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PRINCIPAL BREEDING FACTORS INFLUENCING MILK YIELD AND REPRODUCTION IN RED CHITTAGONG CATTLE

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ABSTRACT: The study aimed to investigate the principal breeding factors influencing milk yield and reproduction in the Red Chittagong cattle (RCC). Retrospective records of a total of 20 dairy cows from the 1st to the 2nd parities were collected from the record sheet from January 2020 to June 2022. Results indicated that birth weight of the RCC was 7.5% higher (P=0.023) in parity 2 when compared with parity 1. Accordingly, total milk yield per lactation was 10.2% higher (P=0.004) in parity 2 in comparison with parity 1. Age at first service was 34.7% higher (P=0.001) in parity 2 compared with parity 1. Accordingly, age at first conception was 38.3% higher (P=0.001) in parity 2 compared with parity 1. The dry period was 22.8% higher (P=0.001) in parity 1 compared with parity 2. Age at first service was 18.3% higher (P=0.014) in natural service (NS) compared with artificial insemination (AI). Age at first conception was 16.5% higher (P=0.023) in NS compared with AI. Post-partum period was 11.9% higher (P=0.008) in AI compared with NS. Days open was 8.9% higher (P=0.018) in AI compared with NS. Calving interval was 2.9% higher (P=0.006) in AI compared with NS. An increased probability of infertility was associated with NS compared with AI. Birth weight of the calf and dry period of the dam were negatively correlated while live weight and post-partum period of the dam were positively correlated milk yield at the expense of reproductive health. A decreased probability of milk fever, mastitis, metritis and infertility was associated with increased milk yield. Principal component analysis revealed that days open, calving interval and service per conception were the principal eigenvectors determining performance of RCC. Overall, RCC performed better in the 2nd parity compared with the 1st parity.

Keywords: Birth weight, Lactation, Milk yield, Parity, Red Chittagong cattle.

INTRODUCTION

The Red Chittagong cattle (RCC) are known as one of the popular zebu type native cattle breeds in Bangladesh (Das et al., 2021). The RCC is a legacy breed which is distributed mostly in the south eastern parts of Bangladesh (Amin et al., 2013). The breed has some typical characteristics like smaller size with red coat color and distinct reddish muzzle, horn, hoof, ears, eyeball, eyebrow, vulva and tail switch (Bhuiyan, 2013). The breed is famous for dual-purpose both in dairy and beef production which plays an important role for poverty alleviation of the smallholder dairy farmers. The breed is popular among the rural communities because of short post-partum heat period, high conception rate with greater milk fat content (Bhuiyan, 2013), great calving rate (Khan et al., 2012) and moderate average daily milk production capacity of 2.0±0.65 kg in farm condition and 1.80±0.87 kg under rural farming systems (Koirala et al., 1970). They achieve early sexual maturity and calve regularly than the other non-descriptive indigenous breeds under farm condition. Further, they are more resistant to the parasites and common diseases prevalent in their own habitats than the other cattle (Chowdhury et al., 2017) exhibiting good survivability almost in all ages (Quaderi et al., 2014). RCC raising is more cost-effective than other local cattle breeds, according to a lifelong economic analysis of several dairy cow breeds done in Chittagong's rural districts (Khan et al., 2012). Given the aforementioned characteristics, the RCC may be considered a suitable cow genotype to help Bangladesh overcome the issues associated with large-scale animal production. Although few studies were conducted to evaluate the performance of RCC under extensive system of management in Bangladesh, consistent data pertinent to parity and breeding type-based performance indices under intensive system are scant. Therefore, the purpose of the present research was to look into the deeper impact of parity and breeding type on the production potentials and reproductive efficiency of the RCC while also examining the variables influencing individual and herd productivity in the context of the current intensive farming systems in Chittagong, Bangladesh.

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MATERIALS AND METHODS

A cross-sectional survey was conducted during January 2020 to April 2022 at the Government dairy and cattle development farm, Hathazari, Chattogram which is located at 22.5083°N 91.8083°E. total 20 milch cows of 2nd parity were selected from the farm for the study purpose. The farm occupies 20 acres of land, total 238 animals, milch cow 34, dry cow 80, heifer 43, male calf 29, female calf 21 and bull 31. The milch cow sheds are arranged in the face in and face out system with east-west direction. The sheds have concrete roof type and unpaved floor with plenty of natural light and ventilation. To collect the data needed to meet the study's goals, a structured questionnaire was created. Both close and open questions were addressed in the survey. The questionnaire comprised information on the kind of farm, breed, genotype, housing system, parity, feeding systems, milking systems, service per conception, age, weight, lactation time, average daily milk supply, age at puberty, age at first calf, postpartum duration, and dry period. The questionnaire was pretested before being finalized for pilot testing.

Data collection

All information was gathered directly from farm records, as well as through visiting the chosen farm in the research region and speaking with the officer and personnel during interviews. Direct interviews with the personnel and officers took place. During interview, the staff's verbal approval was obtained. 20 milch cows were purposefully chosen from a total of 238 cows originally chosen throughout the trial period.

