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Research Article

Phenotypic and Genetic Trends in Growth Traits in a Nucleus Herd of Red Chittagong Cattle

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Abstract

The aim of this study was to estimate phenotypic and genetic trends in growth of Red Chittagong cattle (RCC), an indigenous breed of Bangladesh. The numbers of animals used to estimate body weights at birth, 3-months, 6-months, 9-months, and 12-months, pre- and post-weaning average daily gain (ADG) were 352, 245, 257, 215, 186, 251 and 154, respectively. Least squares means were calculated using SAS (9.3.1) to describe phenotypic trends in body weights and growth rates. Heritability and estimated breeding values were obtained using Best Linear Unbiased Prediction (BLUP) methods utilizing VCE (4.2.5) and PEST (3.1) software. Phenotypic and genetic trends were estimated by regressing yearly mean phenotypic and breeding values on year of birth. Phenotypic trends for birth weight, 3-month and 6-month weights were nearly invariant, whereas 9-month and 12-month weight, pre-weaning ADG and post-weaning ADG fluctuated for animals born from 2005 to 2016. Similarly, genetic trend for birth weight was uniform while other growth traits fluctuated widely during this time period. Estimated breeding values for birth weight, 3-month, 6-month, 9-month and 12-month weight, pre- and post-weaning ADG were (-0.09±0.16, 0.68±1.53, 0.44±1.34, 0.26±1.35, -0.20±1.73) kg/year, (3.42±7.60 and -1.17±9.01) g/day, respectively. While all estimates from this small sample size included zero, genetic trends indicated modest gains in all traits except birth weight and post-weaning ADG. As expected, selection is a pathway to improved for growth in RCC. Therefore, it can be concluded that, RCC selected at an early age can increase body weights at later ages, as reflected by the positive phenotypic and genetic trends for 3-month and 6-month weight and pre-weaning ADG.

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Keywords: Body Weights; Genetic Trends; Growth Traits and Red Chittagong Cattle; Phenotypic Trends

Introduction

Red Chittagong cattle (RCC), which is yet to be recognized as a breed, is considered a valuable indigenous bovine genetic resource of Bangladesh with many attributes equal or superior to other indigenous breeds. It is readily distinguishable from others due to its distinct phenotype [1]. Thorough research has been conducted by many researchers on aspects such as morphometric characteristics of RCC [2], rates of inbreeding status [3], lactation and reproductive performance [4, 5], fertility [6], parasitic infestation [7], and feeding and management in two Chittagong upazilas [8]. In situ studies were conducted in Chittagong province and other plains of Bangladesh. Considering their accepted performance, adaptability and suitability to the low-input socio-economic conditions of farmers, RCC was incorporated for their conservation and development into the livestock breeding policy of the Ministry of Fisheries and Livestock of Bangladesh [9]. Accordingly, since 2007 the government and other breeding service providers are producing and distributing RCC semen. Growth performance is important to all cattle production systems [10]. Body weights and derived growth rates are easy measure, are economically important with sufficient heritability to obtain changes through selection, and have been under scientific study for more than a century [11].

Genetic aspects of growth through selection are important to calf production. Growth performance has been a prime selection goal in beef cattle breeding [12]. Knowledge about the genetic parameters of traits in different environmental settings is needed to manage breeding programs and to realize genetic gains from selection [13, 14]. Accurate prediction of breeding value of animals, which depends on corresponding genetic parameters, is one a fundamental tool for managing response to selection programs [15]. Apart from this, annual genetic gains for calf growth traits should be monitored over time to verify realized gains and to investigate the direction and amounts of genetic change [16]. In any breeding program, the monitoring of genetic gain per unit of time (i.e., the rate of genetic progress) is essential to genetic management of livestock populations [17].

The average differences between the years constitute a measure of genetic trend. These trends reflect the amount of genetic gain obtained in a population [18]. Genetic trends in production traits of cattle breeds have been reported from many different countries [19-22]. However, until this study no report been made about early growth performance of RCC.

Therefore, the objective of this study was to assess the phenotypic and genetic trends in body weights at birth, 3-month, 6-month, 9-month and 12-month of age for RCC and their corresponding pre- and post-weaning ADG in a small nucleus herd undergoing selection for milk yield managed semi-intensively and with low inputs.

