Growth Performance and Survival Rate of Boer X Central Highland Goat under Extensive Production System

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Abstract
This study was conducted to evaluate the growth performance and survival rate of Boer x Central Highland goats. Data collected under field condition were utilized for this study. The overall least squares mean for birth weight (BWT), weaning weight (3MWT), six-month weight (6MWT), weight gain from birth to weaning (ADG1) and weight gain from weaning to six months of age (ADG2) for Boer crossbred goats were 2.73 kg, 10.4 kg, 14.5 kg, 84.4 g day^{-1} and 49.4 g day^{-1}, respectively. Whereas the overall least squares mean BWT, 3MWT, 6MWT, ADG1 and ADG2 for Central Highland goats were 1.79 kg, 6.77 kg, 10.6 kg, 54.1 g day^{-1} and 50.4 g day^{-1}, respectively. Sex, birth type and year of birth were the major determinants for growth traits. The pre-weaning survival rate of crossbred goats was 81.7%. The overall mean litter size at birth, litter size at weaning and weaning rate for Central Highland does were 1.48 kids, 1.21 kids, 81.7%, respectively. The pre-weaning growth performance of Boer crossbreds was superior to the indigenous Central Highland goats. However, the post-weaning growth rate was found to be similar for both genotypes. Central Highland goat had a moderate prolificacy and mothering ability.

Keywords: Central Highland, growth rate, mothering ability, prolificacy, survival

1. Introduction

Goat production is ideal for poverty alleviation due to their high multiplication rate, adapting to a wide range of agro-ecologies including harsh climatic conditions, low capital investment, ability to better utilize the limited and poor quality feed resources as compared to large ruminants [1]. Goats are thus an important genetic resource for meat, milk, skin, fiber production and play an important role in the socio-economic life of rural people in tropical and developing countries [2].
In spite of the large goat population and contribution in the country, the present level of productivity is low. In order to improve their productivity, crossbreeding was considered as one genetic improvement tool and meat type Boer goat has been introduced to Ethiopia since 2007 [3]. Boer goats are known for large frame size, high growth rate, and carcass attributes [4]. Central Highland goat (*brown goat*) is one of the indigenous goats in Ethiopia known for its best quality skin [5].
Since 2011, Boer x Central Highland crossbred goats with 50% exotic gene level were disseminated to farmers and crossed with indigenous Central Highland goat in order to improve the productivity of indigenous goat. Once the exotic breeds are imported, evaluating the performances and fitness are keys for further expansion of that genotype or changing to the appropriate breeding system for the future. For this reason, the objectives of the present study

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were to evaluate the growth performance and survival rate of Boer x Central Highland crossbred goats and prolificacy of Central Highland goat under an extensive management system.

2. Materials and methods

Study site

The study was conducted at Raya Kobo district which is found in Eastern Amhara Regional State of Ethiopia. The district is located at a geographical coordinate point of 12° 14' 60.00" N latitude and 39° 29' 59.99" E longitude. The altitude of Raya Kobo ranges from 900 to 2400 m.a.s.l. Mean annual rainfall, maximum and minimum temperature of the study area is 630 mm, 29 °C and 15 °C, respectively. Generally, the area is characterized by seasonal moisture stress and erratic rainfall.

Crossbred goat dissemination modality

Three *kebeles* (Abuari, Aradom and Ageregenet) from Raya Kobo were selected based on their goat population and production potential through discussion made with district agricultural office. Farmers who have at least 5 breeding female goats were selected and grouped based on their interests. Training about goat management, genetic improvement and health care was given for selected farmers, enumerator and developmental agents. Culling and castration of local bucks based on participant's interest were conducted to control unwanted mating and all female breeding goats were identified with an ear tag. Then, 52 crossbred bucks with 50% exotic blood level were disseminated to the aforementioned *kebeles* in different years in order to improve the productivity of indigenous goat through crossbreeding.

In order to control inbreeding, the exchange of buck between participant farmers was done after one complete breeding season and the process was continued until each crossbred bucks serve all local breeding doe of each farmer. During the genetic improvement program, all the animals in the selected farmers flock have received a vaccine and treatments as required by vet assistants.

