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Early growth trend and performance of three Ethiopian goat ecotypes under smallholder management systems

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Abstract

Objective: The present study aimed to evaluate the early growth performance of three Ethiopian goat populations (Bati, Borana and Short-eared Somali) from birth to 180 days and the influence of non-genetic factors such as sex, gemellarity and parity as well as goat ecotype on body weight (BW) and average daily weight gain (ADWG).

Methods: A total of 350 heads of breeding does (113 Bati, 137 Borana and 100 Short-eared Somali) were used, and the kids were monitored for 1 year at birth, 30, 90 and 180 days of age. A total of 125 household flocks (46 Bati, 48 Borana and 31 Short-eared Somali) were monitored.

Results: The birth BW of Bati (2.71 ± 0.04 kg; $n = 139$), Borana (2.36 ± 0.05 kg; $n = 123$) and Short-eared Somali (2.15 ± 0.08 kg; $n = 46$) remained significantly different ($p < 0.01$) in all successive observations until 180 days (16.31 ± 0.02, 13.9 ± 0.22, 13.75 ± 0.36, respectively). In overall, the sex of kids, gemellarity and parity of doe factors influenced the kid BW and ADWG during the early growth period mainly until 90 days, and consistently in Bati goat ecotype. In consequence, higher ($p < 0.05$) BW and ADWG were observed in males and singletons than in females and twins, respectively. In conclusion, our study confirms that non-genetic factors genetic affect these three Ethiopian goat ecotypes. The relative high BW of Bati goats suggest that this ecotype is profitable to improve growth performance using genetic selection.

Keywords: Locally adapted animals, Pastoral systems, Non-genetic factors

Background

Ethiopia has a total of about 30 million heads of goats [1] raised in different parts of the country for the purpose of food source, income generation, socio-cultural wealth and source of other valuable non-food products used as raw materials for various traditional household products manufactured in local cottage industries. Goats in the lowlands of the country kept both for milk and meat production, whereas in the highlands they are mainly kept for meat and income generation [2].

Goats contribute an estimated 14% of meat products, 10.5% of milk production and 6% of all animals exported [3]. Nevertheless, the contribution of goats to the national economy is still low. To facilitate sustainable development of the segment, we need to design improvement programs. Designing of improvement programs will only be successful when accompanied by a good understanding of different farming systems and when simultaneously addressing several constraints, e.g., feeding, health control, management. Currently, there are different research works done on indigenous goats which can contribute for designing of improvement programs. Most of the researches done were focused on issues like characterization of production systems [4], physical description [5], molecular genetic characterization [6] and health [7] of different breeds. But studies on the growth performance of kids particularly for Bati, Borana

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and Short-eared Somali goat populations are scarce and poorly documented.

According to Kume and Hajno [8], knowing the growth dynamics of young animals may be used as one of the indicators to evaluate the level of adaptation under conditions of a given production system. In addition, birth weight and the growth of kids until weaning, together with other reproduction characteristics, are reliable indicators of the breed efficiency in the production of meat [9]. Therefore, the information on early growth performance of goats in different agro-climatic conditions is utmost important for researchers and producers to craft improvement strategies that can enhance productivity. In addition, results of this study can be used to predict the time of marketing weight for targeted goat types.

In view of the above problem, this study was aimed to study early growth trend and the effect of non-genetic factors (population and/or production environment, sex of kid, parity of dam and gemellarity) on growth performance of goat kids.

Methods

Description of the study areas

The study was conducted in four districts that are found in three administrative regions in Ethiopia (Fig. 1). The four districts in three administrative regions were selected, representing three district goat populations: Bati and Kalu for Bati goats in Amhara Region; Yabello for Borana goats in Oromia Region; and Shinile for Short-eared Somali goats in Somali Region. Goat production system in Bati area is characterized by mixed-crop livestock system, while Jabillo and Shinile are pastoral production systems. We have published the study locations detail weather condition information and others in [7].