Materials and Methods

Source of experimental data: The data of the present study were collected from the Nucleus Herd of Red Chittagong Cattle maintained at Bangladesh Agricultural University (BAU) Dairy farm funded by United States Department of Agriculture (USDA) at the Department of Animal Breeding and Genetics, BAU, and Community Herd, Char Jailkhana, Mymensingh. The structure of the nucleus breeding program is shown in Figure 1 and information about sample sizes are in Table 1. Due to the national crossbreeding program through AI, the RCC population size was in decline. Hence, a USDA-funded project, Characterization, Conservation and Improvement of Red Chittagong Cattle of Bangladesh, was initiated in 2004 by the Department of Animal Breeding and Genetics, BAU, Mymensingh. The RCC nucleus herd was begun at BAU with a 50-cow herd in August 2005 providing a pedigree and performance-recorded population. In 2009, the nucleus herd was moved to the farmer community at Char Jailkhana, a village adjacent to BAU. Through this collaboration, the main herd was farmer-maintained under regular supervision by an animal recorder, an AI technician and a Scientific Officer. The general goal of the breeding program (Figure 1) was conservation of RCC through its effective utilization. The program established two breeding criteria: (i) purity of RCC based on external characteristics and (ii) average daily milk yield. Data on individual animals were regularly recorded from 2005 to 2017. Years were divided into three seasons to partially account for e environmental variation. Seasons of birth were summer (March to June), rains (July to October) and winter (November to February).

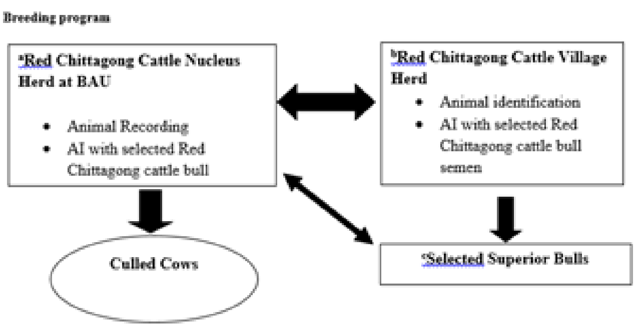

Figure 1: Red Chittagong Cattle Nucleus Breeding System.

[a]Red Chittagong cattle Nucleus herd at BAU was maintained from 2004 to 2008,

[b]Red Chittagong cattle village herd in the community was maintained from 2009 to 2016,

[c]selected superior bulls were put into nucleus herd and bulls were always maintained at BAU station from 2004 to 2016.

Traits	N[a]	Sex		Herd	
		Male	Female	Nucleus[b]	Community[c]
Birth weight (kg)	352	154	198	119	233
3- months weight (kg)	245	130	115	68	177
6- months weight (kg)	257	131	126	93	164
9- months weight (kg)	215	112	103	59	156
12- months weight (kg)	186	79	107	52	134
Pre-weaning average daily gain (g/day)	251	129	122	90	161
Post-weaning average daily gain (g/day)	154	79	75	60	94

Table 1: Numbers of observations of the Red Chittagong Cattle data.

[a]N= number of observation

[b]Number of observations of each trait in the nucleus from 2005 to 2008

[c]Number of observations of each trait in the community from 2009 to 2016.

Place of study: The study was conducted at the Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh. The data on individual animals were collected from the two sites by trained animal recorders: (1) Site 1: records were maintained at the nucleus herd at BAU, and (2) Site 2: records were maintained at farmers' home at Char Jailkhana, Mymensingh district.

Traits under study Growth-related traits were body weights (kg) at birth, 3- months, 6- months, 9-months, 12- months, and pre- and post-weaning ADG (g/day).

Feeding and management practices: Nucleus herd: Management practices were nearly uniform across years at the nucleus herd. Animals were stall-fed with concentrate feeding twice daily. Rice straw was used as roughage with some additional green grasses. Animals were supplied fresh-chopped maize, German and roadside grasses.. During winter when fresh forage is scarce animals received rice straw with urea and molasses (UMS). Forages were not provided ad libitum throughout the year due to poor unavailability [6].