Data collection and studied traits

The study design was retrospective type. On-farm flock monitoring was carried out at Raya Kobo district. Data collection was initiated in 2012, then discontinued for two years and collected again from 2015-2018. Body weight at different ages (birth, 3 and 6 month) and mortality data were collected by trained enumerators recruited from the respective village. In addition, litter size at birth (the number of kids born alive per doe kidding) and litter size at weaning (the number of kids present at three month per doe kidding) were recorded and considered in this study.

Data analysis

Preliminary data analysis like screening of outliers and normality test were employed before conducting the main data analysis. The general linear model procedures of SAS [6] were applied for the analysis of growth and prolificacy data. Differences between least squares means of a trait for different genetic and non-genetic factors were tested using the Tukey-Kramer test. The statistical model for growth and prolificacy was as follows:

$$Y_{ijklmn} = \mu + B_i + S_j + X_k + P_l + T_m + G_n + e_{ijklmn} \quad (1)$$

where; Y_{ijklmn} is dependent variables, μ is the overall mean, B_i is effect of i^{th} birth type (2 levels: single and multiple), S_j is effect of j^{th} season of birth (3 levels: main rain, short rain and dry), X_k is effect of k^{th} sex of kid (2 levels: male and female), P_l is effect of l^{th} parity of dam (5 levels: 1, 2, 3, 4 and ≥5), T_m is effect of m^{th} year of birth (5 levels: 2012, 2015-2018), G_n is effect of n^{th} genotype (2 levels: Central Highland and Boer x Central Highland) and e_{ijklmn} is random error term associated with each observation. All fixed effects except for birth type and genotype were fitted for prolificacy traits.

Survival data were analyzed using the GENMOD procedure of SAS [6] by a linear logit model with a binary response variable, which was modeled as a binomial variable (y_i). The dependent variable (y_i) can assume the value of 1 with a probability of survival π_i or the value 0 with a probability of death 1 - π_i for observation i. The logit link function was denoted as follow:

$$g(\pi) = \log [\pi_i / 1- \pi_i] = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_{p-1} x_{(p-1)I} \quad \ldots\ldots(2)$$

where, π and π_i is the probability of kid survival up to 3 months of age, x_{1i}, x_{2i},..., $x_{(p-1)i}$ is independent variables, β_0 , β_1 , β_2 ,..., β_{p-1} is regression parameters. Least-squares means of

analyzed effects in the model were estimated on the logit scale and back-transformed to the probabilities using the inverse link function: $\pi_i = exp\ (LSMEANS) / [1 + exp\ (LSMEANS)]$. Differences between least squares means of survivability for different risk factors were tested using DIFF option from the Least Squares Means procedure in PROC GENMOD [6]. The generalized linear model for pre-weaning survival rate was as follow:

$$log\ [\pi_{ijklm} / 1- \pi_{ijklmn}] = \mu + B_i + S_j + X_k + P_l + T_m + e_{ijklm} \quad (3)$$

where; π_{ijklmn} is a probability of kid survival, μ is overall mean effect, B_i is a fixed effect of the i^{th} birth type, S_j is a fixed effect of the j^{th} season of birth, X_k is a fixed effect of the k^{th} sex of kid, P_l is a fixed effect of the l^{th} parity of dam, T_m is a fixed effect of the m^{th} year of birth and e_{ijklmn} is a residual error.

3. Results and discussion

Growth performance of Central Highland and their crossbred with Boer goat

Body weight at a specific age and weight gain for Central Highland and Boer x Central Highland goat under extensive production system are presented in Table 1. The growth rate of the crossbred goat was highest up to three month age and showed a decreasing trend from three month to six-month while it was consistent for pure Central Highland goats. In fact, the influences resulted from dam reduce as the age of kids increases and the post-weaning performance of an animal is determined by its genetic potential and other environmental factors. However, 6MWT of the crossbred goat was greater than Central Highland goat. The superior 6MWT while similar ADG2 with Central Highland goat implies that body weight advantages of crossbred at six-month could be resulted from its pre-weaning performance due to positive correlation effect among growth traits. Rapid pre-weaning growth of crossbreds will minimize the cost of inputs for production and will provide more profits to the producers. However, keeping crossbred goats after six-months of age under low-input production system seems worthless.