Statistical analysis

Inter-quartile range test and variance inflation factors were used to examine outliers and multi-collinearity in the data set. By using the Shapiro Wilk test, the response variable's normality was determined. The general linear model (GLM) was used to examine the data. The dimensionality and strengths of the co-variates were examined using a heatmap comprising several orthogonal comparisons. Bartlett's test of sphericity and Kaiser-Meyer-Olkin criteria of sampling adequacy were used to determine if the data set was appropriate for principal component analysis. SAS 16.2 was used to fit all regression models, Ward's hierarchical cluster models, and response surface models (SAS Institute Inc.). The Duncan's New Multiple Range Test (DMRT) was employed to compare the means where statistical effects were judged significant (P<0.05). Stata 14.1 SE was used to conduct all statistical analyses (Stata Corp LP, College Station, Texas, USA). To calculate the influence of the predictors on the dependent variables, the following model was used (Adhikary et al., 2020; Barua et al., 2021):

Y_{ijkln}	=	$\mu_0 + \alpha_{ij} + \beta_{ik} + \gamma_{il} + \ldots\ldots \omega_{in} + \varepsilon_{ijlkn}$
Where,		
Y_{ijkln}	=	The observed effect of the trait 'i' at the 'jth' level of the predictor 'α', the 'kth' level of the predictor 'β', 'lth' level of the predictor 'γ'......and the 'nth' level of the predictor 'ω';
μ_0	=	The intercept of the regression model;
α_{ij}	=	The slope of the regression model for the trait 'i' at 'jth' level of the predictor 'α' observed on Y_{ijkln};
β_{ik}	=	The slope of the regression model for the trait 'i' at 'kth' level of the predictor 'β' observed on Y_{ijkln};
γ_{il}	=	The slope of the regression model for the trait 'i' at 'lth' level of the predictor 'γ' observed on Y_{ijkln};
ω_{in}	=	The slope of the regression model for the trait 'i' at 'nth' level of the predictor 'ω' observed on Y_{ijkln};
ε_{ijkln}	=	The random sampling error of the trait 'i' at the 'jth' level of the predictor 'α', the 'kth' level of the predictor 'β', 'lth' of the predictor 'γ'......the 'nth' level of the predictor 'ω' which is distributed as $\varepsilon_i \sim NID(0,\sigma^2)$.

RESULTS

Productive performance

Mean birth weight of the RCC calf was 18.0 kg. Mean live weight 286.3 kg, body condition score 3.1, lactation length 260.8 day and milk yield per lactation was 267.5 kg irrespective of breeding type and parity under intensive system of management (Table 1). Distribution of milk yield was symmetric. Birth weight of the calf was negatively correlated with milk yield of the dam (Figure 1). Unlike birth weight, milk yield was positively related with the live weight of the dam. Milk yield gradually increased and reached the peak at 75-150 day which declined latter on (Figure 2). Herd level maximum milk yield (>350 litter/lactation) was recorded at 65-day dry period and 375-day calving interval (Figure 3). Days open, calving interval and service per conception were the principal eigenvectors determining variability of milk yield in RCC (Figures 4-5).

Reproductive performance

Mean age at puberty of the RCC was 18.1 month. Mean age at first service 23.5-month, age at first conception 24.7 months, service per conception 1.1, gestation period 282.1 day, dry period 61.4 day, post-partum period 59.2 day, days open 81.6 day and calving interval was 344.1 day irrespective of breeding type and parity under intensive system of management (Table 1). A decreased dry period and an increased post-partum period was correlated with increased milk yield (Figure 1). There was a strong relationship between age at first service, age at first conception, post-partum period, days open and calving interval (Figure 6). However, increased milk yield had negative effects on reproductive health. An increased probability of milk fever, mastitis, metritis and infertility was associated with decreased milk yield (Figure 7).

Effect of parity

Birth weight of the RCC calf was 7.5% higher (P=0.023) in parity 2 compared with parity1. Accordingly, total milk yield per lactation was 10.2% higher (P=0.004) in parity 2 compared with parity 1 (Table 1). However, parity had no influence (P>0.05) on live weight, body condition score and lactation length of the RCC. Age at first service of the RCC cow was 34.7% higher (P=0.001) in parity 2 compared with parity 1. Accordingly, age at first conception was 38.3% higher (P=0.001) in parity 2 compared with parity 1. In contrast, dry period was 22.8% higher (P=0.001) in parity 1 compared with parity 2. However, parity had no influence (P>0.05) on age at puberty, service per conception, gestation period, post-partum period, days open and calving interval of the RCC.

Effect of breeding type

Breeding type of the RCC had no influence (P>0.05) on birth weight of calf, live weight, body condition score, lactation length and milk yield per lactation (Table 2). Age at first service of the RCC cow was 18.3% higher (P=0.014) in natural service (NS) compared with artificial insemination (AI). Age at first conception was 16.5% higher (P=0.023) in NS compared with AI. Post- partum period was 11.9% higher (P=0.008) in AI compared with NS. Days open was 8.9% higher (P=0.018) in AI compared with NS. Calving interval was 2.9% higher (P=0.006) in AI compared with NS. However, breeding type had no influence (P>0.05) on service per conception, gestation period and dry period of the RCC. Overall, an increased probability of infertility was associated with NS compared with AI (Figure 8).

Table 1 - Effects of parity on performance characteristics of Red Chittagong cattle under intensive system of management (N=20)

Parity type[1] / Parameter	Parity 1			Parity 2			Overall mean	SEM	P-value
	Mean	Min	Max	Mean	Min	Max			
Birth weight of calf (kg)	17.3[b]	15.0	20.0	18.7[a]	16.0	22.0	18.0	0.3	0.023
Live weight (kg)	286.6	275.0	298.0	286.0	281.0	298.0	286.3	0.8	0.724
BCS (1-5 scale)	3.2	3.0	3.5	3.1	3.0	3.5	3.1	0.0	0.121
Lactation length (d)	266.6	209.0	287.0	255.0	180.0	275.0	260.8	3.6	0.113
Milk yield/lactation (l)	253.1[b]	208.5	307.5	281.8[a]	216.0	367.5	267.5	5.1	0.004
Age at puberty (m)	18.1	15.0	20.0	18.1	15.0	20.0	18.1	0.2	1.000
Age at first service (m)	18.6[b]	15.0	28.0	28.5[a]	9.0	31.0	23.5	1.0	<0.01
Age at first conception (m)	18.9[b]	15.0	30.5	30.5[a]	27.5	33.5	24.7	1.0	<0.01
Service per conception (n)	1.1	1.0	2.0	1.1	1.0	2.0	1.1	0.0	0.561
Gestation period (d)	282.1	275.0	290.0	282.1	279.0	290.0	282.1	0.5	0.961
Dry period (d)	69.3[a]	55.0	90.0	53.5[b]	40.0	70.0	61.4	2.0	<0.01
Post-partum period (d)	59.5	45.0	80.0	59.0	45.0	80.0	59.2	1.4	0.852
Days open (d)	82.2	66.0	102.0	81.1	66.0	107.0	81.6	1.6	0.752
Calving interval (d)	344.0	324.0	362.0	344.3	328.0	382.0	344.1	1.9	0.930

