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Performance Evaluation of F_1 Progeny of Beef Crossbreds with BLRI Cattle Breed-1

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Abstract

THIS study aimed to produce market beef cattle with an average carcass weight of at least 150.0 kg by the age of 2 years (market age), utilizing on-farm feeding and management practices. To generate crossbred beef cattle, locally given name BLRI Cattle Breed 1 (BCB-1) cows were artificially inseminated using imported frozen semen from American Brahman, Australian adapted Simmental, Charolais, and Limousin breeds. The breeding and production results of crossbred cattle of various F_1 genotypes compared to BCB-1 (control) were evaluated and compared. A total of 65 crossbreds of four types were considered in the research study, consisting of 32 males and 33 females. All F_1 crossbreds outperformed BCB-1 in live weight across all ages, with the exception of the yearling age for both sexes. Nevertheless, significant disparities existed between the groups. Regarding live weight at birth, the Simmental cross male exhibited the highest live weight, succeeded by the Charolais, Limousin, Brahman crosses and BCB-1 crossbreds. The Simmental cross exhibited the greatest daily live weight gain (0.74±0.16) from birth to market age, succeeded by the Charolais, Limousin, Brahman crosses, and BCB-1. The growth rate in Simmental male-female crosses exceeded that of other crosses. Data were analyzed using a completely randomized design, ANOVA and the general linear model from the Agricolae" package in R. The purebred BCB-1 exhibited the highest feed conversion efficiency and the lowest dry matter intake in comparison to other crosses. Based on the present research it can be concluded that market beef cattle and thus synthetic beef breed(s) can be produced by using Simmental breed in Bangladesh.

Keywords: Cattle, BLRI Cattle Breed 1, Beef Breeding, Animal breeding.

Introduction

Cattle are the main source of beef, an exclusive and popular meat worldwide. Beef is known for its high protein content, strong flavor, and significant nutritional value, making it a key part of many cultures' diets. Quality beef is harder to find because most meat comes from culled animals, male dairy calves, and retired cows. During Eid-ul-Azha, young animals with moderate body condition scores are sometimes slaughtered. The meat supply must be greatly increased to resolve this issue. Bangladesh has a high cattle density, estimated at 2.5013 million/147570 Sq Km [1]. The large cattle population falls short of fulfilling the demand for animal protein. Bangladesh faces constraints in increasing its cattle population and should priorities enhancing cattle productivity. In Bangladesh, despite a high density of cattle, productivity is low due to poor genetic quality, limited feed, and inadequate knowledge of housing and management practices. Additionally, Bangladesh does not have a recognized beef breed, and indigenous cattle show slow growth rates. Profitability in beef production hinges on factors like calf growth potential, average daily gains, live weight, and the development of desirable meat-producing traits. These factors are closely related to sire body measurements [2]. Beef cattle production systems' economic efficiency is closely tied to body weight and weight gain [3]. The feed conversion ratio (FCR) of Brahman crossbred bulls is higher at 12.1 than that of native BCB-1 and Red Chittagong cattle, which are at 9.5 and 9.9, respectively, according to the data of BLRI and DLS

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[4,5]. Beef cattle breeds and hybrids were selected historically for performance metrics, carcass value, climate adaptability, feed access, and personal preferences. There has been a growing emphasis on nutritional quality and health safety [6].

In developing countries, crossbreeding is seen as an effective way to boost the productivity of native livestock. The growth capacity is essential in meat production from animals [7]. A systematic crossbreeding program primarily benefits from heterosis, significantly boosting the productivity of crossbred animals beyond pure breed averages [8]. Systematic crossbreeding with selective breeding is essential for improving genetic quality and addressing the performance decline in crossbred animals over generations [9].

Indigenous cattle in Bangladesh show slower growth rates compared to most temperate, fast-growing beef breeds. Simmental, Charolais, Limousin, and American Brahman are recognized global beef cattle breeds. BCB-1 is a breed developed from the selective breeding of native 'Pabna' cattle, which resulted from the combination of Hariana, Tharparker, and Sahiwal genetic lineages [10]. BCB-1 bulls' body size and coat color increase their market value as beef cattle.

