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Factors Affecting Post-Weaning Growth of Boer and Boer Cross Goats in a Closed Breeding Farm Population

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ABSTRACT

This study aimed to analyze the factors affecting the post-weaning growth of Boer and Boer cross goats in a closed breeding farm population. A total of 1,083 female kids were selected from a record of 1,501 weaned kids produced by mating Boer bucks with Boer does, Jawarandu does, and Boer × Jawarandu does. The data collected at a private company's goat farm represent a closed breeding population from January 2013 to January 2016. The data were selected based on the weaning weight and at least one post-weaning weight at approximately 6, 9, or 12 months. Two-step linear models were applied: complete model and reduced model. The complete model factors included genetic group, buck, litter size, birth season, weaning season-year, and their interactions. The reduced model included only significant factors and two-way interactions. The results showed that the genetic group, bucks, litter size, birth season, and weaning season-year significantly affected Boer and Boer cross goats' post-weaning weight and average daily gain. Additionally, interactions between the genetic group with the buck, litter size, and birth season were observed. In conclusion, genetic and non-genetic factors significantly influence the post-weaning growth of Boer and Boer cross goats. Non-genetic factors should be considered in the model and selection to achieve optimal goat performance.

Keywords: Boer Jawarandu cross, Genetic environment interaction, Body weight, Average daily gain

INTRODUCTION

Growth traits are important indicators of meat-type goat performance, given their direct association with the economic value. It is widely recognized that performance and phenotypic characteristics are influenced by genetic factors, environmental conditions, and the interaction between genetics and the environment (Shrestha and Fahmy, 2005). During the pre-weaning phase, the dam's effect, determined by the mothering ability and milk production, is crucial for the kid's growth (Nugroho et al., 2021). However, during the post-weaning phase, the ability of the kid to adapt to its environment becomes equally significant. The non-genetic factors may significantly influence the genetic potential of the goat, subsequently influencing its productivity (Singh et al., 2021).

To refine breeding strategies, comprehending and managing non-genetic factors is crucial to prevent biases in genetic evaluations (Widyas et al., 2019). In this context, numerous non-genetic factors, such as birth type, age, dam, sex, nutrition, season, and water quality, have been identified to potentially influence animal performance (Alemseged and Atkinson, 2015). However, the degree of their influence varies, depending on the specific rearing conditions of the goats. Furthermore, the genetic factor also interacts with the environment, leading to divergent performance outcomes, even under seemingly identical conditions (Ofori and Hagan, 2020; Jasmine et al., 2022).

Crossbreeding is one of the strategies used to address the interaction between genetics and the environment. This approach aims to develop superior genetic qualities that adapt to specific environmental conditions. Crossbreeding between Boer goats and local Indonesian goats has been implemented in Indonesia. This measure was undertaken primarily because most Indonesian goats tend to have smaller body sizes (Widyas et al., 2021). Various local goat breeds have been crossed with Boer goats, such as Boer × Jawarandu (Boerja) (Nugroho et al., 2018), Boer × Etawa Grade (Boerawa, Saburai) (Adhianto et al., 2022), and Boer × Kacang (Boerka) (Ginting and Mahmilia, 2008).

Additionally, Boer goats have been utilized for crossbreeding purposes in several other countries owing to their remarkable meat production capabilities (Girma et al., 2016; Fitsum et al., 2019; Tesema et al., 2021). These crossbreeds are expected to be advantageous due to their larger body size and adaptability to the Indonesian environment. However, as crossbreeds, they may possess diverse genetic potentials, leading to varying responses to environmental stimuli. This condition occurs due to the combination of genetic traits from both the sire and the dam. This study analyses the factors affecting the post-weaning growth of Boer and Boer cross goats in a close breeding population. The result of this study would be beneficial for evaluating the crossbreeding program of Indonesian local goats crossed with exotic goats before it can be implemented widely by the farmers.

