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Effects of genetic and non-genetic factors on growth traits of high yielding dairy seed calves and genetic parameter estimates

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A B S T R A C T

The study was conducted to know the effects of several genetic and non-genetic factors like season, sex, year of birth, genotype of calves and milk yield of dam associated with growth performance of crossbred calves. Data were collected from registered farmers during the period of May, 2011 to April, 2013. Birth weight, three-month weight, six-month weight, weaning weight and heritability estimates of those growth performances were performed using a total of 82 registered calves which had pedigree information having the genotypes of 25% Local - 75% Friesian and 37.5% Local - 62.5% Friesian. The average birth, three-month, six-month and weaning weight of calves were 29.33, 64.32, 99.06 and 151.77 kg, respectively. The effects of non-genetic factors like sex, season of birth and genotype were non-significant (P>0.05) for the traits birth weight, three-month, six-month, weaning weight and average daily gain of calves. However, year of birth was found significant on birth (P<0.01), three-month and six-month (P<0.05) weight; but non-significant (P>0.05) on weaning weight and average daily gain of calves. The heritability estimates were 0.40±0.09, 0.46±0.08, 0.39±0.12 and 0.50±0.12 for the traits birth weight, three-month weight, six-month weight and weaning weight, respectively. Estimated heritabilities of live weights suggest that individual own performance basis selection would be more effective for increasing growth and therefore, should be paid more emphasis in cattle improvement program.

Keywords

Genetic, Growth Traits, Heritability, Non-genetic, Seed Calves

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INTRODUCTION

The livestock sector is highly dynamic globally. In developing countries, it is evolving in response to continuously growing demand for livestock products. Livestock in Bangladesh are important in many ways; as employment generation, store of wealth; form of insurance, recycle of waste products and residues from crops and agro-industries, improvement of the structure and fertility of soil and in controlling pests. The cattle population is 23.34 million (BER, 2013). The demand of milk and meat for an individual is 250 mL/day and 120 gm/day, respectively, whereas per capita availability is only 91.03 mL/day and 65.03 gm/day (BER, 2013). So, it is depicted that there is a remarkable shortage of livestock products in Bangladesh for human consumption. When livestock performance is considered, it depends mainly on the genetic potential of the animal. On the other hand, optimum nutrition, good management and disease control etc. permit full expression of this genetic potential. So, improvement in genetic capabilities as well as environment could only be the suitable way for animal improvement. Knowledge on selection and breeding program and management practices is very essential to increase the productivity of cattle. For any improvement program, genetic parameters like heritability, repeatability and genetic correlation are inevitably important in all the situations (Bhuiyan, 1999).

In a breeding scheme, genetic improvement through selection mainly depends on the perfection of identifying genetically superior animals. Moreover, breeding for better growth performance is an important

part of selection programs. A number of non-genetic factors (sex of born calves, season, year of birth etc.) affect growth traits and directly obscures in the expression of actual genetic worth (Demeke et al., 2003). Several previous works reported that growth performance can be influenced by season of birth, age, parity, year and fertility of the dam, breed and sex of the calf (Mohamed, 2004). Apart from the genotype effects; sex, year of birth and parity were the main non genetic factors that influenced growth and daily weight gain traits until one year of age in Horro (Zebu) and their crosses with Holstein Friesian and Jersey cattle in Ethiopia (Abera et al., 2012). Therefore, the actual performance of animals could be adjusted by removing non-genetic sources of variation from the performance data to get accurate estimates of genetic parameters and breeding values. In addition, the non-genetic factors (fixed effects) which have influence on the accuracy of predicted breeding values could be controlled either experimentally or eliminated statistically.

Knowledge of genetic parameters for economic traits is essential in planning breeding strategies under specific production environment, genetic evaluation of animals and for prediction of response to selection. Thus estimation of heritability for desired traits and further calculation of breeding value using heritability (h^2) for ranking of animals is an important step to speed up selection progress (Rege et al., 1992). Heritability is an extremely important population genetic parameter that is used both for the estimation of breeding values for quantitative characteristics and for predicting the response expected from various selection schemes (Van Vleck et al., 1987; Prayaga and Henshall, 2005). Therefore, the present study was carried out under a farmer-participatory seed bull production system to know the effects of different non genetic and genetic parameters on growth performance traits of high yielding dairy seed calves and heritability estimates of growth traits.

MATERIALS AND METHODS

Place of study: The experiment was conducted in peri-urban farmers' herds of Mymensingh district within 6-8 kilometers around the Artificial Insemination Centre, Bangladesh Agricultural University (BAU) which included one upazila (Mymensingh Sadar), nine unions and a total of 61 villages.