The growth performance of Boer crossbreds is comparable with Girma *et al*. [7]. However, it is not superior to previous reports of several scholars [8-11] for Central Highland goat under an extensive production system. Besides, the BWT, 3MWT and 6MWT of Central Highland goat in this study is relatively lower than previous reports for the same breed by those scholars. These differences could be explained by the difference in sample size, general management practices and prevailing climatic conditions.

Sex of kids had a considerable influence ($P<0.05$) on growth performances of kids up to three month age and male kids showed superior performance than their female counterparts. A similar result has also been observed in a number of other studies [7, 12, 13, 14]. Single born kids had greater BWT and 3MWT than multiple born kids, but the non-significant difference ($P>0.05$) was observed for ADG1, 6MWT and ADG2. This result is agreed well with the report of Deribe *et al.* [15] for Boer x Central Highland goat and Gatew *et al*. [11] for Borana goat. The advantage of single born kids up to 3 month age may be linked to pre-and-early post-natal nutrient competition and inter-uterine space. However, the post-weaning similarity could be explained by the compensatory growth of multiple born kids.

Kids born in 2017 and 2018 exhibited lowest body weight and growth rate compared with kids born in the other years. Season of birth had not a considerable influence on all considered growth traits except for 6MWT and ADG2 in which kids born during the main rainy season were higher than kids born during the short rainy and dry season. Critical feed shortage and cold stress during June – October in the area are the likely reasons for the lower performance of kids born during the short rainy season. Parity of dam had not a significant influence ($P>0.05$) on all considered growth traits in this study. A similar observation has been made by Mustefa [16] for Boer x Central Highland goat.

Table 1. Growth performance (LSM±SE) of goats with different explanatory variables

Source of variation	BWT (kg)		3MWT (kg)		ADG1 (g/day)		6MWT (kg)		ADG2 (g/day)	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	203	2.61±0.05	148	10.0±0.24	148	81.1±2.55	98	13.6±0.47	93	49.5±3.80
CV	203	20.9	148	17.7	148	25.7	98	19.6	93	61.6
Birth type		***		**		ns		ns		ns
Single	69	2.81±0.08	51	11.1±0.38	52	88.4±4.39	28	14.3±0.90	28	49.6±8.16
Multiple	134	2.51±0.06	97	9.43±0.30	96	77.2±3.09	70	13.4±0.54	65	49.5±4.19
Genotype		**		***		***		**		ns
B x CH (25%)	177	2.73±0.04	131	10.4±0.25	132	84.4±2.68	77	14.5±0.53	77	49.4±4.39
CH	26	1.79±0.14	17	6.77±0.43	16	54.1±4.11	21	10.6±0.60	16	50.4±6.71
Sex		**		**		*		ns		ns
Female	83	2.50±0.07	65	9.64±0.38	65	77.8±3.97	43	13.2±0.71	41	47.0±5.79
Male	120	2.70±0.07	83	10.3±0.32	83	83.6±3.31	55	13.9±0.62	52	51.5±5.06
Season		ns		ns		ns		*		*
Dry	92	2.74±0.06	56	10.5±0.52	55	85.0±3.27	52	14.3±0.63b	47	52.6±4.65ab
Main rain	36	2.71±0.13	27	11.2±0.57	27	92.6±5.98	13	16.3±1.27a	13	62.1±8.12a
Short rain	75	2.41±0.08	65	9.10±0.41	66	73.1±4.31	33	11.6±0.70c	33	40.2±7.61b
Year		***		***		***		***		*
2012	39	2.96±0.09ab	27	12.7±0.35a	27	108±3.97a	8	21.7±0.35a	8	101±5.86a
2015	39	3.15±0.06a	34	11.8±0.28ab	34	96.0±3..31b	27	17.4±0.53b	27	61.0±5.93b
2016	28	2.80±0.12b	22	11.5±0.58b	22	97.6±6.04b	13	11.4±1.17c	13	20.2±14.4c
2017	46	2.21±0.08c	37	6.76±0.27d	37	49.5±3.57d	28	10.3±0.47c	23	42.4±5.11bc
2018	51	2.20±0.08c	28	8.19±0.28c	28	65.0±2.92c	22	11.6±0.57c	22	41.3±5.26bc
Parity		ns		ns		ns		ns		ns
1	16	2.85±0.15	10	11.6±0.64	11	85.0±12.4	3	14.3±2.95	3	43.3±31.0
2	27	2.78±0.13	24	11.2±0.56	24	93.7±5.53	16	13.9±1.20	16	43.9±9.99
3	51	2.67±0.09	34	9.53±0.46	34	76.5±4.73	26	13.7±0.90	26	50.0±9.13
4	39	2.65±0.12	30	10.2±0.53	30	84.0±5.07	20	16.2±1.03	20	61.4±7.63
≥5	44	2.59±0.05	33	10.4±0.58	33	85.3±6.23	15	14.1±1.22	15	47.4±7.85