On-farm flock monitoring and data collection

Flock monitoring was carried for 1 year (April 2013 to the end of March 2014). A total of 125 household flocks (46 Bati, 48 Borana and 31 Short-eared Somali) were monitored. The targeted goat population possession (minimum of three does) and willingness of goat owner to participate in the study were the criteria of selection. The mean number (±SE) of breeding does per household was 9.30±0.78, 13.30±0.84 and 3.51±0.91 in Borana, Short-eared and Bati goats, respectively [4].

At the beginning of the study, a total of 350 breeding does (113 Bati, 137 Borana and 100 Short-eared Somali) were randomly selected in each household flocks and identified with numbered plastic ear tags. However, most of the selected pastoralists/agro-pastoralists area in Shinile area were reluctant to continue in flock monitoring

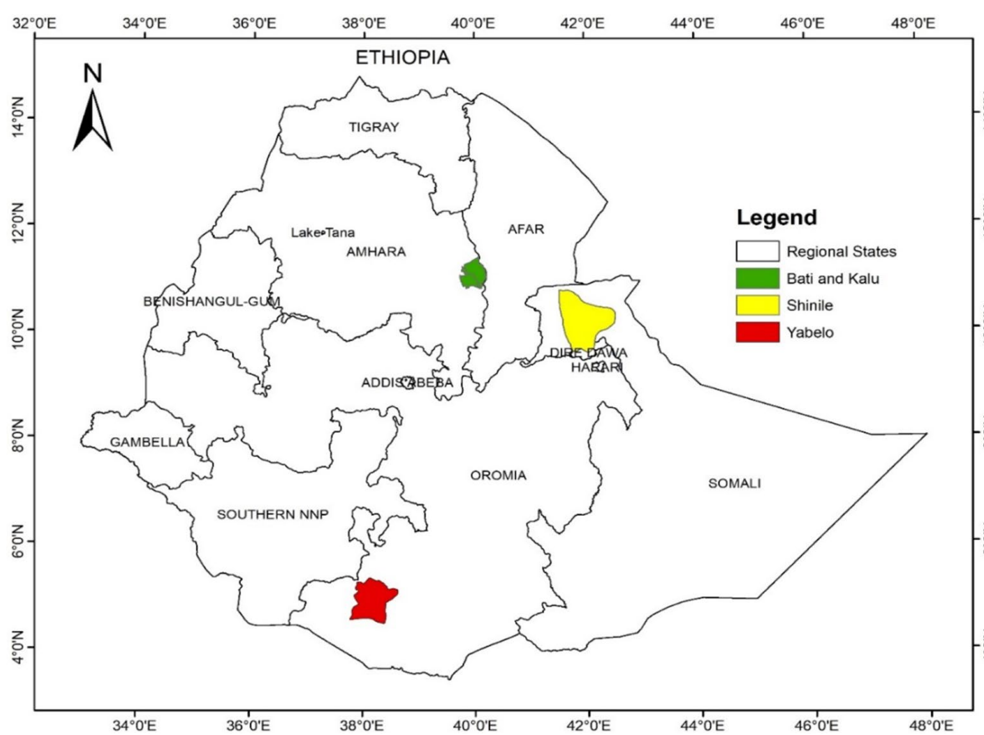

Fig. 1 Map of Ethiopia showing location of districts (Woredas) of the study area

activity and finally, a total of 219 breeding does were stayed to produce 308 kids (139 Bati, 123 Borana and 46 Short-eared Somali). Out of the total number of kids produced, about 140 kids were twins. An enumerator trained on how to take records was recruited in each village and routinely checked by the representatives from the nearest research centers.

During the time of monitoring, sex, birth date, gemellarity (single or twin), live weight at birth, 30, 90 and 180 days of kidding and parity of doe were recorded under the existing management conditions by recruited enumerators. Birth date, birth weight, gemellarity and sex of kid were recorded within 24 h of the new birth. Kids were weighed using Brecknell 235 10S Hanging Scale having 50 kg capacity and 200 g division within 24 h after birth.