MATERIALS AND METHODS

Farm Management and Data Collection

The data were collected from a private company representing a closed goat breeding farm in East Java, Indonesia. The farm locations are the breeding station in Batu, East Java, and the rearing area in Pasuruan, East Java. In this farm, the kids were transferred from the breeding farm upon weaning.

A total of 1083 female kids were selected from 1501 record data of weaned kids observed for their body weight between January 2013 and January 2016. Only data on female kids were included due to the limited rearing of males on the farm. The selected kids for this study had weaning weight data and at least one post-weaning body weight data at approximately 6, 9, or 12 months of age. Following the farm's management preference, the weaning weight (kg) was adjusted to 77 days. The post-weaning weight (kg) was adjusted to body weights (kg) at 180 days (6 months, W6), 270 days (9 months, W9), and 365 days (yearling, W12). The average daily gain ($kg.day^{-1}$) was calculated by subtracting the adjusted post-weaning weight from the adjusted weaning weight and dividing the result by the total days between the two observation times.

The distribution of the data used in this study is presented in Table 1. The kids were produced from the mating of Boer bucks × Boer does (B×B), Boer bucks × Jawarandu does (B×J), and Boer bucks × Crossbred does (B×(B×J)). Boer bucks and does were imported from Australia, and Jawarandu does were obtained from local breeding farms or animal markets near the farm. At the same time, the crossbred goats were previously bred on the farm. A natural mating system was employed by housing 20-25 mixed-breed does with a buck for 45 days. All the kids on this farm received the same intensive management system.

Table 1. Number of records for each body weight and observed variables

Observed variables	Weaning	Six month	Nine-month	Yearling
Bucks	10	10	10	10
Does	695	121	314	425
Offspring	1083	127	391	565
Genetic group[1]				
B×B	140	29	67	44
B×J	524	44	163	317
B×(B×J)	419	54	161	204
Litter size				
Single	416	65	150	201
Twin	667	62	241	364
Birth season				
Rainy	711	90	257	364
Dry	372	37	134	201
Weaning season and year[2]				
Rainy 2013	150	-	-	150
Dry 2013	75	-	-	75
Rainy 2014	247	3	110	134
Dry 2014	257	9	90	158
Rainy 2015	239	78	113	48
Dry 2015	115	37	78	-

[1] B×B= Boer × Boer; B×J= Boer × Jawarandu; B×(B×J)= Boer × (B×J)

[2] No data available on the six and 9-month weight of Rainy and Dry 2013

According to the Indonesian Agency for Meteorological, Climatological, and Geophysics, seasons were classified as dry and rainy based on rainfall intensity (BMKG, 2020).

Data Analysis

The data were analyzed using a two-step linear model: the complete and reduced models. The significance of the sources of variation was verified using the complete model (de Souza et al., 2022). The first step examined the primary factors and all interactions among the genetic group, buck, litter size, birth season, and weaning season-year. Based on the results of the complete model, significant main factors and two-way interactions were used as inputs in the reduced model. All the input's main factors and two-way interactions were analysed except for the interaction between the birth season and the weaning season-year.

A custom script, written in the R programming language, was used for the analysis, and the Duncan Multiple Range Test from the 'agricolae' package was utilized to assess the differences between means (Mendiburu, 2023). A significance level of 0.05 was applied for each factor and interaction in this study.

RESULTS AND DISCUSSION

Effect of Genetic Group

The genetic group significantly affects post-weaning weight (Table 2) and average daily gain (Table 3). Purebred (B×B) demonstrated the highest weaning weight compared to both crossbreeds. However, there was a switch over at W6, W9, and W12, with B×J exhibiting the heaviest body weight during these periods. This finding is supported by the high average daily gain in B×J and the lowest in B×B. Despite the higher ADG from weaning to yearling in B×(B×J) compared to B×B, the initial weight difference at weaning influences the crossbreed's overall performance. It is also shown that the ADG of B×(B×J) falls between B×B and B×J, resulting in lower body weights at 6, 9, and 12 months compared to B×J.

