frontiers in Sustainable Food Systems

REVIEW
published: 12 August 2021
doi: 10.3389/fsufs.2021.688641

Red Chittagong Cattle: An Indigenous Breed to Help Tackle the Challenges of Modern Animal Production Systems

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Modern livestock selection is rapidly condensing the indigenous cattle gene pool. This trend limits the options for future genetic selection to benefit both animal well-being and farmer challenges. Here we reveal the potential of Red Chittagong cattle (RCC), a native genotype of Bangladesh, for tackling these current and pending challenges. Red Chittagong cattle are reddish in color and small in size with mature bulls and cows weighing 342 and 180 kg from birth weights of 16 and 14 kg, respectively. Whilst low mean levels of milk production of 618 L across a 228-day lactation are recorded so are high levels of milk protein (3.8%) and fat (4.8%) with offered feed types typically low in nutritive value, particularly crude protein. However, one in five cows under farm condition yield >1,000 L/lactation. Alongside high levels of milk protein and fat, other key features of this breed include resistance to common diseases and parasites with a high level of adaptation to agro-ecological conditions. As opposed to other indigenous breeds, there is currently high genetic variation in the RCC population, and associated variation in productive and reproductive traits highlighting the opportunity for development through long-term breeding programs alongside improved management conditions. Such efforts would enable this breed to become a global resource for tackling the challenges of modern animal production systems. In addition, further work is required to reveal the demographic distribution of the breed, potential production levels through the provision of improved diets and the mechanisms enabling disease resistance and digestibility of feeds.

Keywords: Bangladesh, genetic variation, heritability, milk production, morphology, origin and distribution

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Specialty section:
This article was submitted to Agroecology and Ecosystem Services, a section of the journal Frontiers in Sustainable Food Systems

Received: *31 March 2021*
Accepted: *20 July 2021*
Published: *12 August 2021*

Citation:
Das NG, Islam MR, Sarker NR, Jalil MA and Clark CEF (2021) Red Chittagong Cattle: An Indigenous Breed to Help Tackle the Challenges of Modern Animal Production Systems. Front. Sustain. Food Syst. 5:688641. doi: 10.3389/fsufs.2021.688641

INTRODUCTION

The transition of agriculture from the Neolithic age to the intensive commercial systems of today helps ensure food security and better standards of living for the growing global population (Silbergeld, 2019). In many commercial animal production systems around the world, high producing animals of similar genotypes are typically reared in confined housing systems with mechanically processed feedstuff. Recently, farms in Bangladesh have introduced Holstein genetics into more intensive systems from Australia and the Netherlands. Such high producing animal genotypes are reared to achieve high productivity and profitability, largely omitting native animal genotypes which threatens their survival as a breed. Moreover, such intensification may increase the risk of disease transmission both between animals, and animal-to-human, alongside antibiotic resistance (Leibler et al., 2017; Aidara-Kane et al., 2018). Therefore, long term sustainability of intensive livestock production using commercial breeds, which mostly developed in the temperate countries, is questionable especially under tropical climatic condition. In contrast, native livestock resources in tropical countries evolved through natural selection based on the phenotype characteristics and organoleptic evaluation (tastes of products) preferred by the native consumers whilst these local breeds are typically adapted to prevailing hot and humid climates, locally available feeds, are resistant to parasitic and diseases, and have a greater survival rate, giving birth to a calf every year (i.e., more fertile). For example, Khan et al. (2012) reported the profitability of rearing crossbred dairy cows in Bangladesh (Holstein × Indigenous cattle) was less than native Red Chittagong Cattle (RCC) on a lifetime productive performance basis. Also, indigenous cattle genetic resources are usually resistant to some parasites, disease infections and environmental stress in their natural habitats (Nyamushamba et al., 2017). Therefore, maintaining an improved balance between intensification of commercial genotypes (mainly Holstein and their crossbreds/hybrids that are frequently reared in commercial farms) and the extension of high producing local genotypes may help ensure food and nutrition security and improve health of local communities by keeping antibiotic resistance of animals and reducing community disease transmission into the future. In this context, this review will focus on the native Red Chittagong cattle (RCC) breed of Bangladesh—a breed developed under highly challenging environmental conditions.

