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Genetic and phenotypic parameter on fertility traits of Red Chittagong Cattle in Bangladesh

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Abstract

The fertility of Red Chittagong Cattle (RCC) of Bangladesh was studied using data from 122 animals from four herds. The least squares means of female fertility traits were 1.4 ± 0.1, 72.6 ± 3.6% and 85.0 ± 2.0%, respectively, for number of services per pregnancy, first service pregnancy rate and overall pregnancy rate. The least squares mean of non-return rate to first service of bull was 58.7 ± 5.1%. The factor having a significant effect on female fertility was herd, while parity had no effect. Herd and parity of dam, season of service and sire had no effect on non-return rate to first service of bull. The heritability of fertility traits were very low: values were 0.07 ± 0.04, 0.03 ± 0.04, 0.05 ± 0.04 and 0, respectively, for number of services per pregnancy, first service pregnancy rate, overall pregnancy rate and non-return rate to first service of bull. The corresponding repeatability values were 0.18 ± 0.08, 0.08 ± 0.07, 0.13 ± 0.08 and -0.07 ± 0.02, respectively. This study reveals the fertility to be good. However, better reproductive management may enhance the overall herd fertility of RCC. (*Bangl. vet.* 2012. Vol. 29, No. 2, 78 –89)

Introduction

Poor fertility is of economic importance for dairy enterprises, because it results in higher levels of involuntary replacement and reduced annual milk production (Goshu *et al.*, 2007). Calving interval of 12 to 13.5 months, 1.3 to 1.5 services per conception and 85 days open are considered as standard values (McDowell 1985; Radostits 2001).
Fertility of dairy cows is influenced by genetics, season, age, production system, nutrition, management, environment and disease. Low fertility of cattle in the tropics is probably related to inadequate nutrition, disease and parasites (Mukasa-Mugerwa, 1989). RCC of Bangladesh is a promising variety. The fertility traits of RCC are comparable with Bos *taurus* and some other indigenous cattle available in the Indian subcontinent and some countries of Africa. Comprehensive reports are not available in this variety of cattle. This study was conducted to investigate the genetic and non-genetic control of fertility of RCC in Bangladesh.

Materials and Methods

Study site

The study was conducted from four different RCC herds located at Anwara (22°10′ to 22°14′ N and 91°52′ to 91°56′ E) and Chandanaish (22°12′ to 22°14′ N and 92°0′ to

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92°06′ E) Upazilas (Sub-district) in Chittagong district and Bangladesh Agricultural University (BAU) nucleus herd (24°30′ to 25°10′ N and 90°15′ to 91°15′E) and Char Jailkhan community herd (24°77′ to 24°78′ N and 90°39′ to 90°41′E) in Mymensingh district. There is a tropical monsoon-type climate with warm temperatures throughout the year, with a hot and rainy summer and a dry winter with little variation from month to month. January tends to be the coolest month with temperatures averaging near 26°C (78°F) and April/May the warmest with temperatures from 33 to 36°C (91 to 96°F). Most places receive more than 1,525 mm of rain a year, and areas near the hills receive 5,080 mm. Most rains occur during the monsoon (June - September) and little in winter (November - February) (Source: http://www.discoverybangladesh.com/meetbangladesh/climate.html).

Management of animals

The feeding and management was semi-intensive. Animals grazed 6-8 h/ day. Road-side grasses were the basal diet, with rice straw, specially during cropping seasons. Most farmers provided rice bran and common salt, and gave drinking water daily. Housing was traditional in a house made of bamboo with thatched roofs. The feeding and management of RCC at BAU nucleus herd was solely intensive. Animals were housed in a paddock with an open house. Animals of the nucleus herd were stall fed throughout the year. The animals were provided concentrate, green grass and straw with urea and, or, molasses. Urea-molasses-straw or sometimes only molasses-straw were provided twice a day *ad libitum* throughout the year. Inadequate green forages (German grass, Sorghum grass, Maize fodder) and roadside grasses were provided. Concentrate mixture was supplied each morning at 600 g/lactating cow, 500 g/pregnant cow, 250 g/dry cow and heifer and 1500 g/stud bull. In addition, germinated grams at 100 g/day were provided to breeding bulls. The pregnant cows were transferred to a separate house a few days prior to calving and returned a few days after calving. The calves were allowed to suck their dam for a few hours after milking and again a few hours before evening, up to 3-4 months. Afterwards, calves were allowed to suck once a day after milking until weaning. Semen was collected from RCC bulls once a week with artificial vagina and diluted with extender to preserve for three days at normal refrigeration temperature. In the herds of Chittagong, farmers seldom vaccinate and deworm their animals. In the BAU nucleus and community herd in Mymensingh, animals were dewormed and vaccinated against foot and moth disease and anthrax at regular intervals.

