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Effect of non-genetic factors on growth performance of Brahman crossbred cattle of Bangladesh

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Abstract

The study was conducted to investigate the effects of non-genetic factors (sex, season and agro-ecological zone) on growth performance of Brahman crossbred cattle population of Bangladesh. Data on 5662 Brahman crossbred (50%) calves were collected from the herdbook maintained by the Department of Livestock Services and Department of Animal Breeding and Genetics of Bangladesh Agricultural University across eight location and four agro-ecological zone of the country from January 2014 to November 2018. Least squares means were analyzed using General Linear Model (GLM) of Statistical Analyses System (SAS). Sex had significant (p<0.001) effect on birth weight, weight at one-, three-, nine-, twelve- and twenty-four month, ADG from 6- to 9-month and from 9- to 12-month of age. However, sex effect was non-significant for 6-month body weight, ADG from birth to 3-month and ADG from 3- to 6-month. Season effect was significant (p<0.001) on almost all growth traits considered in this study except 12-month and 24-month body weight. Agro-ecological zones had significant (p<0.001) effect on birth weight, weight at one-, three-, nine-, twelve- and twenty-four month, ADG from 3- to 6-month and ADG from 6- to 9-month of age. In contrary, ADG from birth to 3-month and ADG from 9- to 12-month were not significantly (p<0.001) affected by agro-ecological zones. It revealed from the present study that difference in management practices by farmers and agro-ecological zones in Bangladesh should be taken into account in formulating beef breeding program.

Keywords: Non-genetic factors, growth, Brahman crossbred, Bangladesh

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1 Introduction

The production of meat by indigenous cattle in Bangladesh is relatively low because of their poor genetic makeup (Hoque et al., 1999). In Bangladesh, a crossbreeding program has been undertaken using Indigenous cows and American Brahman sire to boost up meat production (Rashid et al., 2016). The adaptive traits which specifically suit the Brahman and Brahman based breeds for production in temperate, subtropical or tropical areas include: tolerance of internal and external parasites, tolerance of high solar energy, ambient temperature and humidity and ability to utilize high fiber forages (Mahbubul et al., 2020). The economic viability of cattle farming is coming under pressure due to ever increasing input costs along with climatic and nutritional stresses, managerial and disease limitations. Adaptability is the basis for successful and efficient beef cattle production in the sub-tropics. A certain level is required to achieve adequate reproduction and production levels within specific environmental conditions. It is generally recognized that poor reproductive and reduced growth performance are the major factors limiting cattle production in the tropics (Jones and Hennessy, 2000) and the constraints placed on production traits are predominately environmentally imposed (Duarte-Ortuño et al., 1988).

Beef cattle breeding programs have generally selected for growth traits such as weight or weight gain at certain ages. High growth rates, high weaning weights and vigorous average daily gain contribute to the efficiency of beef production. Growth rate of livestock is influenced by several factors; these include production systems, breed, age, sex, nutritional level, hormonal status and environment (Munim et al., 2006). There is consensus among researchers that, generally, male calves are heavier than their female counterparts and the difference increase as the calves grow older. Bull calves have greater growth potential than heifer calves, therefore, it is possible to exploit its potential superiority to a greater extend. Season is one of the important factors affecting performance and profitability of beef cattle (Koknaroglu et al., 2006). Seasons can directly influence the animal's body temperature, the activity of certain organs, grazing, thus it is affecting production process. The different temperatures of the changing seasons affect the body's physiological processes of livestock. The heat pressure can cause a declining rate of livestock's metabolism due to the decreasing amount of feed intake (McDowell, 1972). The difference level of rainfall also influences food supplies which ultimately influences production of livestock. In winter, low availability of grass can influence the production capacity of cattle. Agro-ecological region, through its main environmental factors (rainfall, temperature and topography) is a significant source of variation in production performance of livestock. Considering the above factors the experiment was carried out to determine non-genetic factors (sex, season and agro-ecological zone) effect on growth performance of Brahman crossbred cattle in Bangladesh.