B = Boer, CH = Central Highland goat, BWT = birth weight, 3MWT = three month weight, 6MWT = six-month weight, ADG1 = weight gain from birth to three month, ADG2 = weight gain from three month to six month
Ns = P>0.05, *** = P<0.001, ** = P<0.01, * = P<0.05, N = number of observations
Least squares means with different superscripts within the same column and class are statistically different

Pre-weaning survival rate of crossbred kids

Pre-weaning kid survival is of primary economic importance to goat producers. The survival rates of Boer x Central Highland goat with 25% exotic gene level under extensive management system are summarized in Table 2. In this study, the overall mortality rate of crossbred kids was 18.3% which is higher than 14.2% reported by Deribe [17] for Central Highland goat, 11.52% reported by Mekuriaw [18] for Somali goat, 6.73% for Boer x Abergele goat [19], but lower than 34.2% for Arsi-Bale goat under extensive management system [20]. Boer goat is mainly selected for growth and carcass traits and suitable for medium to high input production system [21]. Thus, if not managed accordingly, their fitness would be poor under extensive production system.

Non-genetic factors considered in this study had not a significant (P>0.05) influence on the survival rate of kids up to three month age. In line with the current results, the survival of goat up to weaning does not influence by year of birth [22, 23] and non- significant influence of the sex of kids on survival rate was also noted elsewhere [22- 25]. In contrary, Debele *et al*. [26] reported that male kids had a better rate of survival than females.

Non-significant influence of birth type in the present study is not agree with several scholars [23-25] who noted that single born kids had a

higher survival rate than twin and triple born kids. Similar to the present finding, Bolacali *et al*. [23] reported that the age of dam had not a considerable influence on the survival rate of the goat. On the other hand, the lower survival rate of kids from first parity was observed by Al-Najjar *et al*. [22], Debele *et al.* [26] and Tesema *et al*. [25]. The same scholars noted that the trend of survivability increasing with increase in parity up to specific parity number and decline afterward.

Table 2. Pre-weaning survival rate of Boer x Central Highland goats

Source of variation	Survival rate (%)	
	N	LSM±SE
Overall	172	81.7±0.30
Birth type		ns
Single	59	81.3±0.38
Multiple	107	82.2±0.25
Parity		ns
1	16	68.7±0.54
2	25	92.0±0.34
3	45	75.5±0.74
4	35	85.7±0.48
≥5	39	89.7±0.53
Sex		ns
Female	71	87.3±0.35
Male	101	78.2±0.24
Season		ns
Dry	70	77.1±0.28
Main rain	35	82.8±0.45
Short rain	67	86.5±0.36
Year		ns
2012	45	80.0±0.37
2015	39	87.2±0.48
2016	28	82.1±0.49
2017	37	75.5±0.38
2018	23	86.9±0.62