Statistical analysis

General linear model (GLM) procedure of SAS [10] and two mathematical models were used to analyze the growth characteristics. The first model employed fitting genetic group, sex of kids, gemellarity and parity of dam as fixed effect to compare over all live weight between the genetic groups. The second model was used to see the effects of sex of kids, gemellarity and parity of dam on growth characteristics for each genetic group separately. The magnitudes of quantitative variables were expressed as least-square means ((± standard error of mean—SEM). Means were evaluated using Tukey's HSD method ($p < 0.05$). The two fixed effect models were fitted as follows.

Model-I: to compare over all live weight between the three goat populations;

$$Y_{ij} = \mu + G_h + S_i + P_j + T_k + \varepsilon hijkl,$$

where Y_{ij} = observed live weight at birth, 30, 90 and 180 days for the hth genetic group, μ = overall mean, G_h = the effect of ith genetic group (i = Bati, Borana, Short-eared Somali), S_i = the effect of the ith sex (i = 1, 2), P_j = the effect of the jth parity of the doe (j = 1, 2, 3, 4, ≥ 5), T_k = the effect of the kth gemellarity (k = single, twin), $\varepsilon hjkl$ = random residual error associated to Y_{ij}th observation.

Model-II: to see the effects of sex, gemellarity and parity of dam on growth characteristics for each genetic group separately;

$$Y_{ijkl} = \mu + S_i + P_j + T_k + \varepsilon ijkl,$$

where Y_{ijkl} = observed live weight at birth, 30, 90 and 180 days and weight gain from birth to 90 days, and from 90 to 180 days for the sex i, parity j and gemellarity k, μ = overall mean, S_i = the effect of the ith sex (i = 1, 2), P_j = the effect of the jth parity of the doe (j = 1, 2, 3, 4, ≥ 5), T_k = the effect of the kth gemellarity (k = single, twin), $\varepsilon ijkl$ = random residual error associated to Y_{ijkl}th observation.

Result and discussion

Average body weight at different ages (birth, 30, 90 and 180 days)

Bati goats had the heaviest overall live weight at birth (2.71 ± 0.04 kg) followed by Borana (2.36 ± 0.05 kg) which were significantly ($p < 0.001$) higher than Short-eared Somali goats (2.16 ± 0.08 kg). The birth weight of Bati goats observed in this study was close to the birth weight (2.68 ± 0.04 kg) reported by Zergaw et al. [11] for the same goat type but higher than the values (1.91 kg) reported by Deribe and Taye [12] for Abergele and Central highland goats in Ethiopia. Zeleke [13] reported higher value of birth weight (3.19 kg) for Somali goats in extensive management system at Alemaya (currently Haramaya) university as compared with the result found in the present study for same breed. The birth weight of Borana goats found in this study was lower than the birth weight of Abergele (2.6 ± 0.06 kg) goats in intensive management system reported by Birhane and Eirk [14].

Despite their significant ($p < 0.05$) difference in average birth weight, Bati and Borana goat kids had nearly equal overall average live weight at 90 days of age. However, the overall growth rate of Borana goat kids showed retarding trend after 90 days of age, while Bati goat kids maintained their superiority thereafter (Fig. 2). Kume and Hajno [8] stated that the growth period of young animals until the puberty age can be divided into three phases: (1) maternal phase, from birth to weaning; (2) phase of development of bio-physiological mechanisms, from weaning to 6 months old; and (3) growth phase, from the age of 6 months to puberty. According to these authors,

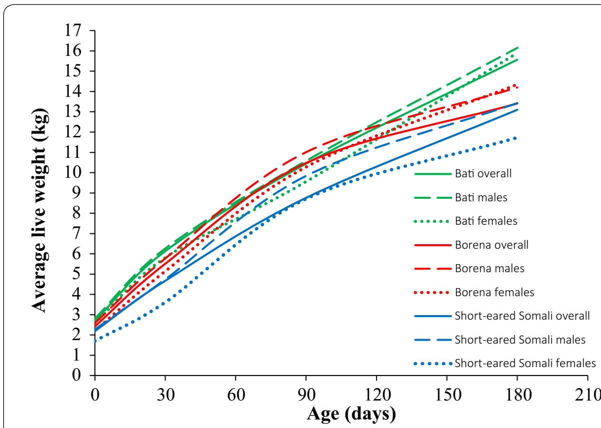

Fig. 2 Growth trends of three young Ethiopian goat types

the second phase (weaning to 6 months) tells us more information in relation to the adaptation rate and/or response of breed under the production environment. Therefore, the reason for retarded growth rate seen in Borana goat kids after 90 days of age might be due to the environmental stress (feed shortage) during short dry season (June–August) and long dry season "Boona" (December–February) on the second phase of development.