The name "Red Chittagong" cattle is derived from the breed's reddish coat color (Huque et al., 2010; Bhuiyan, 2013; Sultana, 2018) and the name of its natural breeding habitat—Chittagong, Bangladesh. Red Chittagong cattle are regarded as an improved native cattle species in Bangladesh (Mason and Buvanendran, 1982; Mason, 1988). Other improved native cattle genotypes found in Bangladesh are Pabna cattle at Pabna region, North Bengal Gray at Northern region, and Munshigonj and Madaripur cattle of Central Bangladesh (BLRI, 2004; Bhuiyan et al., 2005; Hossain, 2005; Bhuiyan, 2013; Sultana, 2018). Red Chittagong cattle are a dual-purpose breed for dairy and beef production and play a key role in poverty alleviation for small holder farmers in its habitat (BLRI, 2004). The breed also has a short post-partum heat period, high conception rates, greater milk fat content (Halim et al., 2010; Bhuiyan, 2013) and high calving rate (Khan et al., 2012). In addition, the breed is more resistant to parasites and diseases prevailing in its habitats than other cattle (Ahmed et al., 2015; Chowdhury et al., 2017) with high survivability in both adults and calves (Quaderi et al., 2013). A life-time economic evaluation of different dairy cattle breeds conducted in the rural areas of Chittagong reported greater profitability of rearing RCC compared to other cattle genotypes (Khan et al., 2012). Considering these attributes, RCC may be regarded as a potential cattle genotype to tackle the future challenges of intensive animal production in Bangladesh. Therefore, the objectives of this review were to synthesize existing research knowledge of the RCC breed and reveal the potential of this breed to tackle the challenges of our modern animal production systems whilst highlighting the opportunities for future research. A review of Red Chittagong cattle distribution, genotype and the interaction of this genotype with the environment (phenotype) are provided here.

TABLE 1 | Number of Red Chittagong cattle at Chittagong, Bangladesh (2008).

Regions	TCN	RCC (%)	RCC (heads, calculated)
Anowara	24,624	9.87	2,430
Chandanaish	28,348	35.42	10,040
Raozan	40,578	19.98	8,106
Potiya	30,586	8.83	2,699
Boalkhali	10,418	14.51	1,512
Satkania	47,082	8.77	4,131
Lohagora	38,374	6.32	2,427
Banshkhali	49,625	5.26	2,610
Rangunia	48,762	1.57	768
Hathazari	26,447	13.48	3,564
Fatikchhari	85,160	1.84	1,570
Sitakunda	29,616	5.52	1,634
Total	459,620	-	41,730

TCN, total cattle number in 2008 (BBS, 2011); RCC (%), Red Chittagong cattle (Huque et al., 2010); RCC (heads), calculates as TCN × $\frac{RCC\ (\%)}{100}$.

THE DISTRIBUTION OF RED CHITTAGONG CATTLE

The main habitat of RCC is in Chittagong. A survey conducted a decade ago (2008) in Chittagong found only 9% cattle were RCC ranging from 2% in the Rangunia region to 35% in Chandanaish (**Table 1** and **Figure 1**) (Huque et al., 2010). Anecdotally, the number of RCC was decreasing due to indiscriminate crossbreeding with Holstein and other native cattle, presumably because of a common conception that crossbreds of native cattle with high-yielding breeds will produce more meat and milk, ignoring potentiality of lifetime productivity and profitability from RCC. Given these dwindling numbers, the Bangladesh Government took the initiative to protect this RCC in its habitat and develop the breed to help ensure its survival (RCC breed Improvement and Conservation Project, implemented by Bangladesh Livestock Research Institute during 2007–2012).