Ns = P>0.05, N = number of observations

Prolificacy and mothering ability of does

Prolificacy and mothering ability of dam are the major determinant for efficiency and profitability of goat production. Litter size at birth (LSB) and litter size at weaning (LSW) are the most important traits [27] and could be considered as an indicator of fitness and mothering ability of does [21]. The litter size at birth (LSB), litter size at weaning (LSW) and weaning rate (WR) are presented in Table 3. The overall least-squares mean for LSB, LSW and WR were 1.48 kids, 1.21kids and 81.8%, respectively. The results obtained in this study are lower than the figure reported by Kebede *et al.* [28], Mia *et al.* [29], but higher than Mustefa [16] and Rashidi *et al.* [30]. The number of kids born and weaned as a doe trait is a collective measure of the prolificacy and mothering ability of the doe, respectively. Central Highland goats had greater number of kids born and weaned than most of the indigenous goats and this breed is a moderately prolific breed. Nevertheless, the higher litter size would be associated with poor kid survival rate if not managed accordingly.

Sex of kid and seasons of kidding had not a significant influence on the prolificacy of Central Highland goats (Table 3). However, the LSB and LSW were tended to increase with the increase in parity of does. The LSB from 3rd parity and above were higher than 1st and 2nd parity. Besides, the LSW from 4th parity was higher by 45.6% and LSW from ≥5 parity was 50.6% higher than the 1st parity. Likewise, the increase in LSB was reported to continue to the 4th parity [31], to 5th parity [32] and to 6th parity [33]. The observed increment with parity could be explained by the increase of uterine capacity, ovulation rate, and other maternal traits affecting reproductive efficiency. Therefore, there should be appropriate management for kids from 1st and 2nd parity in

order to improve the number of kids weaned/does kidding. Dams kidding in 2012 had a lower number of kids born than those kidding in other years. This is likely due to differences in climatic condition, the availability of forage and diseases prevalence across years.

Table 3. On-farm prolificacy of Central Highland goat (LSM±SE)

Source of variation	LSB (kids)		LSW(kids)		WR (%)
	N	LSM±SE	N	LSM±SE	
Overall	114	1.48±0.05	109	1.21±0.06	81.8
Parity		***		**	
1	16	1.00±0.00^{b}	16	0.75±0.14^{b}	75.0
2	20	1.25±0.09^{b}	20	1.10±0.12^{ab}	88.0
3	32	1.62±0.08^{a}	29	1.17±0.14^{ab}	72.2
4	21	1.62±0.11^{a}	21	1.38±0.14^{a}	85.2
≥5	25	1.68±0.11^{a}	23	1.52±0.13^{a}	90.5
Sex		ns		ns	
Female	39	1.43±0.08	38	1.26±0.10	88.1
Male	75	1.50±0.05	71	1.18±0.09	78.7
Season		ns		ns	
Dry	46	1.50±0.07	41	1.15±0.10	76.7
Main rain	20	1.50±0.11	20	1.20±0.17	80.0
Short rain	48	1.45±0.08	48	1.27±0.10	87.6
Year		*		ns	
2012	28	1.36±0.10^{b}	28	1.07±0.12	78.7
2015	22	1.68±0.10^{a}	22	1.42±0.15	84.5
2016	20	1.40±0.11^{ab}	20	1.15±0.15	82.1
2017	25	1.52±0.10^{ab}	25	1.20±0.16	78.9
2018	19	1.47±0.11^{ab}	14	1.28±0.16	87.1

Ns = P>0.05, *** = P<0.001. ** = P<0.01, * = P<0.05, N = number of observations
LSB = litter size at birth, LSW= litter size at weaning, WR = weaning rate

4. Conclusions

The pre-weaning growth performance of Boer crossbreds was superior to the indigenous Central Highland goats under an extensive production system. However, the post-weaning growth rate was found to be similar for both genotypes. Central Highland goat is moderately prolific breed with good mothering ability and prolificacy was tended to increase with the increase in parity of does. Evaluation of both genotypes with enough sample size under similar management for productivity and fitness traits will help to develop a more complete picture of their relative utility in the existing production systems.

Acknowledgements

The authors appreciate Amhara Region Agricultural Research Institute for the financial support.

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