Bangladesh has a high demand for beef, but the prices of beef are increasing significantly especially over the past fifteen years due to low production and availability of beef, as well as the poor carcass yield of local cattle. Per capita meat production stands at just 8.6 kg, while the global average is 42.1 kg and 32.2 kg in developing countries [11].

Bangladesh Livestock Research Institute has initiated a crossbreeding program to enhance beef production, using four high-yielding exotic beef breeds—Simmental, Charolais, Limousin, and American Brahman—combined with the indigenous BCB-1 dam line to produce superior crossbred beef cattle and identify suitable exotic beef sires for seed stock and thus market beef cattle production. After reviewing the literature on beef breeds used in the development of composite beef breeds worldwide, four breeds have been selected that are most commonly used. Furthermore, these four breeds are adapted to the Australian climate, which shares similarities with the climate of Bangladesh, making them well-suited to our local conditions. For these reasons, these four breeds have been selected. This initiative aims to improve beef production by producing crossbred offspring that achieve optimal growth, targeting a carcass weight of at least 150.0 kg under farm conditions at 2 years of age.

Material and Methods

Duration of the research:

The research study started in the 2014-15 fiscal year and concluded in the 2018-19 fiscal year.

Selection of BCB-1 Dams and Artificial Insemination with Exotic Beef Sires

BCB-1 cows and heifers were selected from the BLRI, BCB-1 herd for crossbred beef production through artificial insemination (AI) using semen from exotic beef sires, based on carcass weight, individual and hereditary performance, and reproductive status. Frozen semen from purebred Limousin (light wheat to darker red), Charolais (white and red), and Simmental (black and red) was imported from Australia. Frozen semen of 25 doses of purebred American Brahman sires was collected from DLS for this study. Secondary performance data of the exotic beef breeds were assessed to support selection decisions. A total of 65 crossbreds were considered in the study based on the research objective, consisting of 15 Simmental, 15 Limousin, 13 Charolais, 12 Brahman crossbreds, and 10 BCB-1.

Crossbred beef progeny production through AI

Artificial insemination aligned with the natural oestrus cycle of chosen BCB-1 dams to generate crossbred offspring. All dams were tested for brucellosis and their ovarian condition assessed prior to insemination. The BCB-1 dams were divided into four groups, each containing 15-20 dams for crossing with one beef breed. All cows and heifers had been selected based on their pedigree, individual performances and disease prevalence. The Brucella test was performed using a commercial kit (*B. Brucella* Ab Test Kit) following manufacturer instruction. Artificial insemination (AI) was performed following standard procedure. Four exotic beef breeds were considered as treatment groups whereas, using BCB-1 as the control for assessing progeny production performance. The control BCB-1 males were considered from BLRI BCB-1 herd which produced by natural services. After 2 months of AI, pregnancy was tested by rectal palpation to ascertain the conception. If an animal did not conceive on the first pregnancy, AI was performed again. But not more than two AI services were allowed for single conception and subsequent calculation of service per conception.

Evaluation and Recording of Growth Performance in F_1 Progeny

Birth weight, weaning weight, yearling weight, average daily gains (ADGs) at various physiological stages, calf mortality, and disease incidences were recorded individually. Average Daily Gain (ADG) is defined as the average amount of weight an animal gains each day during the feeding period. ADG is calculated by taking the weight gained by the animal since the last measurement and dividing it by the number of days elapsed since that measurement.

$$ADG = \frac{\text{Final weight gain} - \text{Initial weight}}{No\ of\ Days}$$

The live weight of F_1 progeny was recorded biweekly from birth to 6 months of age. After that monthly live weight was recorded upto 2-3 years of age for males and females respectively. All weights were measured by digital electric weight measuring balance.