2 Materials and Methods

2.1 Study Area

The study was conducted in 80 Upazilas of 38 districts of eight administrative division (Dhaka, Mymensingh, Rajshahi, Rangpur, Chattogram, Sylhet, Barishal and Khulna) of the country under the supervision of Department of Livestock Services (DLS) and Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh from January 2014 to November 2018 with the support of the Government of the Peoples' Republic of Bangladesh project entitled "Beef breed development in Bangladesh". According to Banglapedia (https://www.banglapedia.org/) for convenience of the study, whole country were divided into four agroclimatic zones (flood plains -Dhaka and Rangpur division, Bogura, Pabna, Sirajgonj, Natore, Jessore, Kushtia, Magura, Chuadanga, Jhinaidah; southern coastal belts -Chattogram, Noakhali, Barishal, Patuakhali, Bagerhat and Khulna; north western 'Barind' steppe- Naogaon, Rajshahi, Chapainawabgonj; and the eastern hilly areas-Sylhet, Maulavibazar, Cumilla, Brahmanbaria and Feni) that would rationally represent the whole country. Three seasons of birth as winter (November to February), summer (March to June) and rainy (July to October) were considered in the study.

2.2 Source of data

The data of 50% Brahman crossed population were used in the experiment and were collected from the record sheets maintained at the Central Cattle Breeding Station and Dairy Farm (CCBDF), Savar, Dhaka and the book maintained for recording of growth performance on individual animal at the Upazila Livestock Office of the respective selected areas.

2.3 Traits under study

Birth weight Birth weight (kg) was recorded for all calves within 24 hours of their birth using the digital weighing balance.

One-month body weight With the help of digital weighing balance weight at one month were recorded in the morning before feeding.

Three-month body weight Weight at three-month of Brahman crossbred calves (50%) was recorded in kilogram with digital weighing balance in the morning before the animals were fed.

Six-month body weight Calves weight at six-month was recorded with digital weighing balance in the morning before feeding.

Nine-, twelve- and twenty four-month body weight The nine, twelve and twenty four-month weight were calculated from hearth girth (smallest circumference of body immediately behind the shoulder) and the body length (distance between point of shoulder to the pin bone). Body length and hearth girth were measured in the inches using a measuring tape and the live weight of each calf was calculated according to Shaeffer's formula as follows:

$$L_w = \frac{B_l \times {H_g}^2}{300 \times 2.2} \quad (1)$$

where, L_w = Live weight (kg), B_l = Body length (in), H_g = heart girth (in).

Average daily gain from birth to three-month Amount of weight gained per day per animal during birth to three-month of age. The following formula was used to calculate the Average daily gain in gram (g).

$$ADG = \frac{W_F - W_I}{d} \quad (2)$$

where, ADG = Avergae daily gain (g), W_F = final weight (g), W_I = initial weight (g), and d = days between initial and final weight. Average daily gain from three to six month of age, average daily gain from six to nine month of age and average daily gain from nine to twelve month of age were calculated using the above mentioned formula.

2.4 Feeding management of the animals

New borne calves were allowed to suckle colostrum and were left with dam up to 3 to 4 days. In some cases, calf milk replacer was fed to the calves and calves were separated from dam from day 4 and onward. The calf was fed 5-10 g of grain (maize powder form) at the age of 4-5 days that influence to grow rumen bacteria. After about 3 weeks of eating grain, the calf rumen had enough bacteria fermenting enough feed to supply a substantial amount of energy. All calves were assisted to develop rumen by providing free-choice water and quality grain in the first few days after birth. With this feeding strategy by 3-4 weeks of age the calf rumen was well develop and was ready for the change to a diet of solid feeds.

2.5 Statistical analysis

The general linear model (GLM) procedures of the Statistical Analysis System (SAS, version 9.1.3) computer package, were used to test the significance of fixed effects according the following model:

$$Y_{ijk} = \mu + S_i + M_j + R_k + E_{ijkl} \quad (3)$$

Yijk= μ +Si +Mj + Rk+Eijkl where, Y_{ijk} = dependent variable (individual animal record for the trait), μ = overall mean, S_i = fixed effect of ith sex of calf, M_j = fixed effect of jth season, R_k = fixed effect of kth AEZ, E_{ijkl} = residual error.

Duncan multiple range test (DMRT) was used to detect significant differences between means with the help of Statistical Analysis System (SAS) computer package, version 9.1.3.