The results in this study indicated that male kids weighed more than doe kids at birth and were heavier up to 90 days for all studied goat types (Table 1). The result was in consonance with the findings of other authors who observed that male kids were superior to their female counterparts [15, 16] but contradicted with the report of Khanal et al. [17] and Bharathidhasan et al. [18] who reported that the weight of females were higher than their male counterparts. According to Nkungu et al. [19], the heavier body weight obtained for males may be attributed to the effect of the male sex hormone (androgen) which is responsible for the development of male characteristics but authors have not justified the reason for heavier female kids.

Birth weight was significantly affected by parity of doe in all studied goat types. Bati and Borana, kids from the first parity had relatively lower birth weights than kids in other parities. The effect of parity was retained up to 90 days of age for Bati goats with inconsistent increment of live weight in the advancement of parity at different ages. This result was in line with the report of Gemiyu [20] and in contrast with the report of Zahraddeen et al. [21] who reported inconsistent and consistent increment of live weight in the advancement of parity at different ages, respectively. The effect of parity on live weight was non-significant after birth in both Borana and Short-eared Somali goats.

Kids born as single were significantly heavier ($p < 0.05$) than twins, up to 180 days of age in Bati kids and 30 days in Borana kids. The heavier body weight of single born kids attributed to the weight advantage to competition for nutrients (milk) and the less intra-uterine space in cases where does carry two or more fetuses as compared to one [21]. This study also observed that Short-eared Somali goat kids born single were numerically (but not statistically) heavier than their twin counterparts. Similarly, authors [22, 23] reported non-significant heavier birth weight for single born goat kids. Non-significant birth weight difference between single and twin born goat kids might can be attributed to suppress of environmental stress such as shortage of water and feed in pastoral areas.

Average daily weight gain (birth—90 days]

There was no significant difference in average daily weight gain from birth to 90 days between Bati and Borana goats, but Short-eared Somali goats had significantly ($p < 0.05$) lighter average daily weight gain at the maternal phase than the two goat types (Table 2). The average daily weight gain found at this phase for Bati and Borana goats in the present study was higher than the report of Gemiyu [20] (82.34 g) as well as [12] (76.6 g) for indigenous goats in Southern and Northern part of Ethiopia, respectively. The average daily weight gain between birth and 90 days obtained for Short-eared Somali kids in this study was lower than the previous reports of Zeleke [13] (61.25 g) for Somali goats. Such variations in early daily weight gain can be attributed to the management difference of both dams and kids at early age.

Sex of kids affected significantly ($p < 0.05$) the total daily weight gain (birth–90 days) of Bati goats thus males had the heavier daily weight gain (86.82 ± 3.05 g/day) as compared to their female counterparts (78.17 ± 3.37 g/day), while daily weight gain for both Borana and Short-eared Somali goats was not significant ($p > 0.05$) between males and female.

In this study, Bati goat kids from 5th parity were significantly ($p < 0.05$) heavier than kids from the 1st, 2nd, and 4th parities and non-significantly ($p > 0.05$) kids from the 3rd parity. This result suggests that Bati does even $\geq$5th parity can be used as breeders in order to obtain an efficient and maximum production. Both sex and parity were non-significantly ($p > 0.05$) affected the average daily weight gain (birth–90 days) of both Borana and Short-eared Somali kids, but parity had a significant ($p < 0.05$) effect on Bati kids daily weight gain. In the literature, Dadi et al. [24] reported significant effect of parity on early daily weight gain of local goats in Ethiopia. As it was reported by different authors, kids from 3rd and 4th parity had relatively higher daily weight gain as compared with kids from 1st and $\geq$5th party [12, 21, 24].