Animals and data preparation

The data consisted of records of 249 services to 110 dams sired by 12 bulls with known identity and 14 bulls with unknown identity (due to natural services) 2005 to 2011. For the analysis of male fertility (non-return rate to first services), the records of 307 services to 110 dams in the two herds (nucleus and community) sired by 8 bulls at BAU AI centre were examined (Table 1).

All unauthentic or doubtful data, extreme values from animals assumed to be reproductive problems, missing identification or other anomalies were removed. The number of removed data varied from 0 to 0.4% (Table 2).

Table 1. Total data set

Traits	Number of observations (N)				
	Herd-1	Herd-2	Herd-3	Herd-4	Total
Number of services per pregnancy (NSP)	31	45	98	75	249
First service pregnancy rate (FSPR)	31	45	98	75	249
Overall pregnancy rate (PR)	31	45	98	75	249
Non-return rate to first service (NRRFS)	-	-	307	-	307

Table 2. Final data set after applying checking and editing criteria for analyses

Traits[1]	Total records	Accepted range	Records removed		Records used
			No.	%	
NSP	249	1-5 nos.	1	0.4	248
FSPR	249	0-100%	0	0	249
PR	249	20-100%	1	0.4	248
NRRFS	307	0-100 %	0	0	307

[1]Traits described in Table 1

Traits analyzed

Traits considered in the analyses included: number of services per pregnancy (NSP) calculated from the number of cows becoming pregnant and the total number of services given; first service pregnancy rate (FSPR) the percentage of heifers/cows that became pregnant after the first service; overall pregnancy rate (PR) calculated from the proportion of cows becoming pregnant and number of all services given; and non-return rate to first service (NRRFS) of bull calculated from the proportion of cows not seen to return to oestrus after first service and number of services.

Data analysis and statistical model

Animals were arranged in contemporary groups according to parity, herd and season of service. The general linear model (GLM) procedure of SPSS 11.5 was used to test the main fixed effects as well as interactions that influenced the fertility traits. The following generalized linear model was used for least squares analysis:

$Y_{ij} = \mu + par_i + hrd_j + e_{ijk}$ (for female fertility traits)
$Y_{ijkl} = \mu + par_i + hrd_j + sea_k + bull_l + e_{ijklm}$ (for male fertility trait)

Where, Y_{ij} = Dependent variables (NSP, FSPR and PR)

Y_{ijkl} = Dependent variable (NRRFS)
μ = Overall population mean for the trait;
par_i is the fixed effect of parity (0-7+),
hrd_j is the fixed effect of herd (4 herds, but 2 herds for NRRFS),

sea_k is the fixed effect of season of service (3 seasons),
$bull_m$ is the fixed effect of bull (8 bulls), and
e_{ijk} and e_{ijklm} are the random residual errors

Heritability was estimated using REML procedure by VCE 4.2.5 software (Groeneveld, 1998) with single trait animal model. Random effect considered in the model was animal's additive genetic effect. In the animal model parity, herd, season of service and individual bull were included as fixed effects. Each year was divided into 3 seasons: March - June (summer), July - October (rainy) and November - February (winter). All relationships among individuals were considered in the animal model. The general form of animal model was as follows:

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

Where, Y = Vector of observations
X, Z, and W = Known incidence matrices associated with levels of b, a and c with Y.
b = Unknown vector of fixed effects (parity, herd, season etc.)
a = Unknown vector of breeding value
c = Unknown vector of permanent environmental effects
e = Vector of residual effect

The animals selected for repeatability estimation of fertility traits were those with more than one service. Repeatability was estimated by intra-class correlations from analysis of variance with the following formula (Lush, 1945):

Repeatability (r) = $\sigma^2_B/(\sigma^2_B + \sigma^2_W)$, where σ^2_B is the variance between animals and σ^2_W is the variance within animals. The standard error of repeatability was estimated as described by Swiger *et al.* (1964).