In this study, the growth of Boer crosses surpassed that of Boer when crossed with Kacang (Ginting and Mahmilia, 2008), Central Highland (Deribe et al., 2015; Mustefa et al., 2019; Tesema et al., 2021), Woyito-Guji (Girma et al., 2016), and Abergelle (Fitsum et al., 2019). However, the body weight at six months in this study was lower than that of Boer × Turkish indigenous hair goat (Bolacali et al., 2017). Another study found that the Saburai (Boer × Etawa) goat produced a higher weaning weight but a lower yearling weight than the current study (Adhianto et al., 2022).

The high post-weaning growth of B×J may be affected by heterosis or hybrid vigor, leading the first crossbreed (offspring) to perform better than the purebred. Heterosis typically appears as an enhancement in the overall fitness of offspring (crossbreds) when compared to their purebred parents (Leroy et al., 2018). Crossbreeding often targets this mechanism, where two distinct animal breeds are mated to improve performance. However, despite being a crossbred, B×(B×J) represents a backcross, resulting in a decline in heterosis effects due to the increase of Boer genetic composition in the resulting offspring. The backcross is part of an upgrading system that does not facilitate the optimization of heterosis. The constraints of this crossbreeding system include adaptation issues arising from the increased proportion of exotic genetics (Leroy et al., 2016). A previous study revealed that the hybrid vigor relative to the dam of B×J decreased from 44 in F1 to -4 in F3, leading to a subsequent decrease in body weight (Prastowo et al., 2019). Therefore, the performance of B×(B×J) cannot be as optimal as that of the first crossbreds.

The adaptability of the goats may also influence the varying performance. The higher body weight of B×B at weaning time could be attributed to the solid maternal abilities of the Boer goat. While the Boer goat is known for its high adaptability to the environment, it may still be inferior to local goats in coping with feed quality and other environmental conditions (Khanal et al., 2019). B×J demonstrates higher farm or local environment adaptability with genetic characteristics inherited from local goats. Consequently, the post-weaning growth rate of B×J is better than that of breeds with a higher Boer genetic proportion.

Effect of Buck

The results showed that each buck affected the post-weaning growth of Boer and Boer cross goats (Table 2 and Table 3). There was no specific pattern of body weight affected by the individual bucks. High or low body weight at weaning did not consistently translate to similar results at W6, W9, or W12. Nevertheless, it was observed that most of the bucks that produced offspring with weaning weights higher than the population average consistently produced offspring with higher weights at W6, W9, and W12, and vice versa. This trend was also evident in the average daily gain. Furthermore, even without conducting an analysis, it was noticeable that the average daily gain exhibited an increasing trend from weaning weight to W6, W9, and W12. These findings align with a previous study identifying a sire effect on post-weaning growth in Pantja goats (Khadda et al., 2019) and Sirohi goats (Gautam et al., 2010).

