size is one of the major non-genetic factors which have a multifaceted influence as it regulates both reproduction and production in sheep 11 . The current result of the twinning rate was higher than Bonga and Horo sheep breeds reported as 39.9 and 36%, respectively[12]. The litter size of Gumer sheep obtained in this study was higher than local sheep breeds such as the local ecotype of Jimma zone, Bonga, BHS, Menz, Washera, Horro and Atsbi highland sheep breeds reported in the range of 1.02-1.45$\pm$0.01[6,8,13-15]. Additionally, the Gumer sheep breed had a higher litter size than West African Dwarf Djallonke sheep, Iranian Afshari, Red Masai and Tumelie-Dorper cross sheep breed reported in the range of 1.05-1.4$\pm$0.5[7,16-18]. Rekik *et al.*[19] reported that litter size can be increased by improving the nutrition management of the pre-mating. According to Thompson[20], a kilogram increase of ewes BW at mating could improve twining by about 3%.

Gumer sheep is mainly known for its uniform coat colour of plain brown-black and brown-black with white and these colours are preferred by farmers. The percentage of these colours among the CBBP population was nearly 71.5% (Table 1). These colours determine the market price of sheep. The other types of coat colours which are not preferred by farmers viz, white, grey and black were introduced due to the continuous flow of animals from markets.

The value of LBMs for mature male and female sheep of the current study was in agreement with the report of[1]. The higher LBMs of males than females might be due to hormonal differences in growth. Gumer sheep have a better frame of HG than indigenous sheep found in south Ethiopia (Kemata and Hadiya, Wolita, Gamogofa and Sidama and Gedio) which is 70.9$\pm$1.6, 72.8$\pm$7.1, 73.0$\pm$6.5 and 72.1$\pm$1.5 but related by BL, HW and other morphometric traits[1]. Additionally, Gumer sheep have large SC than above mentioned South Ethiopian sheep breeds which were 22.5$\pm$2.5, 23.5$\pm$2.3, 20.5$\pm$3.4 and 20.6$\pm$3.0 cm. These variations may be the effect of both genotype and environment in different areas. Naturally, animals raised in the mountain and high rainfall available region tend to be shorter than dry areas due to leaching of some important minerals.

The correlation between the independent variable of morphometric traits was less than 0.90 which suggest that there is no multicollinearity. Similarly, Ibrahim *et al.*[21] explained that the correlation of independent variables which had below 0.90 indicate no multicollinearity. The correlations of BW with BL and HG of the current research was aligned with previous research for female Batur sheep[21].

The regression equations are unique for every category of livestock and vary according to the area, sex, age and breed. Information on the weight of sheep is important for medication, marketing, breeding and supplemental feeding. Under traditional farm conditions where access to a weighing scale is unavailable other options are mandatory. The most widely used method for estimating the weight of sheep under farm conditions are using a regression equation developed from LBMs for the breed because it is practical, faster, easier and cheaper where the resources are insufficient[1]. Using spring balance to measure live body weight need labour to lift up the animals 8. In the current study, both HG and BL are important to determine the BW of male sheep but HG alone is sufficient for female sheep. This is in agreement with the regression equation determined for Washera, Farta and across of Washera and Farta sheep breeds[8].

The implication of this study was to expand the CBBP breed improvement strategy to further improvement for both the growth and prolificacy traits of Gumer sheep. The significant effect of non-genetic factors namely, a birth year, CBBP and litter size of lambs for the BW suggests considering them during EBV determination for selection. A significant correlation between LBMs and BW guarantee the application of using the regression equation to predict live body weight. To get clear within breed variation genetic parameter estimation is important. Therefore, we recommended estimating genetic parameters and evaluating genetic gains across years by using breeding values of selection traits.

CONCLUSION

The BW of Gumer sheep was in increasing trend and positively influenced by CBBP. Within variation of the population was high which indicated the possibility for further improvement through selection for both BW and prolificacy traits. Heart girth is comparatively the primary variable for the prediction of BW for both sexes. The best and accurate prediction equations of Gumer male and female sheep were Y = -42.29+0.46 HG+0.53 BL and Y = -16.11+0.40 HG, respectively. However, if this sheep is raised under varying agro-ecological conditions and different management options, it is logical to expect variation in estimator and accuracy of body weight.

SIGNIFICANCE STATEMENT

This study discovers the possible animal breeding program option, effect of non-genetic factors and method of animal breeding program evaluation. This study will help the researcher and policymaker to uncover the critical area of breed improvement in the low input-output production system. Thus, a new approach of CBBP for breed improvement programs with the full participation of the community at every stage of the program.

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