Results and Discussion

Estimation of phenotypic parameters

Table 3 presents the overall means (± SE) and range of fertility traits of RCC for four different herds.

Table 3. Mean, standard error (SE), minimum (Min.), maximum (Max.) for fertility traits of RCC

Trait[1]	Number of records	Mean	SE	Range	
				Min.	Max.
NSP	248	1.36	0.06	1	5
FSPR	249	72.56	3.64	0	100
PR	248	85.03	2.04	0	100
NRRFS	316	58.73	5.07	0	100

[1]Traits described in Table 1

Number of services per pregnancy (NSP)

The mean number of services per pregnancy was 1.4 ± 0.1. Habib (2011) found 1.4 ± 0.1 for the same herds. The result is similar to the reports (1.2 to 1.4 ± 0.1) reviewed by Azizunnesa *et al.* (2010); Das *et al.* (2010); Habib *et al.* (2003) for the same genotype in different herds. Higher range (1.5 4 ± 0.1 to 1.6 ± 0.6) was reported by Hossain *et al.* (2006); Bag *et al.* (2010) in the same genotype in different herds. The variations may be due to differences in management, skill of inseminator and subfertile bulls. Shiferaw *et al.* (2003) found that cows with reproductive disorders required more services per pregnancy. Tadesse and Zelalem (2003) noted a decrease in the services required per pregnancy for cows supplemented with protein.

First service pregnancy rate (FSPR)

The overall first service pregnancy rate in four different herds is 72.6 ± 3.6%, higher than 65.5 ± 6.7% as reported earlier (Habib, 2011), and higher than the 63.1% in Holstein heifers in Cuba (Buxadera and Dempfle, 1997), 60% in Angus heifers (Bormann *et al.*, 2006), 33.9% for crossbred cows in Kashmir Valley (Bhattacharyya *et al.,* 2010), 45.9% for crossbred cows in Ethiopia (Mureda and Zeleke, 2007). The variation might be due to type of cattle or non-genetic factors.

Overall pregnancy rate (PR)

The average pregnancy rate in RCC in four herds was 85.0 ± 2.0%, near to the 81.5 ± 3.7 (Habib, 2011). Das *et al.* (2010) found 65.8 ± 4.5% pregnancy rate in the same herd, which is much lower than in the present study: this could be due to small number of data. Pregnancy rate depends on genetic and non-genetic factors, including body condition score, genital health, correct oestrus detection, semen quality, time of insemination, efficiency of inseminator and fertility of bulls. Rodriguez and Hernandez (1992) found significant variations in pregnancy rate at different times of insemination after the first sign of oestrus. Higher ambient temperature and relative humidity (Zakari *et al.,* 1981) and poor management reduce fertility in cattle.

Non-return rate to first service (NRRFS)

The mean non-return rate to first service of RCC bulls was 58.7 ± 5.1%, which is closely in agreement (63.1 ± 5.7%) with Habib (2011). The earlier work in the same herd reported 60-day non-return rate of RCC bulls as 63.9 ± 4.2% (Das *et al.*, 2010), which is in line with this study. Miglior *et al.* (1997) reported 65.4% for Holstein-Friesian in Italy. Schaeffer (1993) and Fryer *et al.* (1958) reported values from 52.1 to 75.7% and 44 to 71%, respectively, in different ages of exotic dairy breeds. Almquist (1995) reported the average non-return rate for high fertility bulls ranged from 65 to 74% and average non-return rate for low fertility bulls ranged from 52 to 65%. The result of this study falls within the range of the published literatures. The variations between authors might be due to sample size and herd management.

Effect of non-genetic factors

Table 4 represents the least square means of the female fertility traits for the effects of herd and parity. Table 5 shows the results of the analysis of variance for traits analyzed.