Average daily weight gain (90–180 days)

The average daily weight gain (91–180 days) for Bati, Borana and Short-eared Somali goat kids are summarized in Table 2. For all cases, daily weight gain after 90 days of age was lighter as compared with before 90 days of age. In this study, significant ($p < 0.05$) difference in overall daily weight gain between populations from 91 to 180 days of age was observed.

As expected and documented in studies [15, 16], males have heavier daily weight gain before and after weaning. In this study, it was found that non-significant ($p > 0.05$) heavier daily weight gain in male kids before and after 90 days of age, except in Bati kids

Table 1 Average (LSM ± SE) body weights (kg) from birth to 180 days of age for Bati, Borana and Short-eared Somali goats

Pop.	Factors	BW		30 DW		90 DW		180 DW	
		N	LSM ± SE	*N*	LSM ± SE	*N*	LSM ± SE	*N*	LSM ± SE
	Overall	308	***	292	***	270	***	248	***
	Bati	139	2.71 ± 0.04[a]	133	6.15 ± 0.09[a]	119	10.44 ± 0.18[a]	110	16.31 ± 0.02[a]
	Borana	123	2.36 ± 0.05[b]	114	5.39 ± 0.10[b]	108	10.34 ± 0.12[a]	101	13.9 ± 0.22[b]
	SES	46	2.15 ± 0.08[c]	45	4.63 ± 0.16[c]	43	8.52 ± 0.30[b]	37	13.75 ± 0.36[b]
Bati	Sex		*		*		**		NS
	Female	60	2.58 ± 0.07[b]	57	5.81 ± 0.15[b]	50	9.56 ± 0.32[b]	46	15.9 ± 0.38
	Male	79	2.81 ± 0.07[a]	76	6.26 ± 0.14[a]	69	10.58 ± 0.29[a]	64	16.15 ± 0.34
	Parity		**		*		*		NS
	1	26	2.43 ± 0.11[c]	26	5.8 ± 0.22[ab]	22	9.46 ± 0.48[b]	19	16.0 ± 0.58
	2	26	2.62 ± 0.11[bc]	25	5.55 ± 0.22[b]	23	9.81 ± 0.47[b]	23	15.64 ± 0.55
	3	31	2.74 ± 0.1[ab]	29	6.15 ± 0.20[a]	28	10.5 ± 0.42[ab]	26	15.86 ± 0.5
	4	26	3.0 ± 0.11[a]	23	6.31 ± 0.24[a]	21	9.48 ± 0.5[b]	19	16.0 ± 0.61
	≥ 5	30	2.69 ± 0.1[bc]	30	6.38 ± 0.20[a]	25	11.06 ± 0.44[a]	23	16.6 ± 0.51
	G		*		*		*		*
	Single	47	2.82 ± 0.08[a]	46	6.28 ± 0.17[a]	43	10.57 ± 0.36[a]	40	16.66 ± 0.42[a]
	Twin	92	2.57 ± 0.06[b]	87	5.79 ± 0.13[b]	76	9.57 ± 0.29[b]	70	15.38 ± 0.33[b]
Borana	Sex		**		**		*		NS
	Female	64	2.21 ± 0.09[b]	59	5.14 ± 0.17[b]	55	10.28 ± 0.34[b]	52	14.35 ± 0.31
	Male	59	2.59 ± 0.11[a]	55	5.77 ± 0.17[a]	53	11.01 ± 0.28[a]	49	14.20 ± 0.29
	Parity		**		NS		NS		NS
	1	13	1.87 ± 0.17[b]	13	5.02 ± 0.31	13	10.68 ± 0.51	13	14.7 ± 0.52
	2	31	2.54 ± 0.1[a]	26	5.39 ± 0.2	26	10.89 ± 0.33	23	14.35 ± 0.35
	3	31	2.44 ± 0.11[a]	31	5.54 ± 0.21	28	9.86 ± 0.35	28	13.80 ± 0.35
	4	19	2.67 ± 0.15[a]	15	5.5 ± 0.30	14	11.22 ± 0.5	13	14.55 ± 0.53
	≥ 5	29	2.47 ± 0.12[a]	29	5.84 ± 0.23	27	10.57 ± 0.38	24	13.97 ± 0.42
	G		*		*		NS		NS
	Single	87	2.53 ± 0.07[a]	80	5.71 ± 0.14[a]	76	10.67 ± 0.35	72	14.43 ± 0.24
	Twin	36	2.27 ± 0.11[b]	34	5.2 ± 0.21[b]	32	10.62 ± 0.23	29	14.12 ± 0.37
SES	Sex		**		**		*		NS
	Female	19	1.7 ± 0.17[b]	19	3.61 ± 0.53[b]	17	8.71 ± .0.7[b]	14	11.73 ± 0.88
	Male	27	2.27 ± 0.16[a]	26	4.74 ± 0.58[a]	26	9.84 ± 0.63[a]	23	13.43 ± 0.86
	Parity		*		NS		NS		NS
	1	11	1.96 ± 0.17[b]	11	4.14 ± 0.68	11	10.38 ± 0.78	8	11.81 ± 1.09
	2	9	1.78 ± 0.2[b]	9	4.77 ± 0.65	9	9.53 ± 0.82	5	12.44 ± 1.16
	3	17	1.63 ± 0.19[b]	17	3.60 ± 0.57	15	8.41 ± 0.78	16	13.17 ± 1.04
	4	3	2.52 ± 0.24[a]	3	4.30 ± 0.70	2	7.38 ± 1.11	3	13.01 ± 1.31
	≥ 5	6	2.04 ± 0.2[ab]	5	4.08 ± 0.79	6	10.29 ± 0.81	5	12.45 ± 1.13
	G		NS		NS		NS		NS
	Single	35	2.03 ± 0.14	24	3.92 ± 0.45	32	8.86 ± 0.55	26	12.99 ± 0.73
	Twin	11	1.94 ± 0.2	11	3.85 ± 0.56	11	9.54 ± 0.82	11	12.16 ± 1.05