[1]Min = Minimum; Max = Maximum; SEM = Standard error of the means

Table 2 - Effects of breeding type on performance characteristics of Red Chittagong cattle under intensive system of management (N=20)

Breeding type[1] / Parameter	Artificial insemination			Natural service			Overall mean	SEM	P-value
	Mean	Min	Max	Mean	Min	Max			
Birth weight of calf (kg)	18.0	15.0	22.0	18.0	15.0	22.0	18.0	0.3	0.955
Live weight (kg)	286.8	275.0	298.0	285.6	281.0	292.0	286.3	0.8	0.458
BCS (1-5 scale)	3.1	3.0	3.5	3.1	3.0	3.5	3.1	0.0	0.214
Lactation length (d)	261.8	209.0	287.0	259.6	180.0	287.0	260.8	3.6	0.772
Milk yield/lactation (l)	265.8	208.5	367.5	269.4	216.0	323.5	267.5	5.1	0.730
Age at puberty (m)	18.0	15.0	20.0	18.1	16.0	20.0	18.1	0.2	0.981
Age at first service (m)	21.4[b]	9.0	30.5	26.2[a]	17.0	31.0	23.5	1.0	0.014
Age at first conception (m)	22.7[b]	15.0	32.0	27.2[a]	17.0	33.5	24.7	1.0	0.023
Service per conception (n)	1.0	1.0	2.0	1.1	1.0	2.0	1.1	0.0	0.446
Gestation period (d)	282.9	279.0	290.0	281.1	275.0	290.0	282.1	0.5	0.064
Dry period (d)	63.4	40.0	82.0	58.9	40.0	90.0	61.4	2.0	0.264
Post-partum period (d)	62.6[a]	45.0	80.0	55.1[b]	45.0	65.0	59.2	1.4	0.008
Days open (d)	85.0[a]	66.0	102.0	77.4[b]	66.0	107.0	81.6	1.6	0.018
Calving interval (d)	348.8[a]	328.0	382.0	338.4[b]	324.0	369.0	344.1	1.9	0.006