Community herd: Animals reared in the community herd were mainly pastured on fallow land and by browsing harvested crop fields. Occasionally farmers provided minimal amounts of concentrates along with rice straw [6].

Breeding management in nucleus and community herds: The breeding program for both herds is shown in figure 1. The entire herd was maintained on-station at BAU from 2004 to 2008. From early 2009, cows were shifted to the community herd with bulls maintained on-station until 2016. Cows were artificially inseminated with the semen collected from bulls maintained on-station. Selected sires from the community herd were put into the bull station at BAU [6].

Data: Description of the data set is in Table 1. The data set in the current study consisted of 352 observations for birth weight (kg), 245 observations for 3-month weight (kg), 257 observations for 6-month weight (kg), 215 observations for 9-month weight (kg), 186 observations for 12-month weight (kg), 251 observations for pre-weaning ADG (g/day) and 154 observations for post-weaning ADG (g/day). Nineteen Red Chittagong cattle bulls were used in breeding program from 2004 to 2016. First six bulls were unknown, they did not have pedigree records and considered as base populations. The rest of the bulls had complete pedigree records.

Data analyses: Statistical Analysis Software (SAS 9.3.1) package was used to estimate the least squares means and standard errors of studied traits with the PROC GLM function using the following model [23].

y = SoB + YoB

where y is the vector of observations for each trait, SoB is fixed effect of season of birth, where 3 seasons were summer (March to June), rains (July to October) and winter (November to February), YoB is the fixed effect of year of birth of animal (2005 to 2016). Least square means displayed for 3 levels in season of birth and 12 levels of year of birth (2005 to 2016). Only least square means of each trait according to year of birth were shown in the result section in the current study.

Variance components of each of the traits in the current study were analyzed separately by the following univariate animal model.

y= μ+ sex + SoB + YoB + a + e

Where, y = observation of a trait in the current study (birth weight, 3-month weight, 6-month weight, 9-month weight, 12-month weight, pre-weaning ADG and post-weaning ADG), μ is the general mean, sex is the fixed effect of sex of animals (male and female), SoB is the fixed effect of season of birth where 3 seasons were defined; summer (March to June), rainy (July to October) and winter (November to February), YoB is the fixed effect of year of birth of animal (2005 to 2016), a is the random additive genetic effect with a var (a) ~ N(0, $A\sigma^2_a$) where σ^2_a is the additive genetic variance and A is the relationship matrix and e is random residual with var (e) ~ N(0, $I\sigma^2_e$) where σ^2_e is the residual error variance and I is the identity matrix.

The variance components and heritability of the traits were estimated using Restricted Maximum Likelihood (REML) methodology. Breeding value of animals for each of the traits was estimated using Best Linear Unbiased Prediction (BLUP) methodology and was carried out by computer program prediction and estimation (PEST-3.1) [24]. The matrix of variance components from the VCE (VCE-4.2.5) [25] results for each of the traits was used in the matrix for PEST program to estimate breeding values of each animal for each trait separately.

Estimation of phenotypic and genetic trend: Values of both the phenotypic and genetic trends were estimated by regressing the mean phenotypic values and yearly breeding values for each trait over the years using Microsoft Excel.

Results and Discussion

Phenotypic trends in growth: Least squares means of studied traits are in Table 2. These phenotypic trends for growth traits showed positive and negative responses during the study period, 2005 to 2016 (Figures 2-4). The phenotypic trend in birth weight was invariant, whereas body weights at 6- and 12-months fluctuated. The phenotypic trend for 3-month weight varied little from 2005 to 2012 with a slight increase from 2013, whereas 9-month weight fluctuated throughout. Body weight at 6-months decreased slightly in 2008 and 2010, increasing thereafter until 2016. The 12-month weight continuously fluctuated from 2005 to 2016. The phenotypic trends for average pre- and post-weaning daily gains increased over time from 2005 to 2016. Both pre- and post-weaning ADG fluctuated across years. Pre-weaning ADG followed the same trend as for 6-month weight. There was a sharp rise in post weaning ADG in 2006 followed by sudden decrease in the year of 2008. Afterwards, a small amount of rise and fall was noticed up to 2016. The phenotypic trend of birth weight was negative -0.05± 0.11 kg/year (Table 3). Least squares means for birth weight ranged from 13.9±0.58 to 14.01±0.18 kg. Similarly, 12-month weight also had negative phenotypic trend -0.36±1.76 kg/year (Table 3), ranging from 61.54 to 64.36±5.61 kg. In contrast to birth weight and 12-month weight, the phenotypic trend for 6-month weight was found to be 0.48±1.35 kg/year (Table 3). Range of least square means for 6-month weight was from 50.55 to 50.74±1.40 kg (Table 2). The phenotypic trends of both 3-month weight and 9-month weight were positive (0.72±1.55 and 0.27±1.36 kg/year respectively). Ranges of least squares means for 3-month and 9-month weight were 41.47 to 40.68±1.37 kg and from 54.93 to 61.20±3.02 kg, respectively.