Means in the same column with different superscripts are significantly different

LSM least-square means, *SE* standard errors, *N* number of observation, *BW* birth weight, *DW* day weight, *G* gemellarity, *NS* non-significant *Pop.* population, *SES* short-eared Somali

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 2 Average (LSM ± SE) daily weight gain (birth–90 and 91–180 days) for Bati, Borana and Short-eared Somali goats

Factors	Bati				Borana				Short-eared Somali			
	ADWG g/day (birth–90 days)		ADWG g/day (91–180 days)		ADWG g/day (birth–90 days)		ADWG g/day (91–180 days)		ADWG g/day (birth–90 days)		ADWG g/day (91–180 days)	
	N	LSM ± SE	*N*	LSM ± SE	*N*	LSM ± SE	*N*	LSM ± SE	*N*	LSM ± SE	*N*	LSM ± SE
Overall	119	86.22 ± 2.02	108	56.49 ± 1.70	108	89.88 ± 2.02	101	32.96 ± 1.76	43	73.15 ± 3.20	34	47.20 ± 3.08
Sex		*		NS		NS		NS		NS		NS
Female	50	78.17 ± 3.37^{b}	46	55.83 ± 3.01	55	90.41 ± 3.23	52	30.85 ± 2.66	17	76.65 ± 7.57	12	36.71 ± 6.91
Male	69	86.82 ± 3.05^{a}	62	59.15 ± 20.75	53	94.95 ± 3.22	49	33.67 ± 2.8	26	84.22 ± 7.30	22	43.61 ± 6.91
Parity		*		*		NS		*		NS		*
1	22	77.61 ± 5.07^{bc}	19	59.99 ± 4.62^{abc}	13	98.53 ± 5.75	13	31.46 ± 4.71^{ab}	11	93.56 ± 9.05	8	21.61 ± 8.61^{b}
2	23	80.61 ± 4.96^{bc}	23	60.76 ± 4.35^{ab}	26	92.87 ± 5.70	23	36.63 ± 3.22^{a}	9	85.59 ± 9.45	5	34.42 ± 9.35^{b}
3	28	87.08 ± 4.4^{ab}	26	51.87 ± 3.93^{bc}	28	83.26 ± 3.93	28	38.02 ± 3.20^{a}	15	74.05 ± 9.02	14	44.19 ± 8.75^{ab}
4	21	73.51 ± 5.33^{c}	17	65.44 ± 5.02^{a}	14	97.06 ± 5.70	13	20.53 ± 4.86^{b}	2	57.31 ± 12.89	2	68.9 ± 11.9^{a}
≥ 5	25	93.63 ± 4.69^{a}	23	49.40 ± 4.20^{c}	27	91.67 ± 4.38	24	34.68 ± 3.8^{b}	6	91.69 ± 9.35	5	31.77 ± 9.0^{b}
G		NS		NS		NS		NS		NS		NS
Single	43	86.5 ± 3.81	40	58.14 ± 3.36	76	91.08 ± 2.58	72	34.68 ± 2.14	32	75.88 ± 6.31	23	43.74 ± 5.7
Twin	76	78.48 ± 3.08	68	56.85 ± 2.74	32	94.26 ± 3.99	29	29.85 ± 3.39	11	84.99 ± 9.53	11	36.57 ± 8.96

