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Genotype and environmental interaction in growth and milk yield traits of indigenous Red Chittagong cattle

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ABSTRACT

The present study was conducted to reveal the G×E interaction in growth and milk yield traits of indigenous Red Chittagong cattle reared in two production environments. Traits included: birth weight (BW), weaning weight (WW), average daily gain (ADG), daily milk yield (DMY), lactation length (LL) and lactation yield (LY). Data accumulated on a total of 161 animals during 2005 to 2012 in growth traits and 76 animals during 2005 to 2008 in milk yield traits. The heritability of BW, WW and ADG were 0.47±0.04, 0.49±0.17, 0.49±0.16 respectively and the heritability of DMY, LL, LY were 0.47± 0.07, 0.47±0.06 and 0.47±0.08, respectively. The effect of genotype x environment interaction was non-significant (p>0.05) on BW, WW and ADG whereas its effect was highly significant (p<0.001)on DMY, LL and LY. Correlations (genetic) between the breeding values of BW, WW and ADG in two production environment were 0.19, 0.13 and 0.11, respectively and correlations (genetic) between breeding values of DMY, LL and LY were 0.07, 0.18 and -0.01, respectively. The said genetic correlation values represented the degree of genotype by environment interaction arising on the RCC in the said two production environments.Traits with positive genetic correlation values indicate their acceptability (no difference) where as traits with negative correlation values indicate that RCC parents should be selected and used separately in two production environments.

Key Words: *Red Chittagong Cattle, Growth, Milk yield and G x E interaction*

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I. Introduction

Bangladesh is an agricultural based country in which livestock contributed 2.67% to the GDP (Bangladesh Economic Review, 2014-2015). The need of per capita meat and milk is 120 g and 250 ml per day, respectively, whereas per capita availability is only 65.03 g and 91.03 ml per day (MoFL, 2013). This illustrates how urgent is the need to increase the production of milk and meat. More than 80% of rural people keep 90% local cattle in Bangladesh and according to Bag (2010) among the different types of local cattle, the RCC is one of the most potential and promising type of Farm Animal Genetic Resource (FAnGR) that are more adaptable in our agro-climate condition for improvement of

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meat and milk production. But these indigenous cattle are not yet recognized as a breed but a potential type or variety Mason (1988). The productive and reproductive performances of RCC were better than other non-descript indigenous cattle available in Bangladesh on the basis of high temperature, extreme humidity, poor-nutrient soil, distinct phenotype and small size (Habib *et al*, 2003). Its fertility is also good as they give birth to calves each and every year which is considered as a unique character of RCC (Habib *et al.*, 2003). To fulfill requirement of meat and milk, a well adapted genotype is necessary. According to Falconer and Mackay (1996), genotype by environment interaction means that the best genotype in one environment is not necessarily the best in another environment. For better selection and production performance, it is very important to know the degree of interaction between genotype and environment (G×E) otherwise different productive and reproductive problems such as late puberty, lower conception rate, low milk yield, late pregnancy, anestrous, increased calf mortality, disease etc arises. Data on the degree of G×E interaction of RCC in different feeding and management environmentsdoes not exist. Therefore, this study aims to estimate the GxE interaction in RCC considering on-farm and on-station as two production environments.

II. Materials and Methods

The study was conducted at the Department of Animal Breeding and Genetics, Bangladesh Agricultural University (BAU), Mymensingh-2202. Data used in this study were collected from retrospective RCC Database maintained on two herds, Herd 1: data for growth performance observed on 76 calves and milk production observed on 22 cows were collected from the herd book records maintained at the Nucleus Herd at BAU, Mymensingh during 2005 to 2008**,** Herd 2: data for growth performance observed on 85 calves and data for milk production observed on 54 cows were collected from rural community herdsat Char Jailkhana, Mymensingh Sadar, Mymensingh.

Statistical analysis for estimation of G×E

Two approaches were used for estimating G x E viz.