Table 4. Least square means (LSM) and standard error of means (SEM) of fertility traits[1]

Factors[2]	NSP (no)	FSPR (%)	PR (%)
	LSM ± SEM		
Herd	***	***	***
Site-1	1.1[a] ± 0.2 (31)	86.7[a] ± 8. 6 (31)	93.4[a] ± 4.8 (31)
Site-2	1.1[a] ± 0.1 (45)	90.4[a] ± 7.2 (45)	95.3[a] ± 4.0 (45)
Site-3	1.6[b] ±0.1 (98)	64.3[b] ±5.2 (98)	79.2[b] ± 2.9 (98)
Site-4	1.7[b]± 0.1 (74)	48.9[b] ± 5.6 (74)	72.2[b] ± 3.1 (74)
Parity	NS	NS	NS
0	1.4 ± 0.1 (54)	66.8 ± 6.4 (54)	81.8 ± 3.6 (54)
1	1.2 ± 0.1 (36)	81.3 ± 7.9 (36)	90.4 ± 4.4 (36)
2	1.4 ± 0.1 (35)	66.4 ± 8.0 (35)	82.8 ± 4.4 (35)
3	1.4 ± 0.1 (45)	70.7 ± 6.8 (45)	83.6 ± 3.8 (45)
4	1.5 ± 0.1 (34)	62.9 ± 8.0 (34)	79.9 ± 4.5 (34)
5	1.3 ± 0.2 (20)	79.6 ± 10.4 (20)	89.0 ± 5.8 (20)
6	1.2 ± 0.2 (15)	79.9 ±12.5 (15)	89.7 ± 7.0 (15)
7+	1.5 ± 0.2 (09)	72.9 ± 15.3 (09)	83.2 ± 8.6 (09)

[1]Traits described in Table 1; [2]Herd (Site-1-Anwara; Site-2-Chandanaish; Site-3-Nucleus; Site-4-Community); ***-significant at P<0.001; NS-non significant (P>0.05), Figures in parenthesis indicate the number of observations

Herd

Analysis of variance shows (Table 5) that herd is a highly significant (P<0.001) source of variation for female fertility traits. Cows in Herds 1 and 2 show significantly higher fertility than cows in Herds 3 and 4 (Table 4) and this might be due to close supervision and better oestrus detection by owners as the herd size is manageable. This finding contradicts the findings of Habib (2011) and variation may be due to sample size. Yifat *et al.* (2009); Mureda and Zeleke (2007) found no significant (P>0.05) difference in number of services per pregnancy and first service pregnancy rate for crossbred dairy herds in urban and rural areas in Ethiopia. But the present result agrees well with Tadesse *et al.* (2010) as they detected significant effect (P<0.001) of herd on services per pregnancy for Holstein-Friesian cows in Ethiopia. DeJarnette *et al.* (2001) reported no significant effect (P>0.05) of herd on pregnancy rate.

Table 5. Analysis of variance for fertility traits

Traits[1]	*F* value and significance[2]				R^2
	Parity	Herd	Season	Bull	
NSP	0.7	8.4***	-	-	0.11
FSPR	0.7	9.1***	-	-	0.12
PR	0.7	9.5***	-	-	0.12
NRRFS	1.3	0.1	1.7	0.5	0.05

[1]Traits described in Table 1; 2 ***-significant at P<0.001; - effect not included in the model; R^2-coefficient of determination

The herd that used artificial insemination had no significant effect (P>0.05) on non-return rate of RCC bulls (Table 5), which agrees with Habib (2011). But the result does not agree with Miglior *et al.* (1997) as they found highly significant (P<0.001) effect of herd on this trait.

Parity

Table 4 shows no specific trend of female fertility traits for different parity and parity has no significant effect on all traits studied (Table 5). The result coincides with Habib (2011). In general agreement with the current result, several studies (Habib *et al.*, 2003; Bhattacharyya *et al.*, 2010; Hammoud *et al.*, 2010) reported non-significant effect of parity/age on these traits. In contrast, Buxadera and Dempfle (1997) reported significant effect of parity on these traits. It is evident from many workers that age is negatively associated with fertility. In the present study parity does not show any significant variation on fertility: this could be due to delayed age at puberty in tropical indigenous cattle.

The parity of cow had no significant (P>0.05) influence on non-return rate to first service of RCC bull (Table 5), which agrees with the previous study (Habib, 2011). In contrast, Miglior *et al.* (1997); Rabidas *et al.* (2010) reported significant influence of age of cow on non-return rate of bull of different breeds in different countries. They stated that heifers (12 to 24 months of age) had higher non-return rate, about 20% more than older cows.