3 Results and Discussion

3.1 Sex effect

The effect of sex on body weight and average daily gain are presented in the Table 1. Calf sex had significant ($p<0.001$) effect on birth weight and male calves were heavier (23.89 ±0.10 kg) than female calves (22.85±0.11 kg) which was in agreement with findings Hernández-Hernández et al. (2015) in Brahman calves and Haque et al. (2016) in 25% and 50% Brahman crossbred calves. Male calves have bigger bony structure than female calves. Larger frame contributes to heavier body weight. On the contrary, no differences ($p>0.05$) at birth between male and female calves was reported by Montes et al. (2011) in Brahman cattle, Shejuty et al. (2020) in grade-2 Brahman calves, Papry et al. (2020) in graded Brahman calves. It might be due to the differences among the breeds or genotypes and longer gestation periods of male caves and higher androgen hormone intensity of fetus serum (Manzi et al., 2012). Sex had significant effect on weight at 1-month (Table 1). Male calves were heavier (38.49±0.17 kg) than female calves (36.55±0.17 kg) at 1-month of age. Male calves (59.44±0.30 kg) were superior ($p>0.001$) at 3-month than female calves (57.76±0.31 kg) which was similar with Haque et al. (2016) for 25% and 50% Brahman crossbred but dissimilar with Sagar et al. (2017) in Vrindabani cattle in Inida, Fuad et al. (2014) in Kedah-Kelantan Calves in Malaysia who found no significant effect of sex on 3-month body weight.

Weight at 6-month was not significantly affected by sex (Table 1) which was supported by Shejuty et al. (2020) in grade-2 Brahman calves and contradictory with Papry et al. (2020) in graded Brahman calves, Fuad et al. (2014) in Kedah-Kelantan Calves in Malaysia. Male calves at 9-month of age were heavier ($p<0.001$) than female calves having 183.53±1.31 and 178.50±1.36 kg, respectively for male and female calves. Papry et al. (2020) in graded Brahman calves also found higher body weight of male calves compared to female calves at 305-days of age. Sex had significant ($p<0.001$) effect on weight at 12-month where male (265.73±1.69 kg) had higher body weight than female (251.06±1.75 kg). In parallel to the results obtained in this study, in previous studies Papry et al. (2020) in graded Brahman calves, Hernández-Hernández et al. (2015) in Brahman calves reported that sex had significant effect on the 12-month body weight of calves.

Weight at 24-month of calves were significantly ($p<0.001$) affected by sex in present study. Body weight of male calves (576.44±5.26 kg) at 24-month was higher than that of female calves (513.30±5.01 kg). ADG from birth to 3-month and ADG from 3- to 6-month were not significantly affected by sex (Table 1). These results are in agreement with the findings of Haque et al. (2016) in 50% Brahman crossbred calves up to one year of age while contradictory with the report of Krupa et al. (2011) for birth to 120 days average daily gain in beef cattle breed in Slovakia. Sex effect was significant ($p<0.001$) on ADG from 6- to 9-month and ADG from 9- to 12-month (Table 1). Male calves had grown faster than their female counterparts. Males grow more rapidly and reach a greater mature weight while females have slower rate of growth and reach maturity at smaller size due to the effect of hormonal differences in their

Table 1. Effect of sex on body weight and average daily gain of Brahman crossbred cattle

Traits	Male	Female	Sig. level
Birth weight (kg)	23.89a ±0.10 (2928)	22.85b±0.11 (2734)	***
Weight at 1-month (kg)	38.49a±0.17 (2916)	36.55b±0.17 (2718)	***
Weight at 3-month (kg)	59.44a±0.30 (2905)	57.76b±0.31 (2696)	***
Weight at 6-month (kg)	115.54a±0.78 (2899)	114.91a±0.81 (2685)	NS
Weight at 9-month (kg)	183.53a±1.31 (2876)	178.50b±1.36 (2672)	**
Weight at 12-month (kg)	265.73a±1.69 (2438)	251.06b±1.75 (2266)	***
Weight at 24 month (kg)	576.44a±5.26 (1127)	513.30b±5.01 (1243)	***
ADG from birth to 3-month (g)	397.15a±3.23 (2892)	392.89a±3.36 (2671)	NS
ADG from 3- to 6- month (g)	623.20a±7.11 (2899)	635.37a±7.39 (2684)	NS
ADG from 6- to 9-month (g)	763.60a±7.98 (2836)	710.74b±8.25 (2649)	***
ADG from 9- to 12- month (g)	928.75a±9.61 (2424)	860.21b±9.97 (2250)	***

Figures in the parentheses indicate the number of observation; Mean with different superscripts within same row differ significantly (p<0.05).**(p<0.01),***(p<0.001) and NS, non-significant

endocrinological and physiological functions, longer gestation length of male and to selection pressure that was more intense on males than female calves (Koger and Knox, 1945).