The impact of this government intervention is evident as per a recent survey (BSR, 2018) taken from six administrative regions of Chittagong (Anowara, Banskhali, Chandanaish, Hathazari, Patiya, and Satkania) that showed 15% of the total cattle population to be RCC. More importantly, this survey showed RCC was spreading throughout the country in the districts neighboring Chittagong such as Feni, Noakhali, Comilla, Rangamati, Bandarban, Khagrachori to as north as Mymensingh and Kurigram (Huque et al., 2010; Hamid et al., 2017; BSR,

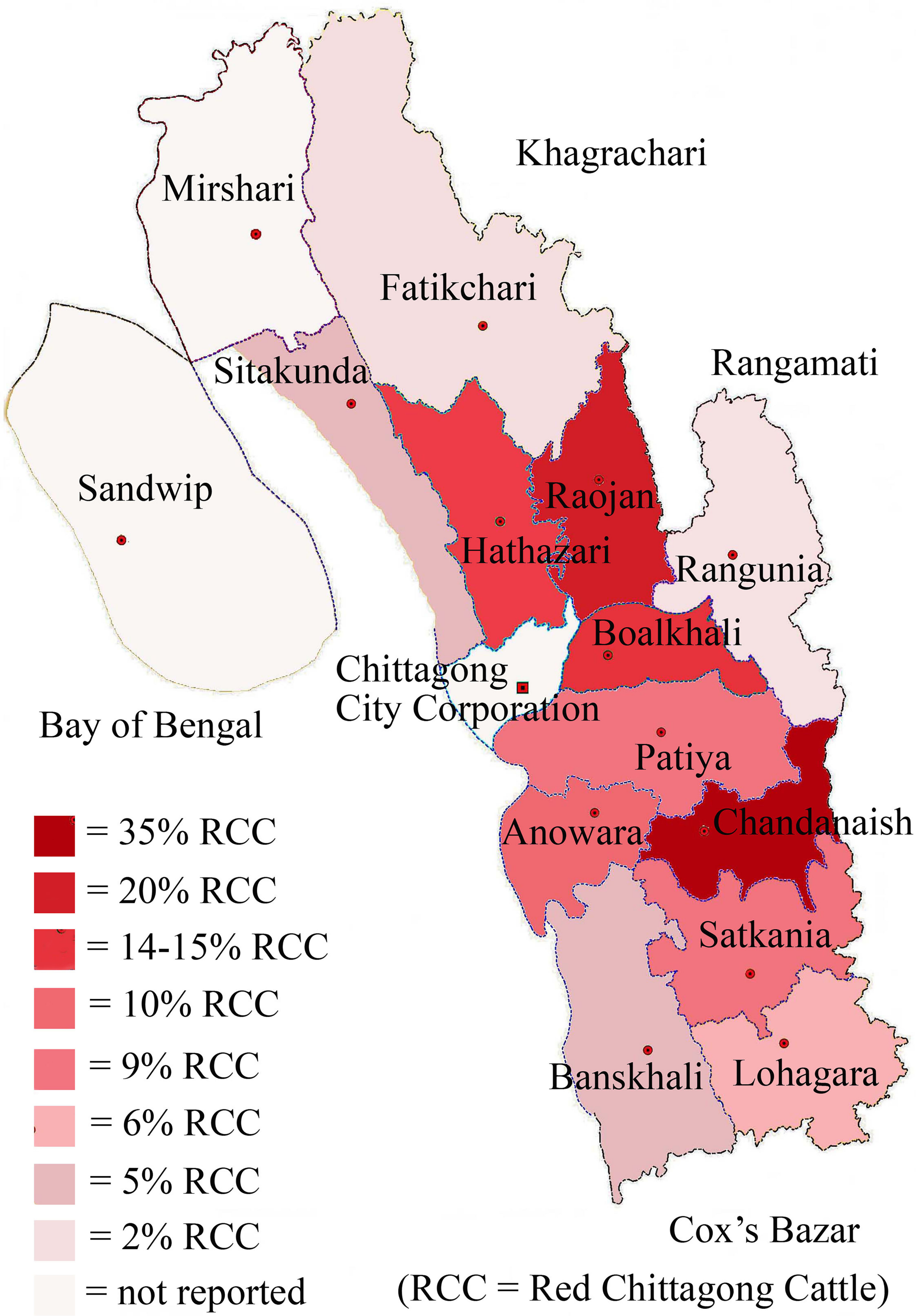

FIGURE 1 | Geographical distribution of Red Chittagong cattle at Chittagong in 2008 [adapted from Huque et al. (2010)].