Table 2. Body weight mean ± standard deviation (kg) of Boer and Boer cross goat

Observed variables	Weaning	6 month	9 month	Yearling
Overall mean	13.51±3.26	22.72±3.73	28.39±5.59	40.26±5.47
Genetic group[1]				
B×B	14.41±3.07^{a}	21.28±3.16^{b}	28.87±5.25^{b}	39.21±5.59^{b}
B×J	13.36±3.26^{b}	24.76±3.84^{a}	30.13±5.49^{a}	40.85±4.88^{a}
B×(B×J)	13.41±3.28^{b}	21.83±3.24^{b}	26.42±5.22^{c}	39.56±6.20^{b}
P value	<0.01	<0.01	<0.01	<0.01
Bucks code				
AD	13.49±3.16	21.19±2.58^{bc}	29.21±5.56^{bc}	41.11±4.74^{bcd}
BR	13.69±3.14	23.10±3.68^{b}	28.69±6.42^{bc}	42.99±4.71^{a}
CC	13.75±3.31	27.06±2.28^{a}	32.45±5.47^{a}	41.83±3.56^{ab}
CH	13.30±3.36	20.09±2.87^{c}	27.80±6.77^{bcd}	38.60±6.11^{e}
DA	13.99±3.36	23.34±4.83^{b}	28.32±4.35^{bcd}	41.37±4.92^{abc}
ER	13.78±3.16	22.01±3.93^{bc}	27.72±4.90^{bcd}	39.36±6.54^{de}
GD	13.38±3.29	22.87±3.20^{b}	29.84±5.91^{b}	39.96±4.96^{cde}
RO	13.42±2.95	23.64±4.03^{b}	27.42±4.92^{cd}	38.52±5.75^{e}
SO	12.33±3.33	22.33±2.99^{bc}	27.50±4.95^{cd}	38.16±6.07^{e}
TR	12.76±3.53	23.32±3.87^{b}	26.45±5.02^{d}	38.34±6.51^{e}
P value	0.13	<0.01	<0.01	<0.01
Litter size				
Single	15.17±3.22^{a}	23.72±3.80^{a}	29.84±6.27^{a}	41.56±4.93^{a}
Twin	12.48±2.83^{b}	21.67±3.38^{b}	27.48±4.93^{b}	39.54±5.63^{b}
P value	<0.01	<0.01	<0.01	<0.01
Birth season				
Dry	13.54±3.43	21.08±4.22^{b}	31.56±4.78^{b}	40.14±4.38
Rainy	13.50±3.17	23.39±3.30^{a}	26.73±5.27^{a}	40.32±6.00
P value	0.36	0.03	<0.01	0.56
Weaning season and year				
Rainy 2013	12.99±3.02^{c}	-	-	40.79±3.67^{a}
Dry 2013	13.07±2.99^{c}	-	-	41.14±4.42^{a}
Rainy 2014	13.86±3.27^{b}	22.10±4.34^{ab}	31.44±4.43^{a}	41.36±4.78^{a}
Dry 2014	13.41±3.44^{bc}	24.91±2.06^{a}	31.80±5.06^{a}	41.44±4.72^{a}
Rainy 2015	14.61±3.15^{a}	23.89±3.56^{a}	22.35±4.00^{c}	30.26±5.90^{b}
Dry 2015	11.68±2.51^{d}	19.76±2.52^{b}	26.79±3.11^{b}	-
P value	<0.01	<0.01	<0.01	<0.01
Interaction P value				
Genetic group × buck	0.99	0.18	<0.01	<0.01
Genetic group × litter size	0.07	0.01	0.38	0.07
Genetic group × birth season	0.28	0.07	0.44	0.28
Genetic group × weaning season year	0.72	0.79	0.05	0.86
Buck × litter size	0.04	0.58	0.28	0.13
Buck × birth season	0.69	0.23	0.95	0.12
Buck × weaning season-year	0.99	0.43	0.37	0.47
Litter size × birth season	0.38	0.53	0.18	0.89
Litter size × weaning season-year	0.65	0.54	0.08	0.45

[1] B×B= Boer × Boer; B×J= Boer × Jawarandu; B×(B×J)= Boer × (B×J)

[abcde]different superscripts within columns and the same variable showed significant different (P<0.05)

The sire effect is crucial for assessing the genetic parameters of goat productivity. Selection is often conducted on sires based on their estimated breeding value compared to other sires in the population. The additive genetic variability may influence the variation in offspring produced by the bucks (Khadda et al., 2019). Additionally, it has been found that the heritability of post-weaning growth in Boer × Central Highland goats is moderate. The same report indicated a high phenotypic and direct genetic correlation (0.66-0.96) for WW, W6, W9, and W12 (Tesema et al., 2020a). Consequently, the effect of bucks is relatively significant, as kids with heavier weights at weaning, sired by a particular buck, tend to have higher weights at subsequent ages.