3.2 Season effect

The effects of season on growth traits are summarized in Table 2. Season had significant (p<0.001) effect on birth weight, weight at one, three, six and nine month body weight except twelve and 24-month body weight where seasonal effect were non-significant. The non-significant effect of season only on twelve and 24-month indicated that body weights at later stages of growth are not affected by season. In this study, birth weight of calves was significantly affected by season of calving which was supported by Aksakal and Bayram (2009) in Holstein Freisian cattle. However, contrary findings reported by Munim et al. (2006) crossbred cattle in Bangladesh, Fuad et al. (2014) in Kedah-Kelantan Calves in Malaysia reported non-significant effects of season on birth weight of calves. The highest birth weight (24.25±0.12 kg) obtained in summer (March-June) and comparatively lower birth weights were found in winter (November-February, 23.00±0.13 kg) and rainy season (July-October, 22.66±0.13 kg). Winter born calves had highest body weight (38.12±0.22 kg) at 1-month of age followed by rainy season (37.70±0.22 kg) and winter season (36.99±0.19 kg). Moreover, winter born calves had higher (60.09±0.38 kg) body weight at 3-month than summer season (58.67±0.34 kg) and rainy season (57.07±0.39 kg). Season of birth have significant (p<0.001) effect on the weight at 3-months of age. This was supported by Sagar et al. (2017) in Vrindabani cattle, Ndofor-Foleng et al. (2011) in Gudali and Wakwa cattle in South Africa. Season of birth had significant (p<0.001) effect on the weight at 6-month of age. These findings were consistent with earlier reports by Sagar et al. (2017) in Vrindabani cattle, Moaeen-ud Din and Bilal (2017) in local and crossbred in Pakistan, Ndofor-Foleng et al. (2011) in Gudali and Wakwa cattle in South Africa but non-significant (p>0.05) effect of sex of calves, parity of dam and season of birth were found by Afroz et al. (2011) at 6-month body weight. Winter season showed best performance with 118.05±1.00 kg 6-month weight followed by 116.77±0.89 kg in summer and 110.24±1.03 kg in rainy season. Weight at 9-month was significantly (p<0.001) affected by season (Table 2). Winter born calves had highest body weight (186.26±1.68 kg) and lowest body weight (177.25±1.51 kg) was in rainy season while summer born calves body weight (180.75±1.73 kg) in intermediary.

Heat stressed animals reduce intake while their maintenance requirement is increased, which leads

Table 2. Effect of season on body weight and average daily of Brahman crossbred cattle

Traits	Winter	Summer	Rainy	Sig. level
Birth weight (kg)	23.00b±0.13 (1771)	24.25a±0.12 (2215)	22.66b±0.13 (1676)	***
Weight at 1-month (kg)	38.12a±0.22 (1757_	36.99b±0.19 (2207)	37.70a±0.22 (1670)	***
Weight at 3-month (kg)	60.09a±0.38 (1742)	58.67b±0.34 (2191)	57.07c±0.39 (1668)	***
Weight at 6-month (kg)	118.05a±1.00 (1741)	116.77a±0.89 (2191)	110.24b±1.03 (1652)	***
Weight at 9-month (kg)	186.26a±1.68 (1733)	177.25b±1.51 (2163)	180.75b±1.73 (1652)	***
Weight at 12-month (kg)	262.01a±2.44 (1176)	257.97a± 1.92 (1904)	257.05a±2.07 (1624)	NS
Weight at 24-month (kg)	546.29a±7.41 (586)	549.17a±5.60 (1025)	533.14a±6.51 (759)	NS
ADG from birth to 3-month (g)	415.14a±4.16 (1734)	388.42b±3.73 (2161)	382.93b±4.24 (1668)	***
ADG from 3- to 6-month (g)	644.71a±9.16 (1740)	645.57a±8.16 (2191)	590.64b±9.40 (1652)	***
ADG from 6- to 9-month (g)	767.89a±10.23 (1708)	673.72b±9.13 (2141)	791.16a±10.45 (1636)	***
ADG from 9- to 12-month (g)	881.19b±13.83 (1168)	942.79a±10.86 (1896)	850.93b±11.78 (1610)	***