[1]Min = Minimum; Max = Maximum; SEM = Standard error of the means

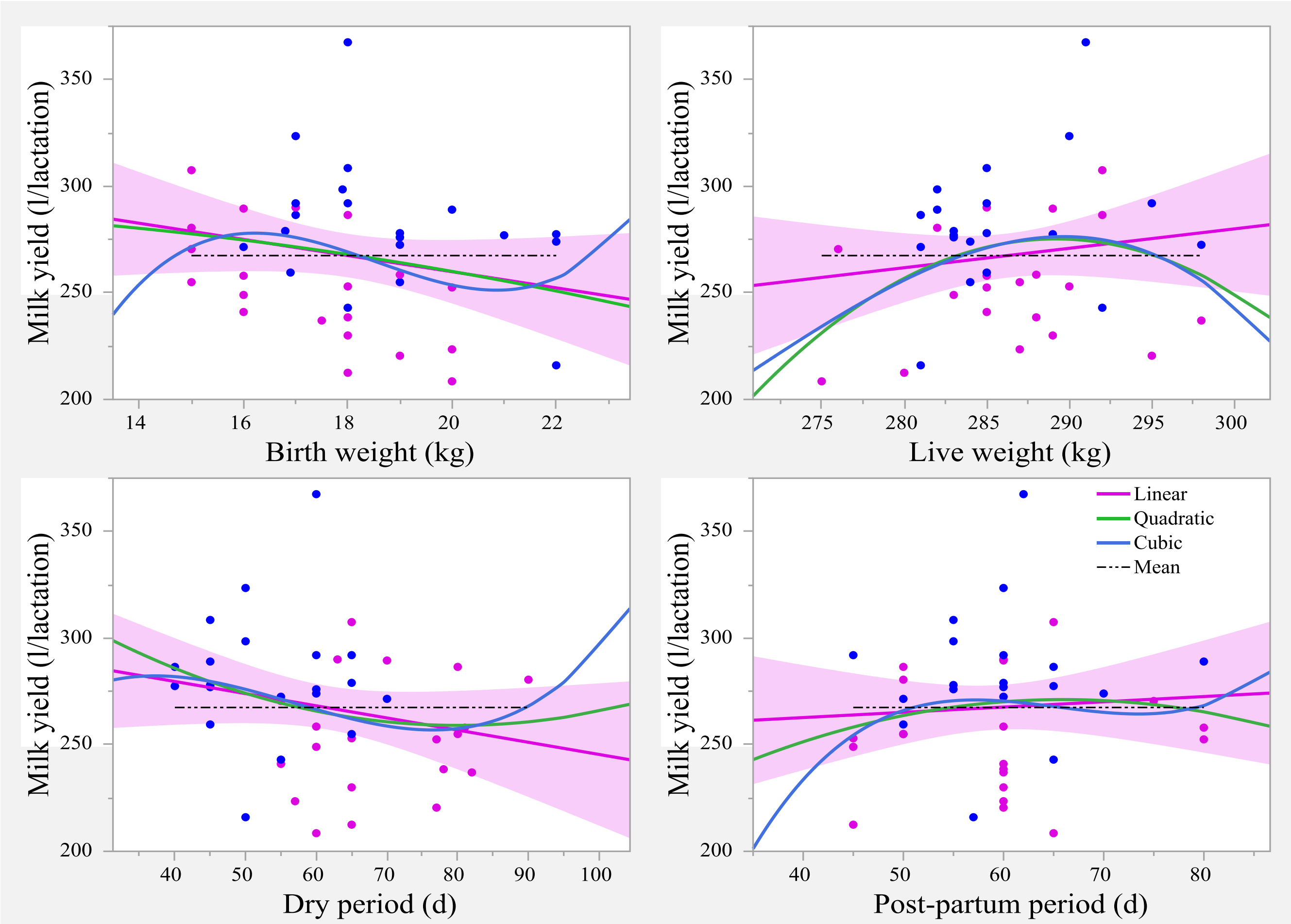

Figure 1 - Effects of birth weight (top left), live weight (top right), dry period (bottom left) and post-partum (bottom right) on milk yield in Red Chittagong cattle (N=20)

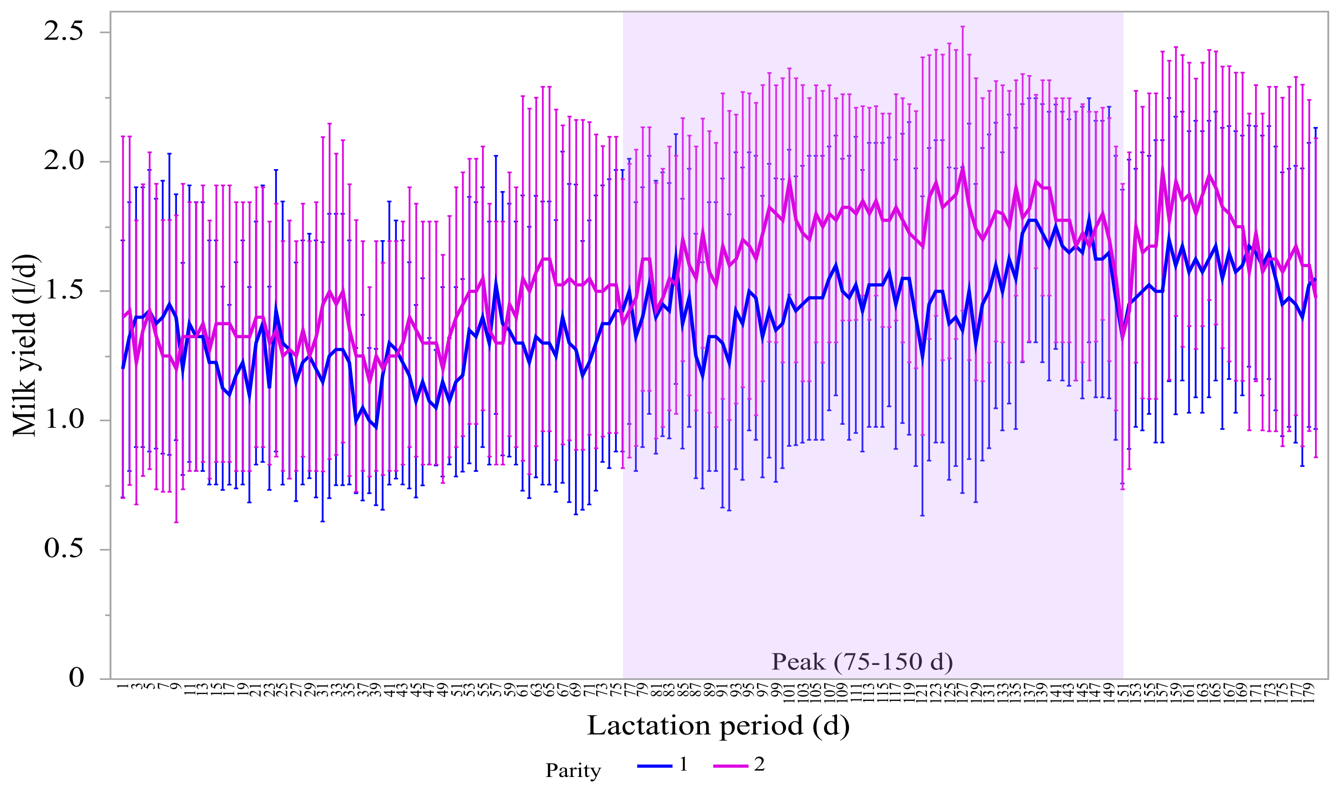

Figure 2 - Effects of parity on least square milk yield in the Red Chittagong cattle (N=20)