SPSS 16.0 2007 computer program was used to estimate G×E interaction.In this study, factorial analysis of variance (Mathur and Horst, 1994) using a linear model, with an environmental factor, a genetic factor and interaction effect between the two factors, was fitted with genetic and interaction effects as random effects**.**

Heritability (h^2) was estimated by using VCE¬ 4.2.5 (Groeneveld, 1998) computer software. PEST-13.4.10 (Groeneveld, 1998) program was used to estimate breeding values of individual growth and milk production traits using single trait animal models. Then SAS (2003) computer package program was used to estimate correlations (genetic) of breeding values(obtained from the aforesaid mixed model analysis PEST program) between animals of two herds for the same trait.

III. Results and Discussion

Effect of various factors on growth traits of RCC calves

The significant effect ($p<0.05$) of sexon growth traits agree with the results of Rabeya *et al.* (2009), who found 15.74±0.32 kg birth weight for RCC males and 13.89±0.34 kg for RCC females. Habib *et al.* (2009) and Alam *et al.* (2007) reported that 15.79±0.29 kg birth weight for male and 13.96±0.30 kg for female and 15.67 kg for males and 13.67 kg for females of RCC, respectively, season that is consistent with Khatun (2012) and Meyer (1997) on birth weight and non-significant effect of parity, year, herd and sire on birth weight which is similar to the results of Habib *et al.* (2010) and Munim *et al.* (2006). The effect of year and herd were highly significant (p<0.001) on weaning weight while their non-significant effect on weaning weight of RC calves was reported by Munim *et al.* (2006) and Rabeya *et al.* (2009) which are in disagreement with the present and the variations between results, between herds might be due to variation in feeding, management etc. The effect of sex, parity, season and sire were non-significant (p>0.05) on weaning weight that was more or less similar to Rabeya *et al.* (2009), who reported that 57 kg weaning weight for male RC calves and 51.66 kg for female RC calves and Afroz *et al.* (2011) also reported similar results. It was also found that there were a highly significant effect ($p<0.001$) of year and herd on average daily gain. Khatun (2012) represented that herd had significant ($p<0.05$) influence on average daily gain which agree with the present study. There were

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non-significant effects of sex, parity, season and sire on average daily gain. Sex had significant (p<0.05) effect on average daily gainin Brahman cross was found by Khatun (2012), male calves (547.42±193.7) weighed heavier than in female calves (470.34±184.52). Effect of various factors on growth traits of RCC calves was shown in Table 01.