Table 3. Average daily gain mean ± standard deviation (kg) of Boer and Boer cross goat

Observed variables[1]	Weaning–W6	Weaning–W9	Weaning–Yearling
Overall mean	77.16±26.33	78.27±24.47	93.32±17.28
Genetic Group[2]			
B×B	79.66±26.09[a]	76.17±21.44[b]	81.85±17.72[c]
B×J	86.35±30.53[a]	88.19±23.61[a]	96.25±14.86[a]
B×(B×J)	68.31±19.46[b]	69.09±22.77[c]	91.23±19.32[b]
P value	<0.01	<0.01	<0.01
Bucks code			
AD	73.66±29.45[bc]	79.94±25.92[bcd]	96.85±16.53[b]
BR	73.15±20.37[bc]	80.5±26.46[bc]	102.14±15.11[a]
CC	113.83±33.58[a]	93.9±17.18[a]	98.58±11.7[ab]
CH	61.31±18.97[c]	75.57±29.13[cd]	87.9±19.11[c]
DA	82.53±33.28[bc]	76.88±21.23[bcd]	94.7±15.73[b]
ER	65.48±19.47[c]	74.25±26.09[c]	88.96±19.93[c]
GD	73.89±25.80[bc]	84.62±23.65[b]	94.16±13.27[b]
RO	89.13±20.16[b]	71.09±23.08[d]	88.74±17.19[c]
SO	75.22±21.59[bc]	76.51±22.5[bcd]	85.84±19.41[c]
TR	78.57±22.18[bc]	75.62±22.38[cd]	88.59±22.43[c]
P value	0.02	<0.01	<0.01
Litter Size[3]			
Single	73.4±25.88	77.94±26.84	91.79±15.6[b]
Twin	81.09±26.43	78.46±22.92	94.16±18.11[a]
P value	0.14	-	0.01
Birth Season			
Dry	73.27±23.18	92.11±16.18[a]	92.97±14.17
Rainy	78.75±27.48	71.04±24.96[b]	93.51±18.79
P value	0.77	<0.01	0.93
Weaning Season Year			
Rainy 2013	-	-	96.52±11.79[a]
Dry 2013	-	-	97.51±14.85[a]
Rainy 2014	80.80±20.73	93.29±19.68[a]	95.35±14.53[a]
Dry 2014	111.62±29.56	94.39±16.56[a]	97.00±13.60[a]
Rainy 2015	74.78±25.35	65.80±20.88[b]	58.92±15.88[b]
Dry 2015	73.48±22.57	56.51±14.08[c]	-
P value	0.13	<0.01	<0.01
Interaction Effect			
Genetic group × buck	0.03	<0.01	<0.01
Genetic group × litter size	0.79	-	0.15
Genetic group × birth season	0.96	0.44	0.04
Genetic group × weaning season year	0.51	0.07	0.40
Buck × Litter size	0.30	-	0.88
Buck × Birth season	0.36	0.94	0.16
Buck × Weaning season year	0.34	0.39	0.48
Litter size × birth season	0.47	-	0.95
Litter size × Weaning season year	0.04	-	0.08

[1]Weaning–W6 = Weaning to 6 month; Weaning–W9 = Weaning to 9 month

[2]B×B= Boer × Boer; B×J= Boer × Jawarandu; B×(B×J)= Boer × (B×J)

[3]Litter size and its interaction were not analyzed due to their insignificance in the complete model

[abcde] different superscripts within columns, and the same variable showed significant differences (P<0.05)

Effect of Litter Size

This study revealed a superior body weight in single-born kids compared to those born as twins (Table 2). However, a significant effect of litter size on average daily gain was only observed from weaning to yearling. No significant difference was found between weaning to 6-month weight, and we did not analyze the weaning to 9-month weight due to the non-significant effect in the complete model (Table 3). Interestingly, it was observed that the average daily gain from weaning to yearling was higher in twins compared to single-born kids. The superior body weight in singletons was unsurprising, as various studies have supported it.