Source of experimental data and data recording system: The research was conducted under farmers' participatory approach where no particular intervention was given to experimental animals. The data were collected on a periodic basic from the farmers' premises. However, institutional animal ethics guidelines were followed during collection of biological data from the animals. The data were collected from farmers' herds whose technical support was provided by the project entitled "Production of HYV vis-à-vis Indigenous Seed Bulls to Support Smallholder Dairying in Bangladesh", Department of Animal Breeding and Genetics, BAU, Mymensingh. The experimental animals were categorized into two groups based on their inheritance level which were 25% Local – 75% Friesian and 37.5% Local – 62.5% Friesian. A total of 82 calves were taken into consideration for analysis of growth performance. Genetic analysis of growth performance traits was performed utilizing 82 calves' data those had pedigree information and their live weights at different ages. Effects of several non-genetic and genetics factors like sex, season of birth, year of birth, genotype of calves and dam's daily milk yield were considered. Seasons were categorized as summer (from March to June), rainy (from July to October) and winter (from November to February). Herd book where detailed information (e.g. animal ID No., date of birth, sire, dam, date of maturity, production performance, reproduction efficiency, disease incidence, vaccination schedule etc.) of an animal was being recorded in written form. Herd books were opened for every registered cows / heifers in the project area. Alongside, all other records demanded by the Herd book such as pedigree, date of birth, weight at birth, age and weight at weaning and maturity, scrotal circumference, testis size, disease incidence were being recorded in a periodic visit of farmer's home by animal recorder who maintained data with the assistance of animal owner and finally, the data were stored in computers for subsequent analysis.

Traits under study: The considered traits of this study were birth weight (BW), three-month weight (3MW), six-month weight (6MW), weaning weight (WW) and average daily gain (ADG) from birth to six-month of age.

Statistical analyses: Descriptive statistic analyses were performed using SPSS ver. 16.0 (2007) computer software to estimate mean along with standard error. In addition, VCE 4.2.5 (Groeneveld, 1998) computer program was used to estimate heritability (h^2). A single trait animal model with REML procedure was employed in all analysis where sex of calf, season of birth, genotype of calf and year of birth were

considered as fixed factors and only additive genetic effect of animals was used as random factor.

The statistical model used was as follows:

$$Y = Xb + Za + Wc + e$$

Where,

Y= Vector of observation

X, Z and W = Matrices associated with levels of b, a, c with Y

b = Fixed effects of calf sex, dam parity, year of birth and season of birth

a = Vector of breeding value.

c = Vector of permanent environmental effect

e = Residual effects

RESULTS AND DISCUSSION

Birth weight

Table 1 represented birth weight of calves according to their sex, birth season, genotype and year of birth. The mean birth weight of calves in this study was 29.33 kg. The estimated birth weight was found lower than that reported by Chen et al. (2012) who found birth weight of Piedmontese and Nanyang as 36.39 kg. The birth weight of this study was found higher than that previously reported by Afroz et al. (2011), Rabeya et al. (2009), Kabir and Islam (2009), Gaur et al. (2003) and Singh et al. (1997) which were 14.7 kg for Red Chittagong (RCC), 15.74 kg for RCC, 24.14 kg for Local and 27.07 kg for FN×HR, respectively. The mean weight of calves at birth for male and female were 29.89 and 28.56 kg, respectively (**Table 1**). Birth weight had a tendency to be higher in males compared to females with non-significant (P>0.05) differences between sexes. These results are in agreement with the findings of Bakir et al. (2004) and Messine et al. (2007). Calf sex had significant effects on birth weights of local and crossbred calves were reported by Afroz et al. (2011), Habib et al. (2009), Kabir and Islam (2009) and Rabeya et al. (2009) which disagree with the present findings.