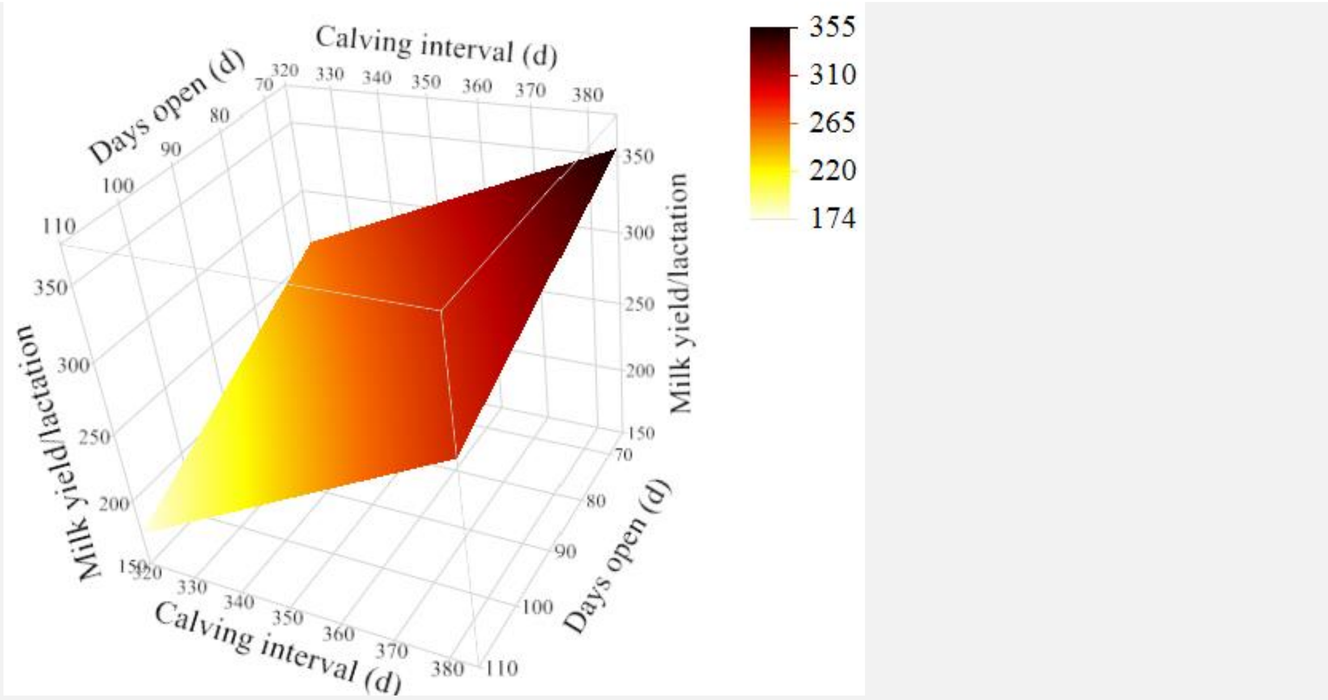

Figure 3 - A response surface model to predict the influence of days open (day) and calving interval on milk yield in Red Chittagong cattle (N=20)

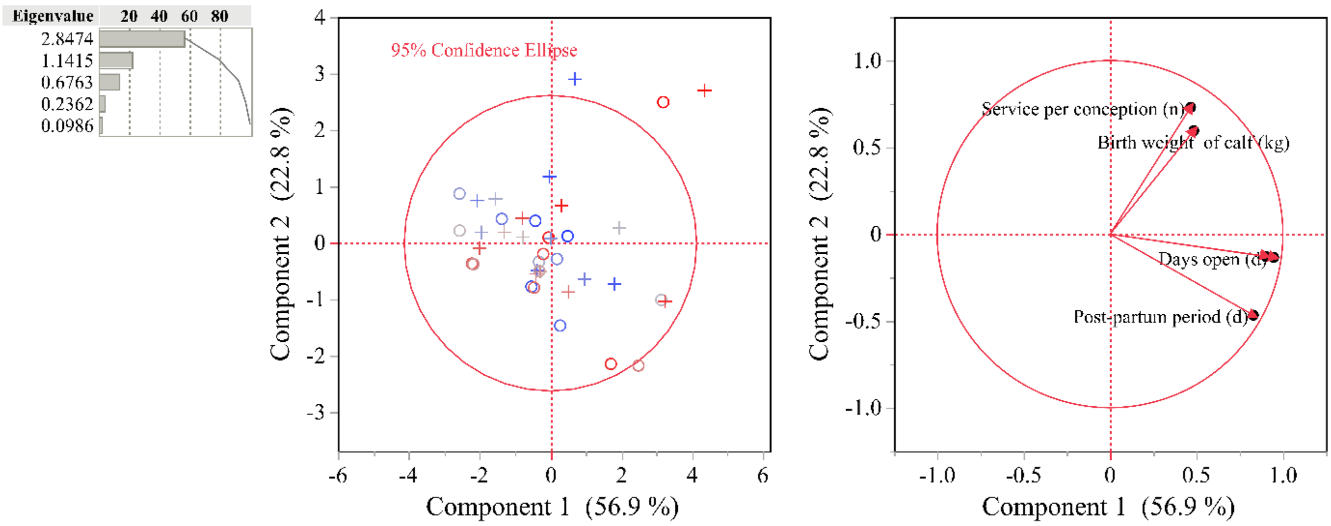

Figure 4 - Extrapolation of the principal component 1 (56.9%; plotted on 'x' axis) and component 2 (22.8%; plotted on 'y' axis) influencing milk yield (litter/lactation) in Red Chittagong cattle (N=20)