Factors such as nutritional supply, placental weight, and cotyledon number during the prenatal phase were highly correlated with birth weight, leading to a comparatively lower weight in twin-born offspring (Tesema et al., 2021). During the pre-weaning phase, kid rivalry over consuming the doe's milk impacts the growth rate and contributes to the lower weight of twins (Nugroho et al., 2018). Although post-weaning growth no longer depends on the mothering ability or the nutritional status and milk production of the dam, the prenatal and pre-weaning growth stages considerably impact the subsequent post-weaning development of the kids. Therefore, the lower weight at weaning is followed by consistently lower weights in the subsequent phases. The rapid daily gain during the post-weaning period is likely due to compensatory growth facilitated by fulfilling nutritional requirements through increased feed consumption (Tesema et al., 2021).

Effect of Season and Year

Kids born during the rainy season had higher body weights at six months but lower weights at nine months compared to those born during the dry season (Table 2). This trend is supported by the average daily gain from weaning to 9 months (Table 3). The weaning season and year significantly affected the body weight of post-weaning goats. No specific pattern indicates that the weaning season and year affected the post-weaning growth of the goats. However, it was observed that the dry and rainy seasons of 2014 produced high weaning weight, followed by high body weight at six months, nine months, and yearling.

Additionally, it was shown that during 2015, goats weaned in the dry season had lower weaning and 6-month weights, while those weaned in the rainy season had lower 9-month and yearling weights than other weaning seasons and years. Despite the variability in weight during post-weaning, it consistently produced similar yearling weight from 2013 to 2014. This finding is supported by the observation that the average daily gain of goats during the dry and rainy seasons of 2014 was high during weaning to 9 months of age. Furthermore, the average daily gain from weaning to yearling weight from 2013 to 2014 was the same. Similar to the weight, the daily gain was also low during the dry and rainy seasons 2015.

The effects of season and year have also been reported in various goat populations in diverse countries (Sarma et al., 2019; Ofori and Hagan, 2020; Singh et al., 2021; Jasmine et al., 2022). As a tropical country, Indonesia experiences two distinct seasons: the dry and rainy seasons. The dry season is marked by rainfall in three consecutive periods, each below 50mm/period (1 period: 10 days), or one with rainfall below 50 mm and the total rainfall in three consecutive periods under 150 mm. The rainy season, on the other hand, is marked by rainfall in three consecutive periods equal to or exceeding 50mm/period, or one period with rainfall exceeding 50 mm and the total rainfall in three consecutive periods exceeding 150 mm (BMKG, 2020).

Based on the calculations, each season's length (total months) varied throughout the year and between years. Under these conditions, weaning season and year's effect on the growth of the Boer and Boer cross goats was inconsistent. Generally, the rainy season influences both quantity and quality of forage production. Kids weaned during the rainy season immediately receive high-quality feed as it is easily accessible to the management (Teklebrhan, 2018; Tesema et al., 2020b). However, at the yearling stage, the body weight of kids weaned during the rainy season was lower than those weaned during the dry season. It could be attributed to the season during which the yearling weighed. Yearling weight measured during the dry season contributes to a decrease in body weight.

Interaction Effect

The results showed that only a few interaction effects were revealed in this study. Interactions were found in the genetic group × buck on W9 and yearling weight. Interactions were also observed in the genetic group × litter size on W6 and buck × litter size on weaning weight (Table 2). Furthermore, interaction effects were observed in the average daily gain for the genetic group × buck at all phases. The genetic group with the birth season also interacted for WW-W12 and litter size with the weaning season year for WW-W6 (Table 3).