2018). BSR (2018) in a recent survey reported 58% of cattle in Mymensingh sadar, 7% in Kurigram (Rajarhat) and 4% cattle in Bandarban (Naikhongchari) were RCC. Thus, a detailed survey is required to document RCC number and distribution across the country, including its impact on farmers to further steps to protect RCC and improve the breed through the genetic selection process.

GENOTYPE

The origin of the RCC breed is closely linked to Indian zebu cattle genotypes (*Bos indicus* sub species). Bhuiyan et al. (2007a) reported that the mitochondrial DNA diversity between RCC and some zebu cattle (Ongole, Sahiwal, Hariana) was lower than the diversity between RCC and some taurine breeds (Friesian and Simmental). The minimum mitochondrial-DNA nucleotide sequence divergence value between RCC and Indian zebu cattle (Sahiwal, Hariana, and Ongole cattle; 0.011, 0.012, and 0.013, respectively) compared to some taurine cattle (Friesian, Hanwoo, and Simmental; 0.054, 0.055, and 0.056, respectively) indicates a close genetic relationship between RCC and Indian zebu cattle (Bhuiyan et al., 2007a), particularly between RCC and Sahiwal. When mitochondrial-DNA nucleotide sequence divergence value was viewed across time between RCC vs. Sahiwal, Hariana, and Ongole cattle, the estimated divergence time were ∼22,700, 24,800, and 26,900 years before present (Bhuiyan et al., 2007a),

TABLE 2 | Heritability estimates of some productive traits of Red Chittagong cattle.

Productive traits	Heritability	*SD*	*N*	Minimum	Maximum	Total cattle observation
Birth weight	0.47	0.02	4	0.45	0.49	419
Weaning weight	0.48	0.01	3	0.47	0.49	401
Lactation length	0.44	0.05	3	0.39	0.47	330
Lactation milk yield	0.38	0.09	4	0.27	0.47	380
Pre-weaning gain	0.47	0.04	4	0.41	0.50	528
Post-weaning gain	0.49	0.00	2	0.49	0.49	288

SD, standard deviation; N, number of articles that reported the parameters. From Afroz et al. (2011), Afroz et al. (2012), Alam et al. (2007), Ferdous et al. (2019), Rabeya et al. (2009), and Rahman et al. (2016).

FIGURE 2 | Red Chittagong cattle of Bangladesh.

suggesting their concurrent emergence long before the time of animal domestication (about 10,000 years). The Y-chromosome specific marker test (INRA-124) also showed no introgression of taurine blood in the RCC male (Bhuiyan et al., 2007a).

Whilst natural selection played a key role in the evolution of RCC, human activity also contributed to shaping the breed such as reddish coat color and strong and stout physical conformation suitable for draft and transport (Bhuiyan et al., 2008; Bag et al., 2010). These characteristics were also in line with the needs of rural farmers and their religious and social rituals, as a mature healthy bull with attractive red color is important for sacrifice during different religious events (such as, Eid al-Adha).

Bhuiyan et al. (2007a) reported a high genetic variation of this breed within the population using mitochondrial DNA sequence

TABLE 3 | Physical appearance of Red Chittagong cattle.

Body part	Color	%	Other descriptions
Body	-	-	The body is blocky. Male is heavier than female.
Physical condition	-	-	They are strong and stout in physical condition.
Head	-	-	Head is narrow and thin with flat forehead.
Hump	-	-	Hump is well-developed and vertically erected. It is more prominent in male than female.
Legs			Legs are medium, firmly set under the body and well-apart from one another.
Ears	-	-	Ears are medium in size, alert and slightly dropping.
Coat color	Reddish	78	The hair coat is fine, short, strong and smooth with remarkable shine.
	Reddish-yellow	13	
	Reddish-white	9	
Horns	Reddish-black	94	Horns are medium and stumpy, tapering to a blunt point.
	Whitish	6	
Muzzle	Reddish	65	-
	Whitish-red	35	
Hoof	Reddish	78	-
	Pale red	12	
Eye ball	Reddish	98	-
	Blackish-red	2	
Eye brow	Reddish	100	-
Vulva	Reddish	100	-
Switch	Reddish	100	-

From Bag et al. (2010) and Bhuiyan et al. (2008).