The mean birth weights at summer, rainy and winter season born calves were 28.67, 28.65 and 30.58 kg, respectively. The effects of season of birth on birth weight of calves were found non-significant (P>0.05). This result is similar to the findings of Rabeya et al. (2009) with Red Chittagong cattle calves, Matin et al. (1993) with Sahiwal, Friesian and their crosses. In this study, higher birth weight was found in winter born calves followed by summer and rainy season. This result contradicts with the findings of Matin et al. (1993). They reported that summer born calves had higher birth weight compared to rainy and winter born calves. Bazzi (2011) reported that effects of season on birth weight of local and crossbred calves were significant which disagree with present investigation. The highest birth weight in winter season may be due to abundant availability of green fodder during this season which increases nutritional status of cows. The mean birth weights of Friesian-Local (75%HF) and Friesian-Local (62.50%HF) upgraded calves were 29.54 and 29.05 kg, respectively. Genotype had non-significant (P>0.05) effect on birth weight of calves which is supported by the studies of Manzi (2011) for Brown Swiss, Friesian, Jersey and Sahiwal and Said et al. (2003) for *Bos indicus* Boran. But Nweze et al. (2012) and Kabir and Islam (2009) reported significant effects of genotype on birth weight of local and crossbred calves which does not support by the present study. In addition, the mean birth weight of 2011, 2012 and 2013 born calves were 33.89, 29.31 and 26.66 kg, respectively. Birth weight of calves of this study varied significantly (P<0.01) in different years. Similar findings were reported by Matin et al. (1993) where they observed significant effects (P<0.05) of year of birth on birth weight. However, Rabeya et al. (2009) reported non-significant effects (P>0.05) on year of birth in Red Chittagong calves which is in disagreement with the present study.

Body weight at different ages and average daily gain

The estimated mean ± SE for three-month, six-month and weaning weight, and average daily gain of calves are presented in **Table 1, 2** and **3,** respectively. The average birth weights at three-month, six-month of age and at weaning weight of registered calves' were 64.32, 99.06 and 151.77 kg, respectively. The estimated three-month weight was lower than the findings of Malau-Aduli et al. (1993) who reported that three-month weight of Friesian and Bunaii crossbred was 72.4 kg. In contrast, three-month weight of this study was found higher than previous investigation by Afroz et al. (2011), Pal et al. (2004) and Gaur et al. (2003) which were 29.26 kg for RCC, 59.38 kg for Karan Fries and 54.25 kg for crossbred respectively. Chen et al. (2012) reported six month live weight of Piedmontese cattle as 194 kg which was higher than the present study, despite the six-month weight was found higher than the previous research findings by Afroz et al. (2011) and Gaur et al. (2003) which were 42.60 kg for RCC and 85.8 kg for crossbred respectively. The

Table 1. Birth and three month weight (kg) of calves according to sex, season of birth, genotype, year of birth and dam's daily milk yield*

Parameter		Birth weight		3-month weight	
		Mean ± SE	Significance level	Mean ± SE	Significance level
Sex	Male	29.89±1.16 (48)	NS	64.25±2.88 (41)	NS
	Female	28.56±0.91 (34)		64.44±3.55 (27)	
	Total	29.33±0.77 (82)		64.32±2.22 (68)	
Season of birth	Summer	28.67±1.00 (28)	NS	61.37±3.80 (22)	NS
	Rainy	28.65±1.06 (25)		62.33±4.32 (19)	
	Winter	30.58±1.74 (29)		68.13±3.53 (27)	
Genotype	75% HF	29.54±1.18 (48)	NS	62.63±2.37 (43)	NS
	62.50% HF	29.05±0.86 (34)		67.24±4.48 (25)	
Year of birth	2011	33.89^{a}±3.05 (15)	**	75.11^{a}±5.85 (15)	*
	2012	29.31^{b}±0.87 (42)		61.69^{b}±2.67 (39)	
	2013	26.66^{b}±0.62 (25)		60.09^{b}±3.69 (14)	
Dam's daily milk yield(l/d)	<10			53.34^{b}±3.19 (20)	**
	11-15			70.22^{a}±3.25 (36)	
	>15			64.95^{a}±3.51 (12)	

*Column wise means with uncommon superscripts differ significantly. NS = non-significant (p>0.05), (*) = significant (p<0.05), (**) = highly significant (p<0.01), values in the parenthesis indicates the number of observation.

Table 2. Six-month and weaning weight (kg) of calves according to sex, season of birth, genotype, year of birth and dam's daily milk yield*