The interaction between the genetic group and buck on body weight and average daily gain reflects the interplay of genetic transmission from the dam's genetic group and the individual sire. The genetic potential of the offspring is influenced by the combined genetics of both the sire and dam. Males directly transmit their genetic information to the offspring, leading to varying performance depending on the genetic transfer from the females and vice versa. Therefore, individual sires are crucial in evaluating the offspring's performance (Gautam et al., 2010; Patil et al., 2020) and determining genetic parameters (Rout et al., 2018). Additionally, the combination of sire and dam body size can significantly impact the performance of the offspring (Kugonza et al., 2014).

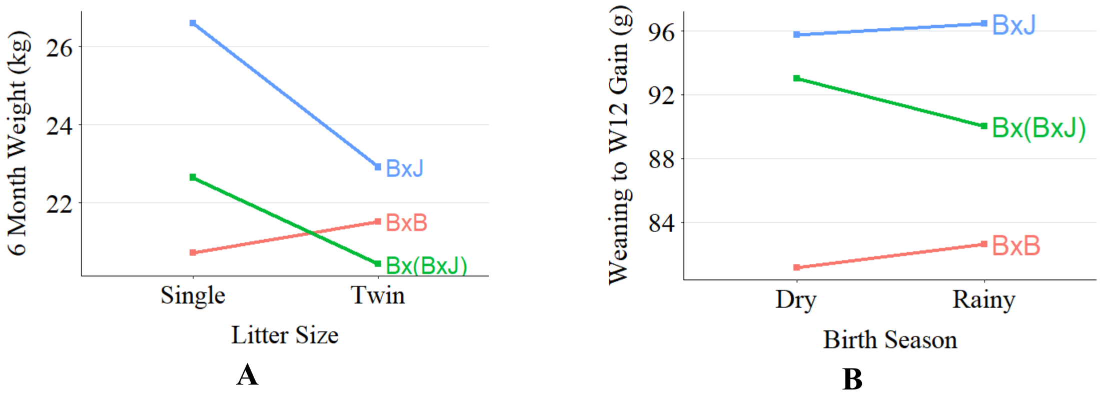

Figure 1. Interaction plots depicting the relationship between genetic groups with litter size on six-month weight (A) and birth season on weaning to yearling weight gain (B)

Twin-born individuals of B×B showed high six-month weights, while for B×J and B×(B×J), twin-borns resulted in lower 6-month weights compared to single-borns (Figure 1A). This finding aligns with a previous study identifying compensatory growth among twin-born Boer kids and their crossbreeds with Central Highland goats (Mustefa et al., 2019). Twin-born B×B goats, when provided with sufficient feed to meet their requirements, exhibited high daily gains, while their crossbreeds showed improvement but not as significantly as the purebreds.

The rainy season at birth improved the daily gain from weaning to yearling in B×B, but this effect decreased in B×(B×J) (Figure 1B). These results indicate that while the growth performance of the purebred was better with sufficient feeding during the rainy season, it also showed that the purebred demonstrated better adaptability to environmental changes. These results differ from a previous study that found purebred Boer goats to have lower survivability than their crossbreeds (Khanal et al., 2019). In addition, it is well known that one of the challenges of crossbreeding is the poor adaptation of crossbreeds to the local environment (Leroy et al., 2016).

CONCLUSION

The current study's post-weaning growth of Boer and Boer Cross goats is affected by genetic and non-genetic factors. Various factors, including genetic group, buck, litter size, birth season, weaning season, and year, impacted post-weaning body weight and average daily gain. Interactions were found in the genetic group with a buck on 9-month and yearling weights. Interactions were also observed in the genetic group with litter size on 6-month weight and buck with litter size on weaning weight. Interaction effects were also observed in the average daily gain for the genetic group with a buck at all phases. The genetic group with the birth season also interacted for weaning to yearling weight and litter size with weaning season year for weaning to 6-month weight. Therefore, controlling or incorporating non-genetic factors in the model for comprehensive genetic assessments and selection programs is imperative. Further study should be conducted to analyze the buck characteristics and determine the best mating scheme as a follow-up to the interaction between genetic groups and the buck.

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