TABLE 4 | Physical measurements of mature Red Chittagong cattle.

Parameters (cm)	Male					Female					Total cattle observation
	Average	*SD*	*N*	Min	Max	Average	*SD*	*N*	Min	Max	
Length (shoulder to pin bone)	132	3	2	130	134	111	5	2	107	114	70
Wither height	125	1	2	124	125	107	1	2	106	108	70
Heart girth	147	13	2	137	156	123	25	2	105	140	70
Horn length	12		1	-	-	11	-	1	-	-	50
Horn diameter	12		1	-	-	9	-	1	-	-	50
Teat length	-	-	-	-	-	5	-	1	-	-	50
Teat diameter	-	-	-	-	-	6	-	1	-	-	50
Distance between fore teats	-	-	-	-	-	7	-	1	-	-	50
Distance between rear teats	-	-	-	-	-	6	-	1	-	-	50
Regardless of sex											
Ear length	16		1			-	-	-	-	-	50
Ear width	12		1			-	-	-	-	-	50
Tail with switch	92		1			-	-	-	-	-	50

SD, standard deviation; N, number of articles that reported the parameters; Min, minimum; Max, maximum.
From Bag et al. (2010) and Habib et al. (2003).

TABLE 5 | Productive and reproductive traits of Red Chittagong cattle.

Parameters	Average	*SD*	*N*	Minimum	Maximum	Total cattle observation
Birth weight of male calf, kg	16	0.9	6	14	16	659
Birth weight of female calf, kg	14	0.8	6	12	15	659
Weaning age, months	8	1	4	7	9	293
Weaning weight, kg	53	5.3	8	48	65	420
Mature weight of male animal, kg	342	70	4	268	436	147
Mature weight of female animal, kg	180	14	4	160	191	721
Age at puberty of male calf, months	25	-	1	-	-	27
Age at puberty of female calf, months	29	4	19	15	33	163
Gestation period, days	283	3	23	279	287	1,742
Age at first calving, months	41	3	11	34	45	754
Post-partum estrous, days	96	33	21	40	141	1,163
Calving interval, months	14	1	26	12	15	1,978
Conception rate of cows, %	78	-	1	-	-	95
Service per conception	1.5	0.2	31	1.2	1.8	1,757
Calf survivability, %	94	2	4	93	97	1,348

SD, standard deviation; N, number of articles that reported the parameters. From Afroz et al. (2011), Alam et al. (2007), Amin et al. (2013), Asaduzzaman et al. (2017a), Asaduzzaman et al. (2017b), Asaduzzaman et al. (2019), Azizunnesa et al. (2010), Bag et al. (2010), Bhuiyan et al. (2008), Das et al. (2018), Habib et al. (2003), Habib et al. (2008), Habib et al. (2009), Habib et al. (2010b), Hamid et al. (2017), Hasanuzzaman et al. (2012), Hossain et al. (2018), Huque et al. (2010), Kamal (2010), Karim et al. (2019), Khan et al. (2000), Khan et al. (2010), Khan et al. (2012), Mostari et al. (2007), Nahar et al. (2016), Nath et al. (2016), Rabeya et al. (2009), Rahman et al. (2016), and Sarker et al. (2015).

TABLE 6 | Milk production of Red Chittagong cattle and its composition.

Parameters	Average	*SD*	*N*	Minimum	Maximum	Total cattle observation
Lactation length, days	228	24	23	161	265	2,805
Lactation milk production, L	618	124	21	453	838	1,579
Milk composition, % fresh milk						
Lactose	5.6	0.21	6	5.3	5.8	119
Milk protein	3.8	0.25	12	3.2	4.1	199
Milk fat	4.8	0.39	13	4.2	5.3	211
Solids not fat (SNF)	9.4	0.94	13	10.8	8.1	211
Total solids	14	1.24	13	13	16	211
Ash	0.3	0.32	3	0.2	0.7	46