The phenotypic result in this study generally agrees with other reports [20, 24]. Animal performance in yearling weight could be improved also through nutritional management strategies to increase nutrient intakes Changes include greater forage nutrient supply from grazing and pasture improvement [16].

The phenotypic trend in pre-weaning ADG was 4.04±1.08 g/day, whereas the trend in post-weaning ADG was negative -1.47±9.37 g/day (Table 3). Fluctuations in these traits might be due to poor post-weaning nutrition of the animals in the community. Therefore, better forage quality and supply opportunities should be developed [16].

Heritabilities of growth traits: Heritabilities of body weights at birth, 3-months, 6-months, 9-months, and 12-months, and associated pre-and post-weaning ADG were 0.489± 0.026, 0.304± 0.046, 0.405± 0.039, 0.407± 0.041, 0.437± 0.043, 0.390± 0.041 and 0.422± 0.047, respectively (Table 4). These results generally agree with those reported by Rabeya [13] for RCC.

Heritabilities are specific to particular populations in time although similar values are typically found for the same trait in different populations. Heritability estimates for growth traits in cattle range from 20 to 50% [26]; and the values obtained in the present study were within this range. The heritabilities of growth traits in the present study were higher than those found by Neser [27, 28] which ranged from 0.13 to 0.25.

Genetic trends for growth traits: Graphical representation of genetic trends (Figures 5-7). The genetic trends of 3-months weight, 6-months weight and 9-months weight were positive 0.68±1.53 kg/year, 0.44±1.34 kg/year and 0.26±1.35 kg/year whereas the genetic trend of birth weight was slightly negative - 0.09±0.16 kg/year (Table 3).

Genetic trend of 12-months weight was also found to be negative -0.20±1.73 kg/year. Both the genetic trends of 3-months weight and 9-months weight showed a fluctuation of wide range during the studied periods. The genetic trend of birth weight was constant from 2005 to 2015 although there was slight decrease in the year of 2016. In contrast, the genetic trends of both 6-months weight and 12-months weight were found to be fluctuating in wide range. The highest genetic gain in 12-months weight was shown in the year of 2006 which suddenly dropped in 2008. After this time, continuous fluctuation happened up to the year of 2013 that again increased in the year of 2015. In case of 6-months weight, the lowest genetic gain was found in the year of 2008 which again continued to rise from 2010 and reached the peak in the year of 2014.

There might be different causes of variation in genetic trend over the years. Gunawan [12] estimated the genetic and non-genetic effect on birth weight, weaning weight and yearling weight using Bali