Season

Season of insemination had no significant influence (P>0.05) on non-return rate of bulls to first service (Table 5). This result coincides with Habib (2011). Rabidas *et al.* (2010) found significant effect (P<0.05) of season of AI on non-return rate to first service in 1650 multiparous crossbred cows sired by five bulls. A decreased rate from July to August was reported by Miglior *et al.* (1997). Their report does not agree with this study: that may be due to sample size, different breeds, health status of animals and management system.

Sire

The non-return rate to first service did not differ significantly (P>0.05) between bulls (Table 5). This is in agreement with Habib (2011). Sarder (2006) studied 71 bull's semen sired on 75550 cows to estimate non-return rate at 60 days and found significant effect (P<0.05) of individual bull on non-return rate. The contradictory results between authors might be due to small number of bulls.

Heritability estimates

The variance components and heritability estimates along with corresponding standard errors of different fertility traits of RCC are illustrated in Table 6.

Table 6. Variance components and heritability (± SE) estimates of fertility traits

Traits[1]	Variance components				h^2 ± SE
	Additive genetic (σ^2_A)	Environmental (σ^2_{PE})	Residual (σ^2_E)	Total phenotypic (σ^2_P)	
NSP	0.039	0.071	0.459	0.569	0.07 ± 0.04
FSPR	78.368	337.553	1997.113	2413.034	0.03 ± 0.04
PR	36.299	106.921	612.231	755.451	0.05 ± 0.04
NRRFS	0	20.795	2464.970	2485.765	0

[1]Traits described in Table 1

Table 6 shows that female and male fertility have very low heritability, ranging from 0 to 0.07. Habib (2011) reported heritability of female fertility traits ranging from 0.04 ± 0.1 to 0.2 ± 0.1, and 0 for non-return rate to first service of bulls in the same herds, in line with this study. Some other authors (Lasley, 1978; Warwick and Legates, 1979; Willis, 1998; Demeke *et al.*, 2004; Haas *et al.*, 2007) reported heritability of number of services per pregnancy as very low, ranging from -0.15 to 0.10, in accordance with this study. For first service pregnancy rate, the result obtained is similar to the 0.01 ± 0.01 and 0.03 ± 0.03 reported by Bormann *et al.* (2006); Haas *et al.* (2007). Dearborn *et al.* (1973) reported the heritability of pregnancy rate to be 0.09 for beef cattle, which coincides with this result. The heritability estimate of non-return rate to first service of RCC bull is in agreement with the reports (0-0.11) reviewed by Lasley (1978) and Warwick and Legates (1979).

Because of low heritability, selection of animals for improvement of fertility is not likely to be effective.

Repeatability estimates

The variance analyses results and repeatability along with corresponding standard errors of different repeatable fertility traits are presented in Table 7.

Table 7. The variance analyses and repeatability (r) (± SE) of fertility traits

Traits[1]	Variance components		r ± SE
	Variance between animals (σ^2_B)	Variance within animals (σ^2_w)	
NSP	0.135	0.595	0.18 ± 0.08
FSPR	191.432	2115.942	0.08 ± 0.07
PR	95.681	654.538	0.13 ± 0.08
NRRFS	-155.447	2518.131	-0.07 ± 0.02

[1]Traits described in Table 1

Table 7 shows that the repeatability estimates of all fertility traits are low, ranging from -0.07 to 0.18. Habib (2011) in the same herds reported repeatability estimates of 0.14 ± 0.08, 0.10 ± 0.08 and 0.13 ± 0.08, respectively for number of services per pregnancy, first service pregnancy rate and pregnancy rate, in line with these findings. Lasley (1978); Warwick and Legates (1979); Willis (1998); Demeke *et al.* (2004) reported repeatability of number of services per pregnancy ranging from 0 to 0.13. Our result is similar. Lasley (1978) reported repeatability estimate of non-return rate to first service from 0.03 to 0.27.

Considering low level of repeatability of fertility traits, selection for those traits may not be successful. Environment has a great influence on those traits.

Conclusions

It may be concluded that the fertility of RCC is encouraging as compared with other cattle breeds. However, there is still opportunity to improve overall herd fertility through proper oestrus detection and correct time of insemination by well-trained technicians with good quality semen, proper nutrition supplementation and health management.

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