Nutritional and management strategies for F_1 crossbred beef progeny:

All pregnant dams with gestation periods over 6 months received prenatal care such as vaccination, milk and feeding schedule and veterinary monitoring. All calves were raised under a consistent nutrition and management program. Total milk and feed intake, feed conversion ratio (FCR), disease incidence, and calf mortality were systematically recorded for BCB-1 and its crossbred genotypes. The FCR. is the mathematical relationship measurement units.

$$FCR = \frac{\text{Feed given}}{\text{Animal weight gain}}$$

A feeding trial was set of about 65 calves to compared the production potential of F_1 crossbreds and BCB-1 from 18 to 24 months of age. All calves received whole milk based on their body weight and they were weaned at three months of age. The control calves were 5 out of 65. Experimental animals received a 55:45 mixed ration (dry matter basis) of German grass and a concentrated mixture with crushed wheat (18%), wheat bran (40%), kesari bran (20%), soybean meal (18%), common salt (1%), dicalcium phosphate (2%), limestone (1%), and premix (0.1%). Table 2 outlines the proximate composition of the supplied feed.

Statistical analysis

Five genotypes were used to generate progeny performance data, with varying sample sizes as dams were inseminated according to their natural oestrus. In a completely randomised design (CRD), a one-way analysis of variance (ANOVA) was used to analyse the impact of genotype on F_1 progeny growth performance. The general linear model was followed and economic traits were analysed by using *Agricolae* package in R (version 3.5.1) [12]. When significant deviations from normality were detected, appropriate data transformations were applied.

Results

The F1 male progeny outperformed the BCB-1 among all crossbreds in terms of live weight at different stages. Except for the weaning (3 months) and yearling (1 year) stages of life, there were significant variations among the groups (Table 3).

The females of the crossbred BCB-1 breed were heavier than the purebred BCB-1 females at birth, weaning, yearling, and 24-month age, similar to the males. The Simmental cross's females weighed the most at market age (413.87±75.88 kg), followed by Limousin BCB-1 (385.25±69.73 kg), Charolais BCB-1 (382.2±47.83 kg), Brahman BCB-1 (323.6±14.32 kg), and BCB-1 (290.8±11.79 kg) (Table 4).

Genotype had a highly significant ($p<0.001$) impact on the average daily weight gain of male progeny aged up-to 24 months. This indicates that the genotype influences growth rates during the early developmental phase. All crossbred male progeny exhibited more significant daily weight gains than the BCB-1 breed from birth to market age. The Simmental cross achieved the highest daily weight gain among the crossbred groups, averaging 0.74±0.16 kg (Table 5)

Crossbreds of different genotypes at 18-24 months had similar total dry matter intake (DMI), percentage of DMI, average daily gain (ADG), and feed conversion ratio (FCR) over the first 68 days of the feeding study ($p>0.05$). Purebred BCB-1 had the lowest DMI and the best feed conversion ratio. It indicated that while crossbreds produced more beef overall, BCB-1 is more profitable to farm and more efficient at utilizing feed. The crosses showed better body condition scores in this case, while the control BCB-1 group initially showed some compensatory growth effect (Table 6).

Out of 65 calves born, two died due to delivery difficulties and coccidiosis. The calf mortality rate under this breeding program was 3.08% (Table 7).

Discussion

In this study, both male and female Simmental × BCB-1 crosses showed the highest growth rates and live weights at market age. Genetic factors (breed and sex) and environmental factors such as feed nutrients and management system) influence an animal's body weight. Crossbred cattle consistently outperformed BCB-1 in live weights at all stages. Body development, physical maturity, ease of calving, and maternal qualities are all intimately related to cattle growth and are essential for long-term productivity and reproductive efficiency [13]. Across several growth stages, the F_1 male offspring in the present study showed higher live weights than the purebred BCB-1, showing the benefits of crossbreeding to promote early growth as well as potential future mother performance. Animal growth is the best assessment of gaining live weight at the target age, typically one year. Birth weight has a significant effect on calving ease, especially in first-time mothers (71%) compared to those giving birth for the second time (61%). This shows that birth weight is an important factor to consider when selecting animals [7]. The factors like birth year, herd, and calf sex significantly affect birth weight, weaning weight, and daily gain in Czech Fleckvieh and Simmental crosses [14]. Studies showed that birth weight and calf sex significantly impact calving difficulty in pregnant cows [15,16].