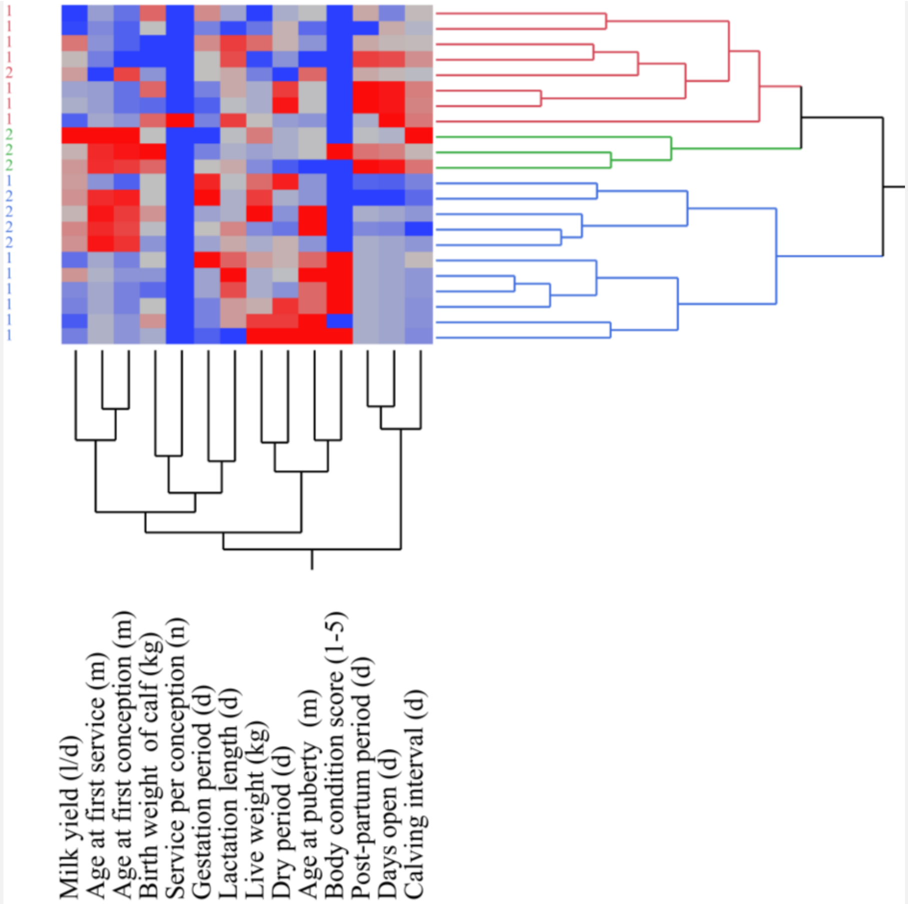

Figure 5 - Hierarchical cluster of the three principal clades (production, breeding and reproduction) of the overall performance parameter of Red Chittagong cattle considering parity as the base level (N=20).

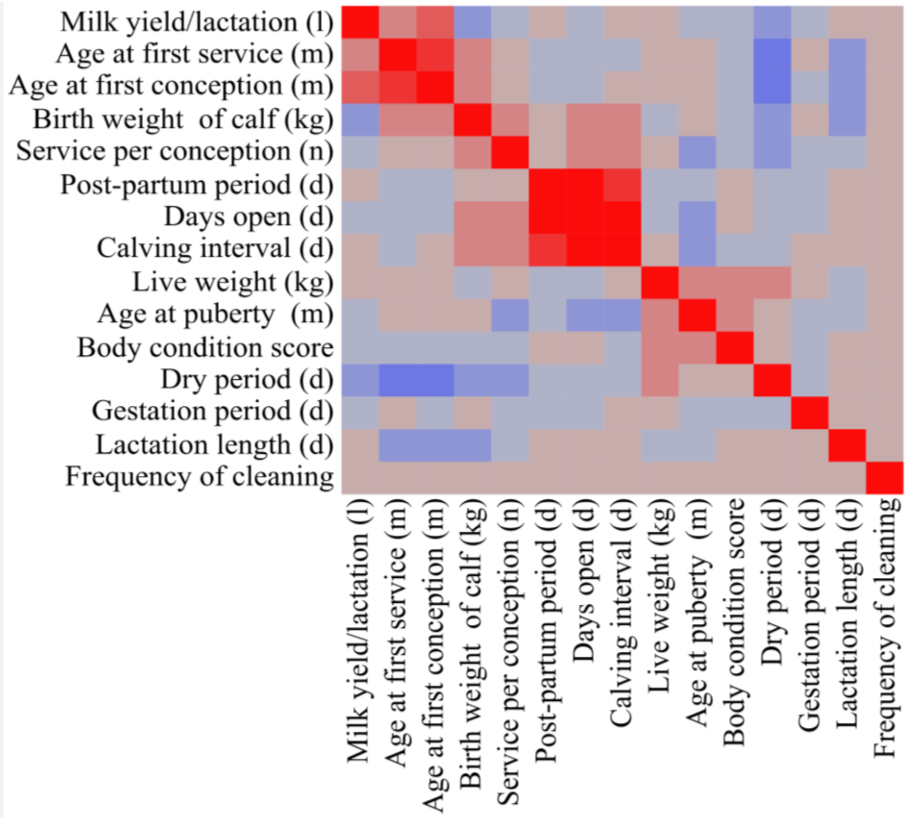

Figure 6 - Heatmap showing orthogonal contrasts of the principal factors influencing milk yield in Red Chittagong cattle (N=20)