Traits	Year of birth											
	2005	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16
Birth weight (kg)	13.91±0.58(14)	14.95± 0.38 (34)	14.98± 0.42(24)	14.89± 0.51(25)	14.91± 0.52(22)	14.79± 0.28(31)	14.43± 0.17(37)	14.09± 0.18(28)	14.67± 0.15(41)	14.19± 0.18(38)	13.41 ±0.14 (29)	14.01± 0.18(29)
3- months weight (kg)	41.47(1)	32.88± 1.02 (21)	30.14± 1.05(24)	29.5± 1.42(24)	30.06± 1.44(22)	32.47± 1.56(28)	30.23± 0.94(32)	31.60± 1.04(27)	37.54± 2.29(16)	42.65± 1.04(26)	42.41± 1.66(16)	40.68± 1.37(15)
6- months weight (kg)	50.55(1)	47.84± 1.44 (21)	43.17± 1.53(24)	39.93± 1.92(24)	45.72± 2.08(20)	40.61± 2.19(27)	41.51± 1.56(32)	42.57± 1.70(26)	46.49± 1.78(30)	53.05± 1.61(26)	52.48± 1.83(16)	50.74± 1.40(10)
9- months weight (kg)	54.93± 0(1)	59.43± 2.13 (15)	57.29± 2.34(19)	48.79± 2.11(24)	54.16± 2.6(20)	49.20± 2.66(24)	51.74± 2.04(32)	53.69± 1.68(21)	51.56± 1.67(28)	61.65± 2.60(20)	61.20± 3.02(13)	NA
12- months weight (kg)	61.54 (1)	77.22± 6.33(5)	70.84± 3.92(16)	57.55± 2.95 (24)	63.32± 3.9 (19)	58.96± 3.35(22)	62.67± 1.59(28)	60.1± 2.26 (19)	61.94± 1.78 (30)	69.19± 2.37 (16)	64.36± 5.61 (6)	NA
Pre-weaning ADG (g/day)	193.50 (1)	179.41± 7.59 (21)	157.20± 8.06 (24)	139.77± 9.91 (24)	170.91± 10.78 (20)	144.13± 11.96 (27)	150.80± 8.61 (32)	158.19± 9.50 (26)	177.04± 9.77 (30)	217.06± 9.04 (26)	215.91± 9.85 (16)	216.55± 19.13 (6)
Post-weaning ADG (g/day)	60.32± 0 (1)	177.71± 25.97 (5)	157.88± 16.86 (16)	103.05± 7.84 (23)	117.99± 11.46 (15)	110.50± 10.15 (18)	124.23± 8.99 (25)	104.75± 8.50 (18)	96.56± 9.07 (21)	125.71± 12.14 (10)	104.30± 8.17(4)	NA

Table 2: Least squares means (± SD) of studied traits according to year of birth in Red Chittagong Cattle.

*Numbers in parentheses () indicate the numbers of observations of studied traits in each year

*NA indicates the missing values for the traits.

*SD indicates values of standard deviation.

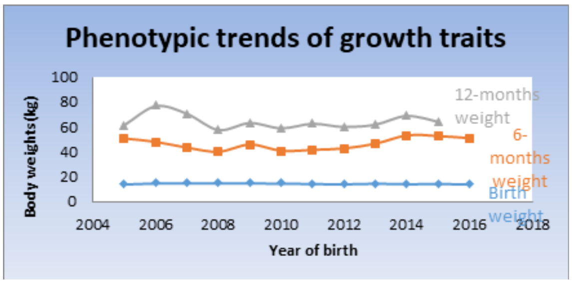

Figure 2: Phenotypic trends for growth traits (birth weight, 6-months weight, 12-months weight) of Red Chittagong cattle.

Yearly least squares means for body weights of Red Chittagong cattle estimated by PROC GLM were plotted over the year of birth. Standard deviation ranged from 0.15 to 0.58 (birth weight), 1.4 to 2.19 (6-month weight) and 1.78 to 6.33 (12-month weight).

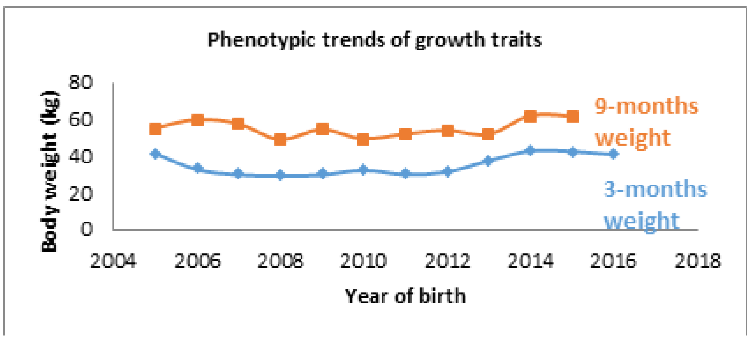

Figure 3: Phenotypic trends of growth traits (3-months weight, 9-months weight) of Red Chittagong cattle by plotting

yearly least squares means for body weights estimated by PROC GLM over the year of birth. Standard deviation ranged from 0.94 to 2.29 (3-month weight) and 1.67 to 3.02 (9-month weight).