The results of this study support previous research showing that the calves from heavier cows generally exhibit faster growth at birth [17]. The growth indicators for Simmental and Limousin bulls in this study are very similar to those in previous research, with Simmental-sired calves performing the best in terms of both birth weight and postnatal growth [17,18].

Birth weight, one-year age, and average daily gain in young Switzerland Simmental bulls were reported as 43 kg, 536 kg, and 1469 g, respectively, highlighting the strong influence of genetics on growth potential [19]. The observed findings are also similar to weaning weights reported in previous studies, which were 155.17±20.88 kg for Limousin and 146.50±22.04 kg for Simmental calves [20].

A successful crossbreeding experiments between *Bos taurus* and *Bos indicus* was done to improve the growth and carcass performance of *Bos indicus* breeds [21]. Body weight is a key indicator of animal condition, affecting breeding or slaughter decisions [22]. During the weaning period, muscle and bone development can be negatively affected by nutritional restrictions, hindering growth [23]. In semi-intensive fattening up to 16 months, young bulls of various genotypes had average live weight gains of 1190g for Simmental, 1250g for F_1 (Simmental × Limousin), and 1275g for F_1 (Simmental × Charolais), aligning with the current study [24]. A fattening program in Orenburg, Russia, showed that Simmental cattle had an average daily weight gain of 1300-1400 g, with carcass weights between 380 and 395 kg at 24 months [25]. The observed values were higher than those in this study, likely due to genetic differences. Simmental bulls at 205 days in Indonesian breeding stations weighed 197.11±45.73 kg, exceeding the body weight found in this study [17]. Simmental-sired steers were 22 kg heavier than Angus-sired steers at 400 days and 37 kg heavier at 600 days ($P<0.05$) noted in an experiment [26]. Simmental and Angus progeny had a growth rate of 1.97 kg/day, exceeding other breeds [27]. Average daily gains varied, with Limousin at 1.03 kg and other groups at 1.57 kg, while Angus reached the peak growth rate of 1.97 kg [28]. Simmental bulls are an excellent choice as sires for various dam genotypes, yielding offspring ideal for second-calving cows in meat production [28].

European breeds like Charolais, Simmental, and Limousin outperformed the typical American Brahman. Charolais × Thai native cattle outperformed Brahman × Thai native cattle in growth and carcass quality, aligning partially with the current study [29]. Simmental sires produced faster-growing progeny with larger carcasses in dam lines of straight-bred Angus, Angus-cross-Holstein Friesian, Angus-cross-Jersey, or Angus-cross-Kiwicross compared to Angus bulls [26]. On the other hand later-maturing cattle should be fattened to higher weights, as slaughter age significantly impacts meat tenderness more than growth rate [30].

Body measurements are essential traits in dairy and beef cattle [31]. Growth rates vary among organs and tissues, leading to changes in body shape and proportion. Mature size refers to the point when an animal's weight shifts due to increased fat content [32]. In a study it was revealed that carcasses experiencing compensatory growth often contain more fat, influenced by the fattening period [33]. It was found that Hereford-sired crossbred, Angus steers showed faster growth rates after weaning, indicating that crossbreds might reach higher final weights and offset earlier growth delays [30]. Earlier maturing breeds like Aberdeen Angus, Hereford, and Jersey typically exhibit lower muscularity and higher fat content than later maturing breeds such as Limousin, Holstein, Charolais, and Beef Simmental, particularly at the same age [34,35]. These early maturing breeds, with smaller body frames, reach adolescence earlier and attain lighter mature weights [30,34]

It was noted that crossbreeding British or Dairy breeds with later-maturing European beef breeds improves calf growth rates, dressing percentage, and lean meat yield [30]. In an experiment it was emphasized that the advantages of hybrid vigour in crossbred calves, showing that genetic diversity between breeds enhances performance [36]. This method provides a practical way to enhance these traits by leveraging the considerable genetic diversity in bovine breeds [27].