Table 01. Effect of various factors on growth traits of RCC calves

Factor		N	BWT (kg) Mean ± SE	P Val.	Lev. Of Sig.	WWT (kg) Mean ± SE	P Val.	Lev. Of Sig.	ADG (g/d) Mean ± SE	P val.	Lev. Of sig.
Sex	Male	83	15.26±0.26	.040	*	49.89±1.87	.760	NS	128.28±6.68	.986	NS
	Female	78	14.55±0.27			49.12±1.94			128.04±6.95		
Parity	1st	33	14.19±0.37	.605	NS	45.39±2.65			115.56±9.44	.434	NS
	2nd	28	14.82±0.39			50.24±2.87	.399	NS	131.19±10.25		
	3rd	27	14.89±0.41			50.37±2.98			131.42±10.63		
	4th	29	15.02±0.39			52.26±2.83			137.93±10.12		
	5th	18	15.33±0.50			51.39±3.63			133.61±12.98		
	6th	13	14.94±0.63			53.18±4.56			141.61±16.27		
	7^{th+}	13	15.16±0.59			43.73±4.28			105.82±15.26		
Season	Summer	48	15.24^{a}±0.34	.016	*	48.91±2.42	.073	NS	124.72±8.64	.131	NS
	Rainy	50	14.17^{b}±0.33			46.36±2.39			119.22±8.54		
	Winter	63	15.31^{a}±0.29			53.26±2.16			140.56±7.71		
Year	2005	13	16.08±1.35	.594	NS	37.57^{c}±3.35	.000	***	88.75^{c}±12.15	.000	***
	2006	24	16.62±1.22			59.65^{a}±3.26			164.51^{a}±11.20		
	2007	24	15.18±1.19			59.69^{a}±2.91			165.55^{a}±10.43		
	2008	14	15.06±1.20			47.14^{bc}±4.89			121.16^{bc}±17.5		
	2009	20	13.93±1.16			54.84^{ab}±5.42			149.21^{ab}±19.9		
	2010	26	14.72±1.16			46.31^{bc}±2.58			116.03^{bc}±9.17		
	2011	32	14.11±1.10			46.19^{bc}±2.29			117.82^{bc}±8.39		
	2012	08	13.53±1.32			45.38^{bc}±2.51			115.28^{bc}±8.89		
Herd	Nucleus	76	13.76±1.03	.199	NS	54.62±2.27	.000	***	147.83±8.14	.000	***
	Community	85	16.05±1.09			47.09±1.39			120.35±5.01		
Sire	Unknown	36	14.15±0.47	.119	NS	49.00±3.39	.455	NS	129.10±12.08	.387	NS
	Tag no. 41	11	16.79±0.79			45.24±5.73			105.37±20.44		
	Tag no. 45	15	15.68±0.72			56.37±5.21			150.72±18.59		
	Tag no. 52	21	14.89±0.61			46.72±4.46			117.88±15.89		
	Tag no. 63	38	13.67±0.43			45.33±3.14			117.23±11.19		
	Tag no. 92	17	14.34±0.62			43.37±4.45			107.54±15.88		
	Tag no. 136	10	13.99±0.78			55.03±5.63			151.96±20.08		
	Tag no. 141	13	15.72±0.72			55.01±5.19			145.49±18.53		

N= No. of observation, BWT= Birth weight, WWT= Weaning weight, ADG= Average daily gain, SE= Standard error, means with uncommon superscripts along the column within a factor differ significantly (p<0.05). Unknown sires are those who served the dams naturally.

Effect of various factors on milk yield traits of RCC

It was found that there was a highly significant effect (p<0.001) of parity and herd on daily milk yield and non-significant effect of season, year and sire on daily milk yield (Table 02). The highest mean daily milk yield was found in 3rd parity as 3.07±0.13 liter. Munim *et al.* (2006) and Habib *et al.* (2010) found significant (p<0.05) effect of parity on daily milk yield for RCC which was consistent with the present study who reported highest average daily milk yield in 5th parity but the result differed from that of Habib *et al.* (2003) who found non-significant (p>0.05) effect of parity on daily milk yield. The variations between results with year of calving might be due to feeding, management etc.The effect of parity was significant (p<0.05) on lactation length which is similar to the results of Cilek (2009), who found significant effects of parity on lactation length but not with the results of Zafar *et al.* (2008), Erdem *et al.* (2007) and the effect of season, year, herd and sire were non-significant on lactation length that was consistent with the result of Zafar *et al.* (2008), Erdem *et al.* (2007). It was also found that there was a highly significant effect of parity (p<0.01) and herd (p<0.001) on average lactation yield and non-significant effect of season, year and sire on lactation yield.

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Table 02. Effect of various factors on milk yield traits of RCC calves