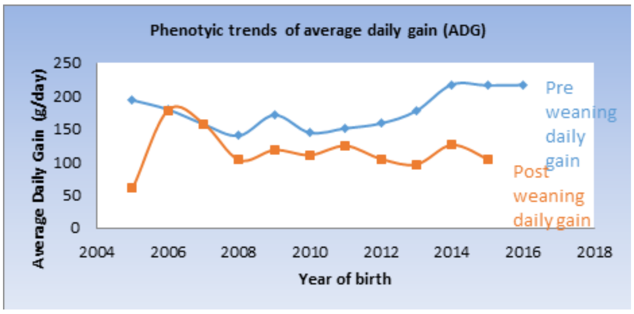

Figure 4: Phenotypic trends for pre-weaning and post-weaning average daily gain (ADG) of Red Chittagong cattle.

Yearly least squares means for body weights estimated by PROC GLM were plotted over the year of birth of the animals. Standard deviations ranged from 7.59 to 19.13 (Pre-weaning ADG) and 7.84 to 25.97 (Post-weaning ADG).

Trait	Phenotypic trend (b ± SE)	Genetic trend (b ± SE)
Birth weight (kg)	-0.05±0.11	-0.09±0.16
3- months weight (kg)	0.72±1.55	0.68±1.53
6- months weight (kg)	0.48±1.35	0.44±1.34
9- months weight (kg)	0.27±1.36	0.26±1.35
12- months weight (kg)	-0.36±1.76	-0.20±1.73
Pre-weaning daily gain (g/day)	4.04±8.21	3.42±7.60
Post-weaning daily gain (g/day)	-1.47±9.37	-1.17±9.01

Table 3: Phenotypic and genetic trends (b ± SE) of the studied traits of Red Chittagong cattle.

Traits	N	Variance components		h^2± SE
		σ^2_E (residual variance)	σ^2_A(additive genetic variance)	
Birth weight	332	0.06	1.307	0.489± 0.026
3- months weight	245	25.04	19.447	0.304± 0.046
6- months weight	251	17.84	38.169	0.405± 0.039
9- months weight	215	22.815	49.854	0.407± 0.041
12- months weight	157	14.718	51.286	0.437± 0.043
Pre-weaning ADG	251	636.866	1126.629	0.390± 0.041
Post-weaning ADG	154	378.331	1025.55	0.422± 0.047

Table 4: Variance components and heritability of growth traits of Red Chittagong cattle.

• N= Numbers of observations

• h2= heritability and SE = standard error

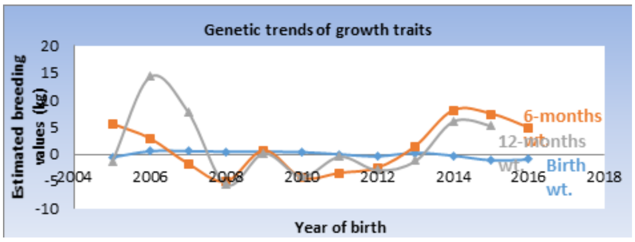

Figure 5: Genetic trends for growth traits (birth weight, 6-monthsweight, 12-months weight) of Red Chittagong cattle.

Yearly mean estimated breeding values were plotted over the year of birth of animals. Blue curve indicates genetic trend of the birth weight, light blue curve indicates genetic trend of 12-month weight and orange curve indicates the genetic trend of 6-month weight. Standard error was estimated to be 0.11 for birth weight, 1.35 for 6-month weight and 1.76 for 12-month weight.