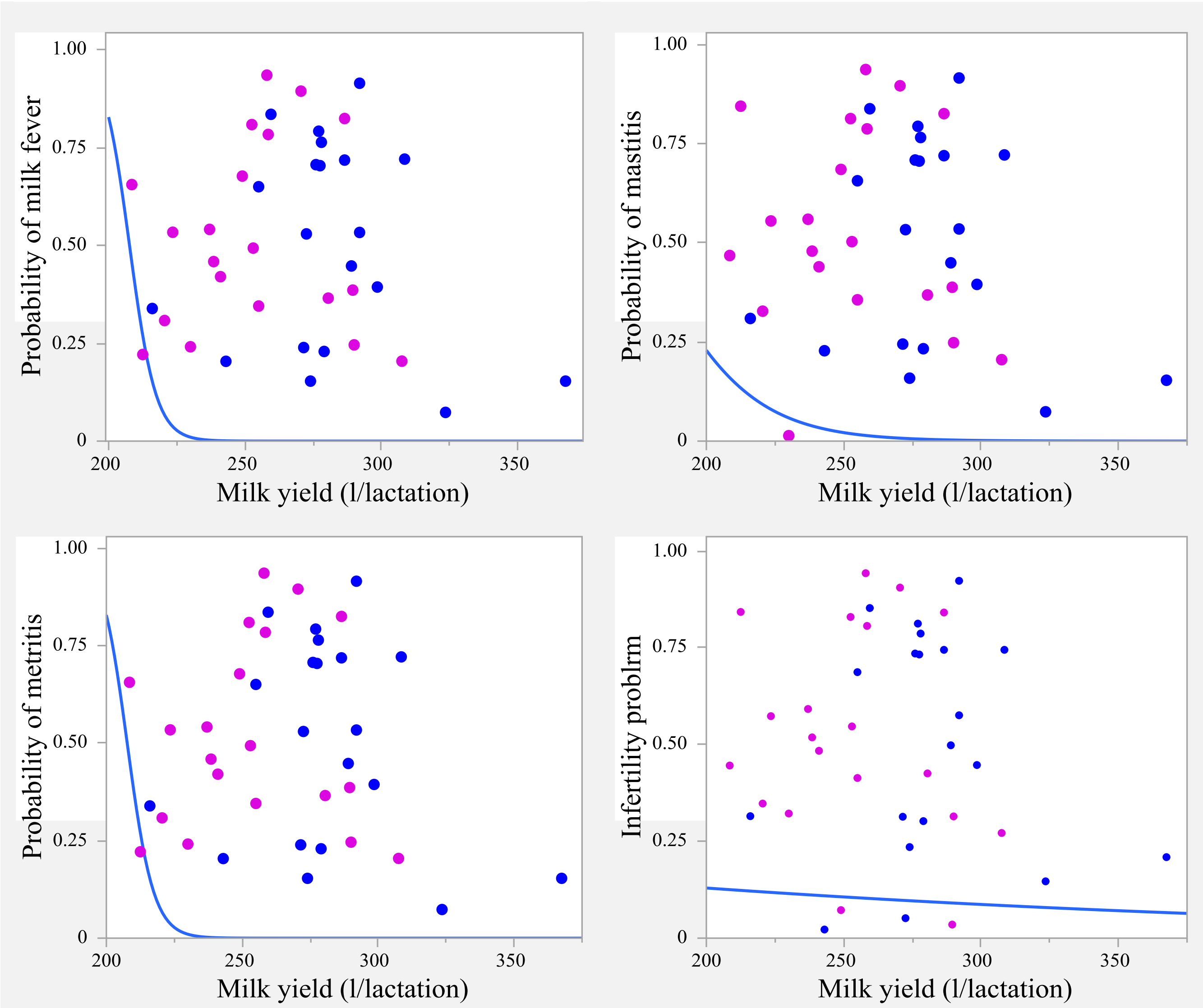

Figure 7 - Bivariate logistic regression showing effects of milk yield on probability of milk fever (top left), mastitis (top right), metritis (bottom left) and infertility (bottom right) in Red Chittagong cattle (N=20)

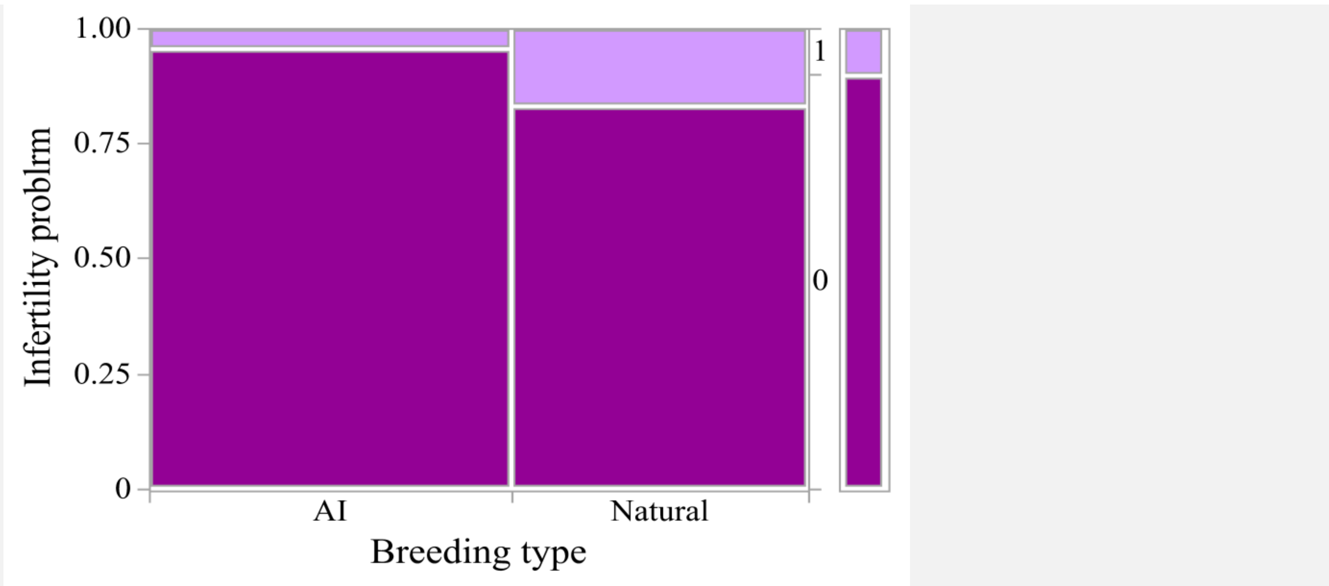

Figure 8 - Mosaic plot showing effects of breeding type on infertility problem in Red Chittagong cattle (N=20)

DISCUSSION

Productive performance

The increased birth weight of the RCC calf was observed in parity 2 compared with parity 1 (Table 1). Similar result was reported in a previous study where cows at parity 4 delivered calves that recorded higher birth weight (39.0 kg) compared with parity 2 (29.2 kg), although, these observed differences were not statistically significant (P>0.05). Calf birth weight usually tends to elevate with increased parity because of less competitive demand for nutrients, reduced mobilization rate and increased live weight of the dam with increased parity number (Hoka et al., 2019; Duncan et al., 2023). Similar to birth weight, the parity affected live weight of the dam in our study. Consistent result was reported in a previous study where increased parity resulted increased live weight because of high nutrient intake (Musa et al., 2012). In a previous study, the BCS was the highest at early lactation and lowest between d 40 and 70 after calving (4.1) which increased gradually at the end of the gestation period (Lassen et al., 2003). In tropical cattle, lactation length gradually increases from 1st to the 2nd parity and milk yield also increases simultaneously (Musa et al., 2012). There was no difference between lactation length of the 1st parity from the 2nd parity in our study although milk yield was significantly higher in 2nd parity compared with 1st parity (Table 1). In a previous study (Musa et al., 2012), average daily milk yield increased gradually from the 1st parity at 4.4 kg/day up to 5.8 kg/day in the 3rd parity which reached the peak, persisted for a while and finally decreased for tropical cattle which supports our study.