Factor		N	DMY(kg)	P Val.	Lev. Of Sig.	LL (days)	P Val.	Lev. Of sig.	LY(kg)	P Val.	Lev. Of Sig.
			Mean ± SE			Mean ± SE			Mean ± SE		
Parity	1st	33	2.34^{b}±0.14	.000	***	174.59^{b}±11.58	.034	*	451.26^{c}±42.32	.004	**
	2nd	28	2.96^{b}±0.11			207.22^{a}±9.59			603.75^{bc}±35.0		
	3rd	27	3.07^{b}±0.13			213.89^{a}±11.09			632.64^{ab}±40.5		
	4th+	29	2.85^{a}±0.14			199.81^{ab}±11.7			554.52^{a}±42.92		
Season	Summer	48	2.84±0.12	.140	NS	195.61±9.91	.780	NS	561.995±36.1	.619	NS
	Rainy	50	2.66±0.13			198.23±10.74			539.52±39.22		
	Winter	63	2.92±0.11			202.79±9.51			580.10±34.75		
Year	2005	13	2.83±0.13	.822	NS	190.56±10.62	.304	NS	528.13±38.79	.327	NS
	2006	24	2.75±0.12			202.61±9.79			539.19±35.76		
	2007	24	2.75±0.13			209.64±10.72			550.49±39.15		
	2008	14	2.88±0.17			192.69±14.02			624.35±51.23		
Herd	Nucleus	76	3.29±0.09	.000	***	205.26±7.43	.343	NS	668.07±27.12	.000	NS
	Community	85	2.32±0.15			192.49±12.69			453.01±46.39		
Sire	Unknown	36	2.55±0.08	.119	NS	202.12±6.65	.681	NS	542.17± 24.29	.279	NS
	Tag no. 45	15	2.85±0.18			204.18±14.90			569.45± 54.45		
	Tag no. 63	38	3.17±0.20			211.07±16.94			675.47± 61.87		
	Tag no. 92	17	2.71±0.28			171.46±23.11			472.39± 84.41		
	Tag no. 141	13	2.73±0.23			205.54±18.85			543.22± 68.84		

N= No. of observation, DMY= Daily milk yield, LL= Lactation length, LY= Lactation yield, SE= Standard error, means with uncommon superscripts along the column within a factor differ significantly (p<0.05). Unknown sires are sires those served the dam naturally.

Alam *et al.* (2007) and Habib *et al.* (2003) found non-significant effect of parity on lactation milk yield which was contradictory to the current study. The highest and lowest lactation milk yield were found in 3rd and 1st parity as 632.64±40.52 and 451.26±42.32 litre, respectively. Zafar *et al.* (2008) found lowest milk yield for the 1st lactation and highest in 6th lactation. Aslam *et al.* (2002) found highest milk yield in 4th parity. Many studies have found significant effect of parity on production, especially between first and later parities. This indicated that cows starting lactation at early age are not mature. Effect of various factors on milk yield traits of RCC calves was shown in Table 02.

Heritability for growth and milk yield traits

Additive genetic variance and common environmental variance of birth weight, weaning weight, average daily gain, daily milk yield, lactation length and lactation yield were found to be 1.88 and 0.19, 96.89 and 2.21 and 1242.99 and 15.95,0.065 and 0.007, 416.286 and 38.135 and 5916.907 and 687.057, respectively (Table 03). The heritability for birth weight, weaning weight, average daily gain, daily milk yield, lactation length and lactation yield were calculated as 0.47±0.04, 0.49±0.17, 0.49±0.16,0.47± 0.07, 0.47±0.06 and 0.47±0.08, respectively (Table 03). Afroz *et al.* (2011) from RCC, Deb (2004) from Jersey x Local, Stamer *et al.* (2004) from Holstein calves and Bhuiyan (1999) from Friesian x Local reported more or less similar magnitude of heritability for these traits as 0.48±0.04, 0.497±0.051, 0.48±0.04, 0.63 and 0.64±0.56, respectively. Therefore, the heritability estimate of growth traits of calves in the present study was within the range of the published results. Ibrahim *et al.* (2012) from Holstein cows, Reza *et al.* (2004) from crossbred cattle, Choudhary *et al.* (2003) from Sahiwal cows as 0.17±0.14, 0.20±0.07 and 0.27 ± 0.17, respectively which were lower result for average daily milk yield compared to the present study. Estimated heritability for lactation length was lower than the value obtained by Iqbal (2005) found from FN x LO and JR x LO and Singh *et al.* (2005) found from FNxSL as 0.50±0.03, 0.73±0.08 and 0.80±0.10, respectively.