Figures in the parentheses indicate the number of observation; Mean with different superscripts within same row differ significantly (p<0.05).**(p<0.01),***(p<0.001) and NS, non-significant

to reduced performance. Season of birth had no significant effect on the body weight at 12-month of age. This result was in accordance with Bahashwan et al. (2015) who found non-significant effect of season of birth on weaning weight. A contrast result were found by Sagar et al. (2017) in Vrindabani cattle, Moaeen-ud Din and Bilal (2017) in local and crossbred in Pakistan, Szabó et al. (2006) in seven beef breed in Hungary, Khan et al. (2019) in beef crossbred calves for yearling weight in Pakistan who found season of birth significantly affect twelve month body weight of calves.

Weight at 24-month of calves was not significantly affected by season of birth. This result is also consonance with Manoj et al. (2014) who found the season of birth had no significant effect on body weights at twenty four month age in Sahiwal cattle. Contradictory result was found by Ndofor-Foleng et al. (2011) in Gudali and Wakwa cattle in South Africa where season of birth did not significantly effects 24-month body weight. Summer born calves weighed 549.17±5.60 kg at 24-month of age whereas winter born calves were 546.29±7.41 kg and rainy season born calves were 533.14±6.51 kg at the same stage. Season had significant (p<0.001) effect on ADG from birth to 3-month and ADG from 3- to 6-month of age (Table 2). Oliveira et al. (1982) found that season of birth had no significant (p<0.05) influence on pre-weaning growth rate of in Canchim cattle in Brazil. ADG from birth to 3-month was highest (415.14±4.16 g) in winter born calves and highest (645.57±8.16 g) ADG from 3- to 6-month was in summer born calves.

ADG from 6- to 9-month and ADG from 9- to 12-month of age were significantly (p<0.001) affected by season of birth (Table 2). Rainy season born calves showed highest of 791.16±10.45 g ADG from 6- to 9-month and summer born calves showed highest of 942.79±10.86 g for ADG from 9-to 12-month of age. Manzi et al. (2012) found significant (p<0.05) effect of season of birth on weaning to 18-month average daily gain in crossbred cattle in Rowanda and supports this study. Significant seasonal variations in present study might be mainly due to variations in feed and fodder availability as well as disease incidence in different seasons.

3.3 Agro-ecological zone effect

The effects of agro-ecological zone are presented in Table 3. Agro-ecological zone had highly significant effect (p<0.001) on birth weight and body weight at one, three, six, nine, twelve and 24-month of age. Eastern hilly area born claves had highest (25.76±0.21) birth weight while those calves born in barind steppe had lowest birth weight (19.51±0.38) and two other zone born calves birth weight were intermediary. Mpofu

Table 3. Effect of agro-ecological zone on body weight and average daily gain of Brahman crossbred cattle

Traits	Flood plains	S. Coastal belts	Barind steppe	E. Hilly area	Sig. level
Birth weight (kg)	22.85b±0.08 (4102)	25.46a± 0.20 (722)	19.51c±0.38 (205)	25.76a±0.21 (633)	***
Weight at 1-month (kg)	36.88b±0.14 (4078)	39.38a±0.34 (719)	36.91b±0.63 (205)	40.04a±0.36 (632)	***
Weight at 3-month (kg)	57.98b±0.25 (4056)	60.73a±0.60 (713)	56.63b±1.11 (205)	61.15a±0.64 (627)	***
Weight at 6-month (kg)	113.36b±0.66 (4045)	118.82ab±1.57 (710)	113.37b±2.92 (205)	123.96a±1.68 (624)	***
Weight at 9-month (kg)	177.83b±1.10 (4020)	188.04a± 2.63 (706)	178.33b±4.91 (203)	195.34a±2.81 (619)	***
Weight at 12-month (kg)	254.32b±1.43 (3376)	271.51a±3.42 (593)	250.32b± 6.56 (161)	273.26a±3.47 (574)	***
Weight at 24-month (kg)	522.16b±4.32 (1649)	599.84a±9.90 (314)	460.11c±24.09 (53)	604.24a±9.32 (354)	***
ADG from birth to 3-month (g)	392.99a±2.73 (4036)	399.87a±6.56 (701)	412.41a±12.13 (205)	397.75a±6.96 (621)	NS
ADG from 3- to 6- month (g)	615.38b±6.0 1 (4045)	646.91b±14.35 (709)	630.46b±26.68 (205)	696.92a±15.29 (624)	***
ADG from 6- to 9-month (g)	722.93b±6.74 (3973)	775.77ab±16.08 (698)	736.18b±30.13 (199)	793.75a±17.14 (615)	***
ADG from 9- to 12- month (g)	891.71a±8.18 (3355)	940.82a±19.56 (588)	895.07a±37.49 (160)	873.30a±19.84 (571)	NS