SD, standard deviation; N, number of articles that reported the parameters. From Alam et al. (2007), Asaduzzaman et al. (2017a), Asaduzzaman et al. (2017b), Azizunnesa et al. (2010), Bag et al. (2010), Bhuiyan et al. (2008), Debnath et al. (2003), Ferdous et al. (2019), Habib et al. (2003), Habib et al. (2009), Habib et al. (2010a), Hasanuzzaman et al. (2012), Hossain et al. (2018), Huque et al. (2010), Islam et al. (2015), Khan and Mostari (2015), Khan et al. (2000), Khan et al. (2010), Khan et al. (2012), Mostari et al. (2007), Nath et al. (2016), Rahman et al. (2016), Reza et al. (2008), Sarker et al. (2015), and Sarker et al. (2019).

analysis. It also possesses moderate heritability of its productive traits, ranging from 0.38 to 0.49 (**Table 2**; Alam et al., 2007; Rabeya et al., 2009; Afroz et al., 2011, 2012; Rahman et al., 2016; Ferdous et al., 2019). The moderate heritability of traits imply that additive gene action may play a role in regulating them, and their improvement may be possible by improved management and selection practices. Bhuiyan et al. (2007b) also reported selective breeding programs as a key tool for the development of RCC.

PHENOTYPE

The phenotypic traits of RCC shown (**Figure 2**) are taken from Bag et al. (2010) and Bhuiyan et al. (2008) and are presented in **Table 3**. The measurements of mature male and female Red Chittagong cattle body parts are provided in **Table 4** and were taken from Bag et al. (2010) and Habib et al. (2003). The RCC is a readily distinguishable reddish indigenous cattle genotype with greater average body length, height at wither and heart girth (111–132, 107–125, and 123–147 cm, respectively; **Table 5**) than non-descriptive indigenous and North Bengal gray cattle (106, 100, and 129 and 100–105, 93–94, and 122–127 cm, respectively; Hamid et al., 2017), but much lower than Pabna cattle (164, 118, and 148 cm, respectively; Hamid et al., 2017). Therefore, RCC may be regarded as a medium-size breed amongst native Bangladeshi genotype, but a small genotype compared to crossbreds or temperate breeds.

TABLE 7 | Prevalence of diseases and parasites in Red Chittagong cattle.

Prevalence of diseases and parasites (% cattle)	Cattle genotypes			Total cattle observation
	Red Chittagong cattle	Local	Crossbreds	
Gastrointestinal parasites	55	64	71	100
Blood parasites	9	-	13	560
Subclinical mastitis	28	31	56	198

From Ahmed et al. (2015), Chowdhury et al. (2017), Quaderi et al. (2013), and Siddiki et al. (2010).

GENOTYPE ENVIRONMENT INTERACTION

Production and Reproduction

The productive and reproductive characteristics of the RCC breed are provided in **Table 5**. Overall, the birth weight of the RCC calf was between 14 and 16 kg (**Table 5**) similar to non-descriptive indigenous, but lower than Pabna, and North Bengal gray cattle (15, 21, and 18 kg, respectively; Bhuiyan, 2013). RCC heifers reached puberty 5, 9, and 7 months earlier than Munshiganj, Pabna, and Sahiwal cattle genotype in Bangladesh (34, 38, and 36 months, respectively; Bhuiyan, 2013). The gestation period of RCC (283 ± 3 days) was similar to other cattle genotypes in Bangladesh and the post-partum estrus of the RCC cow (96 ± 33 days) was lower than Sahiwal and Sindhi crossbreeds (105 and 127 days, respectively; Islam et al., 2014a). The mature live weight of RCC (180–342 kg) was greater than indigenous cattle (120–180 kg; BLRI, 2004), but lower than crossbreds (300–550 kg; BLRI, 2004).

The calving interval of RCC at 14 months (14 months; **Table 5**) was similar to non-descriptive indigenous cattle, North Bengal gray, and Pabna cattle (15, 15, and 14 months, respectively; Bhuiyan, 2013). The service per conception (1.5; **Table 5**) was greater than non-descriptive indigenous, Pabna cattle, North Bengal gray, and Munshiganj cattle of Bangladesh (1.4, 1.3, 1.4, and 1.3, respectively; Bhuiyan, 2013) and calf survivability was 94% which was similar to non-descriptive indigenous, but higher than crossbreds at farm level (83%; Khan et al., 2012). The RCC cow reached puberty at 29 months, gave birth every 14 months and returned to heat by 96 days post-partum, better than other indigenous and crossbred cattle in Bangladesh.