Carcass composition is affected by target weight range and the unique growth curves of various breeds [27]. Male carcasses generally exhibit greater muscularity and reduced fat content compared to females [37]. Management and feeding conditions also influence veal carcass quality and growth models, was highlighted in a study [38]. Enhancing growth performance is essential for improving production efficiency, resulting in quicker turnaround times and better economic returns [36]. A strong link found between the weight of fully grown cows and the growth rate of their calves, indicating that early calves may reach better carcass and purchase weights [2]. Optimising cattle breed selection for environmental compatibility enhances growth performance and carcass quality [27,39]. British beef breeds such as Angus, Hereford, and Shorthorn generally exhibit lower dressing percentages compared to continental European breeds, mainly because of their early maturity and increased fat content in non-carcass areas [37]. In an experiment, it was found that the calf mortality rate for graded Brahman calves was 2.13% [18]. The calf mortality rate in commercial dairy farms in Bangladesh was found to be 12.28% [40]. In commercial dairy farms in Bangladesh, the calf mortality rate was 12.28%, found in an experiment [40]. A lower rate of 6.29% was reported in Muktagacha, Mymensing while higher rates ranging from 29-36% were recorded in Sherpur and Bogra [41, 42]. In another experiment, the highest calf mortality rate of 71.1% was observed [43].

Improving growth genetics is essential for boosting beef production, with both growth and reproduction being key components of breeding programs [44]. Positive phenotypic correlations were noted in Brahman crossbred calves across different age weights, especially at six, nine, twelve, and twenty-four months [18]. Beef breeds mainly convert nutrients into proteins, whereas dairy breeds, due to distinct hormonal and metabolic profiles, tend to accumulate more intra-abdominal fat [27]. It was reported that the heritability of average daily gains as 0.27 pre-weaning and 0.30 at weaning [13]. Genotype-dependent variation in carcass composition is affected by the animal's maturity stage [37]. Genetic selection for increased body weight at younger ages can enhance both body weight and reproductive performance at sexual maturity [3]. In another experiment strong correlations found between live weight and heart girth ($r = 0.84$) and body condition score ($r = 0.70$) [45].

Despite being relatively low when compared to other cattle farms, the 3.08% calf mortality rate shown in this study identifies important management areas that require improvement. Higher than 5% mortality rates commonly indicate problems with management processes [46]. The most common causes of death, such as bloody diarrhea, coccidiosis, and premature birth, highlight the importance of better environmental management, maternity care, and disease prevention. It is essential to know that even small losses can affect farm productivity, especially in environments with limited resources, even while the mortality rate is within acceptable limits for tropical crossbreeding programmes [46,47]. Better calving management and preventive measures like better hygiene, vaccination, deworming, and maternal nutrition are important. Disease-resistant and adaptive genotypes like Brahman×BCB-1, Simmental×BCB-1, and BCB-1×BCB-1 should be the main focus of future breeding [48].

Crossbreeding programs have played a significant role in boosting beef production globally.

Although challenges such as high birth weights and dystocia require careful management, crossbreeding programs, such as those involving Belgian Blue cattle in Indonesia, enhance beef production by increasing carcass weight and yield [49]. Furthermore, a meta-analysis of 42 studies conducted in tropical regions revealed that heterosis improves productive traits, including milk production and health [50].

Conclusion

Significant differences in growth performance were noted among the crossbreds. In conclusion, the Simmental Sire, with its higher live weight, faster growth rate, and greater milk production (10-12 liters/day), may effectively produce crossbred BCB-1 for seed stock and thus beef cattle marketing. More F_1 progeny need to be produced to evaluate their performance. Larger number of sample size and optimal management need to be ensured in such kind of breeding program to get the precise results.

Limitations

The main limitation of the present study was small sample size and uneven distribution among the genotypes due to less number of dams, shortage of fund and research materials (cattle shed/space, manpower, feeds & fodder etc.), long generation intervals of cattle, following natural estrus and semen purchasing complexity from abroad. Future studies with larger and more balanced cohorts are recommended to validate these findings and strengthen generalizability.