Parameter		Birth weight		3-month weight	
		Mean ± SE	Significance level	Mean ± SE	Significance level
Sex	Male	97.15±5.29 (33)	NS	150.62±14.48 (12)	NS
	Female	102.20±6.47 (20)		154.52±33.30 (5)	
	Total	99.06±4.07 (53)		151.77±13.55 (17)	
Season of birth	Summer	95.07±8.69 (18)	NS	114.78±18.79 (5)	NS
	Rainy	96.98±5.14 (18)		149.75±26.32 (4)	
	Winter	105.49± 7.03 (17)		175.89±20.29 (8)	
Genotype	75% HF	93.89±4.66 (31)	NS	155.86±20.70 (10)	NS
	62.50% HF	106.35±7.14 (22)		145.93±16.19 (7)	
Year of birth	2011	114.61±10.39 (14)	*	175.01±19.17 (9)	NS
	2012	93.48±3.81 (39)		125.62±15.33 (8)	
Dam's daily milk yield(l/d)	<10	82.38^{b}±4.60 (18)	**	96.89^{b}±10.89 (5)	*
	11-15	110.12^{a}±6.28 (27)		174.07^{a}±15.17 (9)	
	>15	99.27^{ab}± 7.57 (08)		176.33^{a}±40.13 (3)	

*Column wise means with uncommon superscripts differ significantly. NS = non-significant (p>0.05), (*) = significant (p<0.05), (**) = highly significant (p<0.01), values in the parenthesis indicates the number of observation.

weaning weight of this study was lower than the findings of Chen et al. (2012) in Piedmontese and Nanyang as 293 kg; Neser et al. (2012) in Brangus as 226 kg and El-Saied et al. (2006) in Charolais as 278.21 kg, respectively. Afroz et al. (2011) and Gaur et al. (2003) reported that weaning weights of RCC and crossbred cattle were 54.99 and 136.85 kg, respectively which are lower than this present study. Breed/genotype difference might be the major contributing factor for this variation.

The average body weight of male and female calves at three-month, six-month and weaning weight of calves were 64.25, 97.15, 150.62 kg and 64.44, 102.20, 154.52 kg, respectively. The average daily gain (birth to 6-month) of male and female calves was 366 and 398.85 gm/day, respectively. In this study, calf sex had non-significant effect on three-month, six-month, and weaning weight of calves (P>0.05) which is supported by the study of Janus and Antoszek (1999) and Rabeya et al. (2009). Likewise, calf sex had also non-significant effect on average daily gain (birth to six-month) of calves (P>0.05). In the study area, farmers usually provide

Table 3. Average daily gain (gm/day) of calves according to sex, season of birth, genotype, year of birth and dam's daily milk yield.

Parameter		No of observation	Mean ± SE	Significance level
Sex	Male	33	366.00±27.62	NS
	Female	20	398.85±31.85	
Season of birth	Summer	18	362.07±45.24	NS
	Rainy	18	375.38±26.58	
	Winter	17	398.88±35.87	
Genotype	75% HF	31	345.70±22.87	NS
	62.50% HF	22	424.47±37.17	
Year of birth	2011	14	445.36±53.40	NS
	2012	39	354.36±20.12	
Dam's daily milk yield(lit/day)	<10	10	382.07±36.82	NS
	11-15	40	386.45±25.74	
	>15	3	258.74±24.13	

NS = not significant (p>0.05)

Table 4. Variance components and heritability estimates for birth, three-month, six-month and weaning weight.

Trait	N	(Co)variance matrices		h^2± SE
		Additive genetic	Common environment	
BWT	82	22.82	12.09	0.40±0.09
3MWT	68	163.74	26.83	0.46±0.08
6MWT	53	406.92	240.06	0.39±0.12
WWT	17	1659.48	270.164	0.50±0.12

inadequate balanced feed and milk to their calves, they give priority to female calves compared to males. For this reason weight of males might be lower than females. However, after six month body weight of males is higher than female and it may be due to sample effect.

The mean weight of calves at three-month, six-month and weaning period born in summer, rainy and winter seasons were 61.37, 95.07 and 114.78 kg; 62.33, 96.98, and 149.75 kg, and 68.13, 105.49 and 175.89 kg, respectively. The average daily gain of calves born in these three different seasons was 362.07, 375.38 and 398.88 gm/day, respectively. Season of birth had non-significant (P>0.05) effect on three-month, six-month, weaning weight and average daily gain of calves. Season of birth did not affect significantly (P>0.05) on 6-month weight of crossbred calves which conforms with the findings of Pugashetti et al. (2009), while significant effect of season on calves were reported by Rabeya et al. (2009) for three-month (P<0.001), six-month(P<0.01), weaning weight (P<0.01) and Manzi (2011) for weaning weight (P<0.001).