The quantity and quality of RCC milk is presented in **Table 6**. On average, the RCC cow produced 618 L of milk across a 228-day lactation period, with a daily milk yield of 2.7 L/day, which contained high fat and protein content. The greatest RCC milk production herd was from the Bangladesh Livestock Research Institute (BLRI) recorded to be 838 L from a 219-day lactation (4 L/day; Khan and Mostari, 2015). In the BLRI herd, 18% of the cows produce more than 1,000 L of milk in a lactation, with the greatest recorded production from a single cow being 1,436 L in one lactation (Khan and Mostari, 2015). This high phenotypic variation in milk production per lactation (618–1,436 L) suggests that there is a great prospect for the development of RCC through selective breeding. Production of 1,436 L milk per lactation is substantial from a mature RCC cow of 180 kg live weight (**Table 5**), and it would be equivalent to ∼6,000 L/lactation from a modern Holstein Friesian of 700 kg mature live weight. This suggests that the feed conversion ratio of RCC could be similar to Holstein Friesian cows but there is no comparative study available on this issue. A 2-year comparative study at farm level reported greater lactation length and milk yield of RCC (265 days and 597 L, respectively) than non-descriptive indigenous varieties (258 days and 497 L, respectively), but lower than crossbreds (285 days and 1,272 L, respectively) (Khan et al., 2012). However, rearing RCC was reported to be more profitable than Holstein x local crossbred cows based on lifetime production performance (Khan et al., 2012). These researchers reported greater calving rate and calf survivability and lower calving intervals of RCC compared to crossbred cows. In addition, feed requirements, health and reproduction costs of RCC were lower compared to crossbred cows. The fat content of RCC milk (4.8%; **Table 6**) was greater than indigenous and Holstein crossbreds in Bangladesh (3.7 and 3.4%, respectively for indigenous and crossbreds; Islam et al., 2014b). Also, RCC milk contained greater milk protein and lactose (3.8 and 5.6%, respectively; **Table 6**) compared to indigenous cattle (3.6 and 5.1%, respectively), Holstein crossbreds (2.7 and 4.6%, respectively), and buffaloes (3.5 and 4.7%, respectively) (Islam et al., 2014b).

Disease Resistance

The prevalence of diseases and parasites in RCC is presented in **Table 7**. RCC cattle is more resistant to common diseases and parasites than other native and crossbreds. The prevalence of gastrointestinal parasites in RCC was about 9 and 16% lower than local cattle and crossbreds, respectively (Ahmed et al., 2015; Chowdhury et al., 2017). Blood parasites were also 4% less prevalent in RCC than crossbreds (Siddiki et al., 2010). Subclinical mastitis in RCC was half the prevalence in crossbreds (Quaderi et al., 2013).

CONCLUSIONS AND RECOMMENDATIONS

Red Chittagong cattle are a red colored, small-sized genotype that are more fertile and resistant to common parasites and diseases compared to crossbreds and suitable for the small-holder farmers in the tropics. This genotype has the potential to be developed as a native dairy cattle breed of Bangladesh by the establishment of a well-planned, long-term, selective breeding program due to the high genetic and phenotypic variation within the current population. Also, promoting the benefits of this genotype across Bangladesh may help conserve this genetic resource at a farm level. A long-term plan is necessary to benchmark its current distribution throughout Bangladesh and its impact on smallholder farming. In addition, research is required as to the mechanisms enabling their resistance to environmental stress and tropical diseases.

AUTHOR CONTRIBUTIONS

ND literature search, data synthesis, imagery processing, and drafting manuscript. CC and MI conceptualizing, literature search, drafting reviewing, and editing of manuscripts. CC, MI, NS, and MJ supervising the work. All authors contributed to the article and approved the submitted version.

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