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Conflict of interest

No conflict of interest

TABLE 1. The milk-feeding schedule of produced calves from birth to weaning

Calf Age (Days)	Milk supplied % of Body Wt. (Kg)
Birth to 30	10
31 to 45	8
46 to 60	6
61 to 75	4
75 to 90	2
91 to 97	Gradual decreases from 2 % to 0 % (Weaning)

TABLE 2. Chemical composition of feed supplied to the animals

Feed	% DM	% CP	% Ash
Concentrate	88-89	17.5-18.0	10-11
German Grass	15-16	14-16	10-12

TABLE 3. Effects of genotypes of F_1 male progeny on live weight at different ages

Live weight (kg)	Genotype Mean±SD(n)					Sig. Lev.
	Limousin× BCB-1	Simmental× BCB-1	Charolais× BCB-1	Brahman× BCB-1	Purebred BCB-1	
At birth	21.24^{bc}±3.36 (8)	23.00^{abc}±2.34 (5)	26.40^{a}±6.84 (7)	24.90^{ab}±2.48 (7)	18.84^{c}±3.41 (5)	*
At weaning (3 months)	62.74^{ab}±11.79 (8)	63.20^{ab}±18.23 (5)	66.30^{ab}±13.94 (7)	75.00^{a}±13.94 (7)	52.30^{b}±5.63 (5)	NS
At 1 yr	231.62±41.41 (8)	235.60±60.32 (5)	246.14±74.19 (7)	250.14±19.75 (7)	202.20±9.75 (5)	NS
At 2 yrs	472.66^{b}±38.00 (6)	543.50^{a}±105.35 (2)	495.00^{ab}±40.92 (4)	407.14^{c}±15.23 (7)	348.00^{d}±20.0 (5)	***
At 3 yrs	602.80^{a}±32.58 (5)	658.00^{a}±70.71 (2)	633.50^{a}±51.62 (4)	583.50^{a}±36.84 (4)	460.20^{b}±67.12 (5)	***

***Highly significant (p<0.001); *Significant (p<0.05); NS=Non-significant, SD= standard deviation, parenthesis indicates several observations, means with different superscripts are different.

TABLE 4. Effects of genotypes of F_1 female progeny on live weight at different ages

Live weight (kg)	Genotype Mean±SD					Sig. lev.
	Limousin× BCB-1	**Simmental× BCB-1**	**Charolais× BCB-1**	**Brahman× BCB-1**	**Purebred BCB-1**	
At birth	$22.59^{a} \pm 6.13$ (7)	$22.73^{a} \pm 3.21$ (10)	$25.55^{a} \pm 4.16$ (6)	$22.54^{a} \pm 2.01$ (5)	$16.84^{b} \pm 4.13$ (5)	*
At weaning (3months)	$60.33^{a} \pm 11.44$ (7)	$68.34^{a} \pm 13.70$ (10)	$68.83^{a} \pm 13.35$ (6)	$59.80^{ab} \pm 7.82$ (5)	$45.86^{b} \pm 5.98$ (5)	*
At 1 yr	$205.57^{ab} \pm 37.13$ (7)	$229.72^{a} \pm 45.49$ (11)	$225.83^{a} \pm 43.7$ (6)	$210.6^{ab} \pm 26.43$ (5)	$173.6^{b} \pm 9.31$ (5)	NS
At 2 yr	$385.25^{ab} \pm 69.73$ (4)	$413.87^{ab} \pm 75.88$ (8)	$382.2^{ab} \pm 47.83$ (5)	$323.6b^{c} \pm 14.32$ (5)	$290.8^{c} \pm 11.79$ (5)	**

**Highly significant ($p<0.01$); *Significant ($p<0.05$); NS=Non-significant; SD= standard deviation, value in the parenthesis indicates several observations, means with different superscripts are different.