Medium to high heritability estimates for growth and milk traits of the present study would allow breeder to go for selection of better cows for milk yield and lactation length on the basis of individual selection. Differences in magnitude of heritability might be due to differences in population structure, breed or type of cattle, methods of estimation and other unknown causes. Estimates of variance components and heritability for growth and milk yield traits are given in the Table 03.

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Table 03. Estimates of variance components and heritability for growth and milk yield traits

Trait	N	Additive genetic variance	Environmental variance	Heritability ± SE
BWT	161	1.88	0.19	0.47±0.04
WW	161	96.89	2.21	0.49±0.17
ADG	161	1242.999	15.927	0.49±0.16
DMY	76	0.065	0.007	0.47±0.07
LL	76	416.286	38.135	0.47±0.06
LY	76	5916.907	687.057	0.47±0.08

N= No. of observation, SE= Standard error, BWT= Birth weight, WW=Weaning weight, ADG=Average daily gain, DMY= Daily milk yield, LL= Lactation length, LY= Lactation yield

Estimates of G×E interaction for growth and milk yield traits

Estimates of G×E for growth traits of RCC are given in Table 04. Herds under consideration were intensive management system (Nucleus) and traditional management system (Community herds). Effects of Herd × Sire interaction on birth weight, weaning weight and average daily gain were non-significant (p>0.05) and the effect of Herd × sire interaction was highly significant (p<0.001) on daily milk yield, lactation length and lactation yield.

Table 04. Genotype × Environment interactions for growth and milk yield traits

Trait	Effect of Herd × Sire	Trait	Effect of Herd × Sire
Birth weight	NS	Daily milk yield	***
Weaning weight	NS	Lactation length	***
Average daily gain	NS	Lactation yield	***

NS=Non-significant (p>0.05), (***) = highly significant (*p*<0.001)

Nuruzzaman (2012) estimated G×E interaction on crossbred dairy calves between traits in two peri-urban production systems of Mymensingh Sadar area for birth weight and average daily gain and no significant (p>0.05) interaction was observed for birth weight which support the result found in present study but he found highly significant (p<0.01) interaction at average daily gain which is in disagreement with the present study.

Estimates correlations (genetic) of breeding value between animals of two herds on birth weight, weaning weight, average daily gain, daily milk yield, lactation length and lactation yieldwere 0.19 ± 0.078, 0.13 ± 0.078, 0.11 ± 0.078, 0.07 ± 0.115, 0.18 ± 0.114 and -0.01 ± 0.116, respectively (Table 05). This smaller positive correlation values indicated that birth weight, weaning weight, average daily gain, daily milk yield and lactation length were genetically positively correlated between animals of two herds in GxE under two management systems. Lactation yield was negatively correlated between animals of two herds.

Table 05. Correlation (genetic) of breeding values for growth and milk yield traits between animals of two herds

Trait	Value of genetic correlation (r_g)	Trait	Value of genetic correlation (r_g)
Birth weight	0.19 ± 0.078	Daily milk yield	0.07 ± 0.115
Weaning weight	0.13 ± 0.078	Lactation length	0.18± 0.114
Average daily gain	0.11± 0.078	Lactation yield	-0.01± 0.116

However, results normally vary for genotype by environment studies. Several studies which involved multi-state distribution of genotypes typically reported significant effects of G×E (Burns *et al.*, 1979; Northcutt *et al.*,1990; Pahnish *et al.*, 1985). This suggests that G×E is more prevalent in comparison across regions in production environment, while within states similar climate and management

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practices reduces the magnitude of G×E. The inconsistency between regions and specific traits leads to the need for additional research to determine the effect of genotype by environment interaction.

IV. Conclusion

The RCC had almost similar performance in both production systems (intensive management system and traditional management system) and hence be considered as equally suitable breed for both situations. Considering large within population variation in the studied traits, there is opportunity of improvement for RCC if proper selection and breeding methods be applied along with optimum feeding, management and disease control measures.

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