The mean three-month, six-month and weaning weight of Friesian-Local (75%HF) and Friesian-Local (62.50%HF) calves were 62.63, 93.89 and 155.86 kg and 67.24, 106.35 and 145.93 kg, respectively. The average daily gain of Friesian-Local (75% HF) and Friesian-Local (62.50% HF) calves were 345.70 and 424.47 gm/day, respectively. Non-significant effect on growth performance and average daily gain of calves was found for the parameter genotype of calves. This findings is consistent with the previous studies of Mendonca et al. (2003) and Drennan and McGee (2004) for weaning weight. These results are indicating that environment has effect on genotypes and 62.50%HF is more suitable than 75%HF in Bangladeshi environment particularly for 6 month body weight.

The average three-month, six-month and weaning weight of calves born in 2011 and 2012 were 75.11, 114.61, 175.01 kg and 61.69, 93.48, 125.62 kg, respectively. The average daily gain of calves born in 2011 and 2012 were 445.36 and 354.36 gm/day, respectively. The mean three-month of calves born in 2013 were 60.09 kg. The effect of year of birth found significant on three-month (P<0.05) and six-month (P<0.05) body weight but non-significant (P>0.05) results were observed for weaning weight and average daily gain parameters. This result conforms with the findings of Rabeya et al. (2009) for three-month (P<0.01) but Manzi (2011) for weaning weight which is contradicted with the present findings. However, these

variations might be due to no. of samples investigated or environmental fluctuation between years.

The mean dam's daily milk yield (L/day) of <10, 11-15 and >15 categorized and their calves weight at three-month, six-month and weaning stage were 53.34, 82.38, and 96.89 kg; 70.22, 110.12 and 174.07 kg, and 64.95, 99.27 and 176.33 kg, respectively. The average daily gains of calves (birth to 6-month) as per dam's daily milk yield were 382.07, 386.45 and 258.74 gm/day, respectively. The effect of dam's daily milk yield was found significant on three-month (P<0.01), six-month (P<0.01) and weaning weight (P<0.05) and non-significant on average daily gain (birth to six-month) of calves (P>0.05).The variation in body weights of calves of different levels of milk producing cows may be due to the management and calves' feeding management in respect of time and amount of milk allocated for calves.

Heritability estimates

Table 4 represents heritability estimates of birth weight to be 0.40±0.09. Exactly similar results were obtained by Prayaga and Henshall (2005), Westerhuizen et al. (1994) and Rege et al. (1992) where they reported h^2 of birth weight as 0.41, 0.409 and 0.40, respectively. This result also supported by the findings of Chen et al. (2012) and Martinez et al. (2002) as 0.38±0.01 and 0.38, respectively. As presented by Orenge et al. (2009) and El-Saied et al. (2006), h^2 estimates of birth weight were 0.36 and 0.37±0.45, respectively which are lower than the present investigation. A number of researches have performed heritability estimates of birth weight considering different cattle breeds in various corner of the world. Some of these are conducted by Afroz et al. (2011), Wasike et al. (2009), Rabeya et al. (2009), Plasse et al. (2002) and Bhuiyan (1999). Estimated h^2 value of these works ranged between 0.09 and 0.57 for growth parameters traits which also support this study. The resultant medium heritability estimates of birth weight suggest that individual selection based on their own performance would be more effective for increased gain in birth weight and therefore, should be paid more attention in cattle improvement program. Besides, small number of observations might be one of the attributing factors for higher h^2 estimates of birth weight or may be large differences between maximum and minimum range in birth weight among the calves considered.

Heritability estimates of three-month, six-month and weaning weight of this study were 0.46±0.08, 0.39±0.12 and 0.50±0.12, respectively (**Table 4**). The increased error value might be due to decreased number of observations. The obtained results of present study are more or less similar to the findings of Afroz et al. (2011) and Rabeya et al. (2009) for three-month as 0.49±0.06 and 0.468; Afroz et al. (2011) and Rabeya et al. (2009) for six-month as 0.50±0.08 and 0.475; Afroz et al. (2011), Rabeya et al. (2009) and El-Saied et al. (2006) as 0.47±0.06, 0.467 and 0.36, respectively for weaning weight. Moderate heritability of 3-month, 6-month and weaning weight indicated that these traits are not much influenced by environment. So, there is scope for improvement of these traits by minimizing the environmental variation.

CONCLUSION

It could be pointed out that both genetic and non-genetic factors like genotype, sex and season of birth had non-significant effects on growth traits in crossbred dairy calves. However, year of birth and dams' milk yield capacity played significant role for the considered traits. In addition, most of the traits possessed medium heritability value which reflected pivotal roles of additive gene action. Estimated heritability values for body weight related traits suggest individual own performance based selection would be more effective to achieve increased gain in growth traits.

COMPETING INTERESTS

The authors do not declare any competing interests.

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