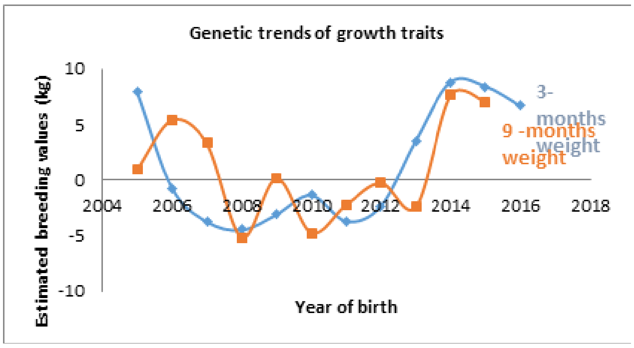

Figure 6: Genetic trends for growth traits (3-months weight, 9-months weight) in Red Chittagong cattle by plotting.

yearly mean estimated breeding values for growth traits over the year of birth of the animals. Blue curve indicates the genetic trend of 3-month weight and orange curve indicates the genetic trend of 9-month weight. Standard error was estimated to be 1.55 for 3-month weight and 1.36 for 9-month weight.

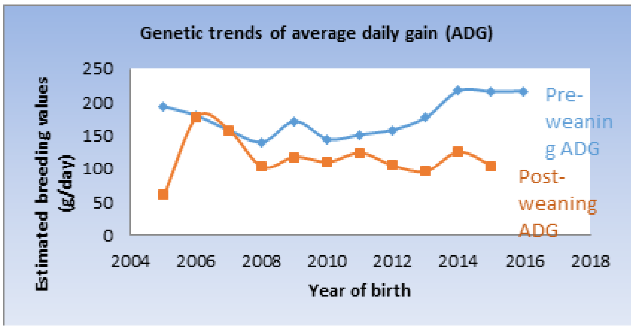

Figure 7: Genetic trends of Average Daily Gain in Red Chittagong cattle.

Yearly mean estimated breeding values for average daily gain of Red Chittagong cattle were plotted over the year of birth of animals. Blue curve indicates the genetic trend of Pre-weaning ADG and orange curve indicates the genetic trend of Post-weaning ADG. Standard error was estimated to be 8.21 for Pre-weaning ADG and 9.37 for Pre-weaning ADG.

cattle. It is difficult to compare different studies because variation in results could be due to breed differences, use of different animal models in statistical analysis, selection pressure within the population, sample size and environmental effect [12]. In the current study, as herd was shifted from on-station to community in the beginning of 2009, village herd experienced poor nutritional condition which might be another cause of low genetic progress [12]. Fluctuation of traits in the current study over the years might be due to lower selection accuracy because after all, animals were selected based on phenotypic measurements not on BLUP estimated breeding value for the studied traits [16]. So, genetic and management practices should be improved simultaneously for gradual improvement in genetic progress [16]. Differences between estimated genetic values for these traits in comparison with other studies in general, is due to difference in animal breeding standard and follow that different program selection, difference between models and calculation method and also effects of environmental and breed factors [29, 30].

The genetic trend of pre-weaning ADG was found to be positive 3.42±7.60 g/day whereas post-weaning ADG showed negative genetic trend -1.17±9.01 g/day in the present study. Both the genetic trends showed fluctuation. The genetic trend of pre-weaning ADG slightly decreased in 2008 and 2010 and then gradual increase continued up to year 2016. Post-weaning ADG was highest in 2006 and then went down sharply in 2008 followed by continuous fluctuation up to 2015.

These annual fluctuations for these traits may be due to sudden changes due to climate condition, management changes, nutrition and hygienic levels or interaction between genetic and environment. Furthermore, Shaat [29] reported that to perform breeding programs, prior to any action optimal environment condition must be provided for appearances of herds genetic potential.

Considering the above findings of present study, it can be concluded that RCCs selected at an early ages can be effective in improving weights at later ages as both the phenotypic and genetic trends of 3-months, 6-months and pre weaning ADG were found to be positive. The heritability estimates, presenting moderate magnitudes, indicated the existence of enough additive genetic variability to allow genetic gains by means of selection for the studied growth traits. Over the years, positive increments were observed for 3-months weight, 6-months weight and pre-weaning ADG.

However, RCC is being selected for breed purity and average milk yield since 2004 but in the present study phenotypic and genetic trends have been analyzed for growth traits. So, here indirect selection responses have been looked at.

Conclusion

The RCC selected at an early age can increase body weights at later ages, as reflected by the positive phenotypic and genetic trends for 3-month and 6-month weight and pre-weaning ADG.

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