Means in the same column with different superscripts are significantly different

LSM least-square means, *SE* standard errors, *ADWG* average daily weight gain, *N* number of observation, *G* gemellarity, *NS* non-significant, *Pop.* population, *SES* short-eared Somali

* $p < 0.05$

where sex exerted significant effect on daily weight gain in favor of males (birth–90 days). Similarly, non-significant effect of sex on daily weight gain of kids from birth to 60 and 100 days of age was reported by Zahraddeen et al. [21] and Nkungu et al. [19], respectively. On the other hand, Bazzi and Tahmoorespur [25] reported heavier average pre-weaning daily gain of females than males.

Significant ($p < 0.05$) parity effect was also observed in this study with respect to kids daily weight gain in each population from 91 to 180 days of age. Even though the increment of daily weight gain in the advancement of parity at different ages was inconsistent, in most cases, kids at 2nd, 3rd and 4th parity had better daily weight gain (Table 2).

Across all goat types, the influence of gemellarity on daily weight gain of kids at different ages (birth–90 and 90–180 days) was not statistically significant ($p > 0.05$) but with numerical differences in favor of kids born as single. Similarly, irrespective of significantly higher birth and weaning weight of kids born as single, Bazzi and Tahmoorespur [25] found non-significant difference in average daily weight gain between kids born as single and twin from 6 to 9 months of age, whereas Zeleke [13], Bushara et al. [26] and Madibela et al. [27] reported higher daily weight gain for single kids compared with multiple births.

Conclusion

In overall, both genetic and non-genetic factors affected the ADWG and BW. Except for SES, the singletons consistently showed higher BW than twins in early growth phase probably due to environmental factors such as milk yield ingestion. A higher BW at kidding time and throughout the study was observed in Bati than Borana and SES goat populations. Therefore, the growth performance of this Bati ecotype is encouraging and can be further improved genetically through selection.

Abbreviations

BW: body weight; N: number of observation; BW: birth weight; DW: day weight; G: gemellarity; NS: non-significant; Pop: population; ADWG: average daily weight gain; SE: standard error; GLM: general linear model; LSM: least-square means; SEM: standard error of mean; HSD: honestly significantly different; SES: short-eared Somali.

Authors' contributions

HG designed, collected the data and wrote the manuscript. HH, AH, and BR designed the general concept of the study and supervised implementation. KK and RNBL reviewed data analysis tools and reviewed the manuscript. All authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

Availability of data and materials
Data that were used to generate these results are available upon request from the corresponding author.

Consent for publication
Not applicable.

Ethics approval and consent to participate
Not applicable.

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