Figures in the parentheses indicate the number of observation; Mean with different superscripts within same row differ significantly (p<0.05).**(p<0.01),***(p<0.001) and NS, non-significant; S. and E. degenate Southern and Easter, respectively.

et al. (2017) found Agro-ecological zone was a significant (p<0.05) source of variation in birth weight for Nguni calves in South Africa. Burfening et al. (1982) in USA and Papry et al. (2020) in Bangladesh also found that location had a significant effect on birth weight.

In case of 1-month body weight, calves those born in eastern hilly area had highest (40.04±0.36 kg) and calves born in flood plains had lowest (36.88±0.14 kg) body weight. Body weight of calves at 1-month from southern coastal belts was close to eastern hilly area and body weight of calves from barind steppe was close to flood plains. Eastern hilly area had highest (61.15±0.64 kg) body weight for 3-month followed by southern coastal belts (60.73±0.60 kg), flood pains (57.98±0.25 kg) and barind steppe (56.63±1.11 kg), respectively. The highest 6-month body weight of 123.96±1.68 kg was found in eastern hilly areas and almost similar body weight of 113.37±2.92 kg and 113.36±0.66 kg were found in flood plains and barind steppe, respectively. Shejuty et al. (2020) also found that area significantly (p<0.01) affected the 3-month and 6-month body weight of grade-2 Brahman graded calves. For 9-month aged calves raised in eastern hilly areas were best performer with highest body weight of 195.34±2.81 kg which followed by southern coastal belts (188.04±2.63 kg), barind steppe (178.33±4.91 kg) and flood plains (177.83±1.10 kg), respectively. In case of 12-month and 24-month body weight highest body weight (273.26±3.47 kg and 604.24±9.32 kg) were found in eastern hilly areas and lowest body weight (250.32± 6.56 kg and 460.11±24.09 kg) in barind steppe, respectively. While second highest body weight (271.51±3.42 kg and 599.84±9.90 kg) were found in southern coastal belts of Bangladesh for 12-month and 24-month of age, respectively.

Agro-ecological zone effect was not significant on ADG from birth to 3-month and ADG from 9- to 12-month while ADG from 3- to 6-month and ADG from 6- to 9-month were significantly (p<0.001) affected with agro-ecological zone (Table 3). The preweaning average daily gain of Nguni calves in South Africa was significantly affected by agro-ecological zone (Mpofu et al., 2017). Highest ADG from birth to 3-month (412.41±12.13 g) was found in barind steppe and lowest (392.99±2.73 g) was found in flood plains while crossbred cattle reared in southern coastal belts (399.87±6.56 g) and eastern hilly areas (397.75±6.967 g) were intermediary. Brahman crossbred cattle reared in eastern hilly area obtained highest (696.92±15.29 g) ADG from 3- to 6-month followed by southern coastal belts (646.91±14.35 g), barind steppe (630.46±26.68 g) and flood plains

(615.38±6.0 g), respectively. Eastern hilly area raised cattle showed highest (793.75±17.14 g) ADG from 6- to 9-month and lowest (722.93±6.74 g) for flood plains. Southern coastal reared crossbred cattle showed highest (940.82±19.56 g) ADG from 9- to 12-month and lowest (873.30±19.84 g) were found in Eastern Hilly area.

4 Conclusions

This study revealed that most of considered traits of growth performance of Brahman crossbred (50%) cattle were influenced by non-genetic factors such as sex, season and agro-ecological zone. Effect of season and agro-ecological zone suggests that planning on season and agro-ecological zone based decision may be considered for genetic evaluation and management decisions to improve beef production under Bangladeshi conditions.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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