Reproductive performance

In a previous study, Karim et al. (2019) reported that the age at puberty of the RCC was 37.0±2.2 month which was higher than the present study. It was also reported that the temperate breeds came into maturity at an earlier age than the breeds of the tropical environment (Nath et al., 2016). Novakovic et al. (2011) reported that in case of Holstein-Friesian (HF) cow, the average age at first conception was 491.2±9.4 day or 16.2±0.3 month which was lower than the present study but there was no comparison between the 1st and the 2nd parities. Desselegn et al. (2016) reported that the average age at 1st service was 18.7±3.7 and 18.7±3.5 month for the cross-breed cattle which support the findings of the present study. In another study, cows in parity 2 had significantly higher (P<0.01) conception rate than the cows in parity 1 (72.8% vs. 44.8%) (Yusuf et al., 2017). Das et al. (2022) reported that the gestation length of the RCC was 283.0±3.0 day which was similar to our study but there was no more information regarding the comparison between the 1st and the 2nd parity although in our study there was no significant difference between the two subsequent parities (Table 1).

Habib et al. (2010) reported that the dry period in the 1st and 2nd parity was significantly different (P>0.05) which is consistent with the present study where 1st parity dry period was higher than the 2nd parity. Habib et al. (2010) further reported that post-partum estrous was higher in the 1st parity compared with the 2nd parity which supports our study. Average length of days open did not differ between parity 1 and parity 2 in a previous study (Yusuf et al., 2017) which is closely consistent with our study. The calving interval of the cows in parity 2 and parity 3 were 508.2±121.5 day and 495.5±144.1 day, respectively in a previous study which indicated no significant difference (P=0.39) between the two groups (Yusuf et al., 2017). Closely similar result was reported in the present study (Table 1).

Effect of parity

Milk yield was related to the order of parity of the cows in a series of previous studies (Marumo et al., 2022; Bafandeh et al., 2023). The lowest milk yield was found in the first parity which increased linearly with advancement of lactation until the 4th parity in case of HF cow (Kul, 2021) which support similar trends that we observed in the present study where milk yield was increasing in the 2nd parity compared with the 1st parity. Consistent results were reported elsewhere by Cinar et al. (2015) and Kul et al. (2019) who observed that milk yield was expressively affected by the advancement of parity. The present study further confirmed the findings of Cobanoglu et al. (2019) who identified that milk yield was considerably high (P<0.01) in the 2nd parity compared with the 1st parity. In the same way, Mostert et al., (2001) described that the cows calving in 1st and 2nd lactations had less milk production than those at further mature ages. The variations observed among these studies could be due to different management systems, feeding regime and other environmental factors (Habib et al., 2010) although milk yield was consistently higher in 75-150 day both in 1st and 2nd parities for all the RCC population. Similarly, Habib et al. (2010) noticed significant (P<0.05) difference in the daily milk yield among different parities.

Effect of breeding type

We assumed that the artificial insemination (AI) calf weight will be higher than the natural service (NS) calf which supports the present study. Valergakis et al. (2007) reported that the daughters of proven AI sires were producing 896 kg more milk per cow per year than the daughter of NS bull. In the same way, the HF herds bred primarily by AI had the greatest percentage of cows in milk than the herds bred primarily by the NS bull. More cows conceived earlier in the breeding season by the AI than the natural services in case of HF cow (De Vries, 2005) which supports the present study. The overall pregnancy loss considering the gestation period from day 28 to 56 in the NS group and 32 day for AI was lower (P=0.02) for NS than the AI-bred cows (10.4% vs. 15.2%; P<0.05), respectively. Smith et al. (2004) observed that HF herds bred primarily by AI had significantly fewer days dry period compared with the other groups which does not support the present research. It may be due to breed-to-breed variation. The post-partum period of HF was greater for NS than the AI (NS=84.8% and AI=76.4%, P=0.009). The median time to pregnancy by 223 day postpartum was shorter for NS bred cows (111 day [95% CI=104 to 125) than the AI bred cows (116 day [95% CI=115 to 117]) (Risco et al., 2009) which does not support present study perhaps because of variations due to breed.

CONCLUSION

Milk yield of RCC is positively correlated with live weight and post-partum period. Decreased probability of milk fever, mastitis, metritis and infertility increases milk yield in RCC. Collectively, days open, calving interval and service per conception are the principal determinants of the performance of RCC. Overall, RCC performs better in the 2nd parity compared with the 1st parity.

DECLARATIONS

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Ethics and consent to participate

The entire experimental protocol was followed by the animal welfare law in Bangladesh.

Authors' contributions

M Tabassum performed development of the questionnaire, baseline survey, data collection, literature research, and first draft. Md. R Prank, SK Paul, N Akter, S Islam and S Islam conceptualized the study and developed the questionnaire. Project management, data curation, generalized linear modelling, principal component analysis, hierarchical clustering, response surface modelling, result interpretation, and draft finalization were handled by Md. E Hossain. The final manuscript was reviewed and approved by all the researchers.

Availability of data and materials

The data may be available on request under reasonable ground.

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Consent to publish

Not applicable.

Competing interests

The authors declare no competing interests in this research and publication.

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