TABLE 5. Effects of genotypes of F_1 male and female progeny on average daily body weight gains (ADG) at different ages

ADG (kg/d)	Genotype (Mean±SD)					Sig. lev.
Male	**Limousin× BCB-1**	**Simmental× BCB-1**	**Charolais× BCB-1**	**Brahman× BCB-1**	**Purebred BCB-1**	
0-3 months	0.46±0.14(8)	0.45±0.21(5)	0.44±0.21(7)	0.56±0.15(7)	0.37±0.06(5)	NS
0-12 months	$0.65^{b} \pm 0.04$(6)	$0.77^{a} \pm 0.09$(2)	$0.76^{a} \pm 0.08$(4)	$0.63^{b} \pm 0.05$(7)	$0.51^{c} \pm 0.03$ (5)	***
0-24 months	$0.65^{ab} \pm 0.04$(5)	$0.74^{a} \pm 0.16$(2)	$0.67^{a} \pm 0.03$(3)	$0.57^{b} \pm 0.05$(4)	$0.46^{c} \pm 0.03$ (5)	***
Female						
0-3 months	$0.42^{ab} \pm 0.14$(7)	$0.51^{a} \pm 0.15$(10)	$0.48^{ab} \pm 0.13$(6)	$0.41^{ab} \pm 0.10$(5)	$0.32^{b} \pm 0.09$(5)	NS
0-12 months	$0.55^{ab} \pm 0.14$(4)	$0.63^{a} \pm 0.12$(8)	$0.57^{ab} \pm 0.12$(5)	$0.52^{ab} \pm 0.08$(5)	$0.44^{b} \pm 0.02$(5)	NS
0-24 months	$0.60^{a} \pm 0.04$(2)	$0.61^{a} \pm 0.05$(5)	$0.56^{a} \pm 0.04$(2)	$0.43^{b} \pm 0.02$(3)	$0.39^{b} \pm 0.03$(5)	***

***Highly significant ($p<0.001$); NS=Non-significant; SD= standard deviation, value in the parenthesis indicates number of observations, means with different superscripts are different.

TABLE 6. Effects of genotypes of F_1 crossbreds and BCB-1 on intake, growth and FCR at 18-24 months of age

Parameters	Genotype Mean±SD(n)					Sig. lev.
	Limousin× BCB-1(3)	**Simmental× BCB-1(3)**	**Charolais× BCB-1(5)**	**Brahman× BCB-1(6)**	**BCB-1(5)**	
Initial LW (kg)	397.67±112.17	396.33±143.29	425.20±92.96	353.67±59.73	307.00±107.84	NS
Final LW (Kg)	445.67±118.73	445.67±151.58	479.00±88.70	397.67±60.06	360.40±106.01	NS
Total DMI (Kg/d)	$8.40^{a} \pm 1.20$	$8.01^{ab} \pm 1.89$	$8.53^{a} \pm 1.23$	$7.44^{ab} \pm 1.12$	$6.02^{b} \pm 1.57$	NS
% DMI/100kg LW	2.05±0.27	1.96±0.24	1.91±0.10	2.00±0.18	1.86±0.24	NS
Total Gain (Kg)	48.00±6.56	49.33±10.07	53.80±13.10	44.00±12.47	53.40±5.68	NS
ADG (Kg)	0.71±0.10	0.72±0.15	0.79±0.19	0.65±0.18	0.78±0.08	NS
FCR	$11.90^{ab} \pm 0.15$	$11.22^{ab} \pm 2.47$	$11.33^{ab} \pm 3.39$	$12.16^{a} \pm 3.22$	$7.79^{b} \pm 2.46$	NS

NS=Non-significant, SD= standard deviation, LW= live weight, DMI= dry matter intake, ADG=average daily gain, FCR= feed conversion ratio, value in the parenthesis indicates number of observations, means with different superscripts are different.

TABLE 7. Calf mortality of crossbred and BCB-1 progeny

Genotypes	Total calf born	No. of calf died	Causes of death	% calf mortality
BCB-1×BCB-1	10	0	-	0.00
Limousin×BCB-1	16	1	Coccidiosis/ Bloody Diarrhea	6.25
Simmental×BCB-1	14	0	-	0.00
Charolais×BCB-1	13	1	Premature Birth	7.69
Brahman×BCB-1	12	0	-	0.00
Total	65	2		3.08

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