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Determination of Conception Rate and Associated Risk Factors in Cattle in Selected Areas of Bangladesh

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Abstract | Conception rate (CR) is an important factor in determining the reproductive efficiency of dairy herds. Numerous factors can affect CR. Correlation of different risk factors for CR in cross-breed dairy cows in different areas of Bangladesh was not studied. The study was designed to estimate the CR in dairy cows and to determine the risk factors that may have an impact on CR. For this purpose, total of 710 cows and heifers were randomly selected from Phultala, Dumuria and Koyra upazila of the Khulna district and Madhukhali Upazila of Faridpur district and their data were collected using a structured questionnaire at the time of artificial insemination (AI). Conception of individual animals were recorded by non-return to estrus after 35 or more days. Descriptive statistics with chi-square test were performed to check the difference of CR according to different risk factors where confidence interval was 95%. A multivariable logistic regression model was used for correcting potential confounders was conducted to test the main effect on CR by using SPSS 26. The overall CR was 70.28% in this study. The result revealed that among the parameters studied in this experiment breed of cow/heifer, breed of bull, percentage of bull semen, season of the year, and experience of the AI technician had minimal effect on CR. Only the time between heat to AI, body condition score (BCS), age of animals and parity were significant terms ($p<0.05$). When considering these four variables in the analysis by logistic regression model, results revealed that only time between heat to AI and BCS of animal were found to be significant predict for CR. Increased time between heat and AI were more likely to lower the CR and BCS 3 can increase the likelihood of conception by 2.03 times compared to BCS 4, which increases it by 1.16 times (95% CI). From this data it was concluded that during insemination the AI time and BCS of the animal should be addressed carefully for maximizing the CR in field condition.

Keywords | Artificial insemination, Conception rate, Age, Parity, BCS

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INTRODUCTION

The artificial Insemination (AI) technique has been used in Bangladesh for over 50 years, and the program is being extended every year. The leading role in this AI sector is being played by the Department of Livestock Services (DLS), run under the Ministry of Livestock and Fisheries, Peoples Republic of Bangladesh. Besides this,

several non-government organizations are also practicing AI in the country, *viz.*, Bangladesh Rural Advancement Committee (BRAC), ACI Animal health, and American Dairy Limited (ADL) etc. All entrepreneurs now-a-days uses frozen semen for AI. But, the CR (CR) differs in field conditions (Kabir *et al*., 2018). CR is an important factor to determine the reproductive efficiency of dairy herds. In some recent studies it was found that CR in cows were 70.0% (Biswas *et al*., 2022) and 72.0% (Howlader *et al*., 2019) at different area of Bangladesh. The difference in CRs is found to be associated with numerous factors according to different studies such as source of semen, breed of cow/bull, age of animals, parity of animals, body condition score (BCS), timing of artificial insemination, experience of AI technician, season of the year, breed of bull semen, daily milk production.

It was found that, higher CR was found in local breeds than other cross breeds cows in different part of Bangladesh (Howlader *et al*., 2019; Hossain *et al*., 2015; Khan *et al*., 2015). In case of parity, higher CR was found in both 2 and 3 number of parities compared to heifers or nulliparous (Khan *et al*., 2015) which contradicts with Hossain *et al*. (2016). It was generally accepted that good BCS between 3.0-4.0 has a great influence on fertility of cows (Pfeifer *et al*., 2021). However, milk production can be influenced by BCS at calving, though it was well established that genetic merit and nutrition could influence the milk production (Cutullic *et al*., 2012). Lower BCS at calving and low milk production at up to 60 days could influence the CR in small scale dairy cows (Montiel-Olguín *et al*., 2019).

Determining the optimal time for AI is a significant challenge. There was a large variation between onset of estrus and ovulation (Bloch *et al*., 2006). Although AI was always performed based on visual observation of estrus behavior. However, highest CR was found when AI was performed between 8-16 hours after estrous signs (Islam *et al*., 2021). CR was also increased when some hormone GnRh was used during AI (Pursley *et al*., 1998). Experience of the AI technician may also affect the CR, experienced AI technicians are supposed to achieve better result (Miah *et al*., 2015; Sepúlveda *et al*., 2020). With continuous changes in weather condition and decreasing the intensity of estrous sign of dairy animals, it is important to investigate the factors associated with CR on regular basis in different part of a country. On the other hand, these two areas were milk pocket for milk production. Additionally, there was a lack of information regarding the CR of small-scale dairy farm in Khulna and Faridpur districts of Bangladesh where cross bred animals have progressed rapidly over last few years with providing of adequate supply of frozen semen for performing AI. Thus, the present study is going to provide a partial scenario of AI status at these areas and also find out the risk factors at these area in regards to conception failure of cross-bred dairy cows. Therefore, the objective of the study was to measure the CR and associated risk factors in the cross-bred cows at the study area.

MATERIALS AND METHODS

Study Area

The study was conducted in Phultala, Dumuria and Koyra upazila of the Khulna district and Madhukhali Upazila of Faridpur district, Bangladesh (Figure 1).

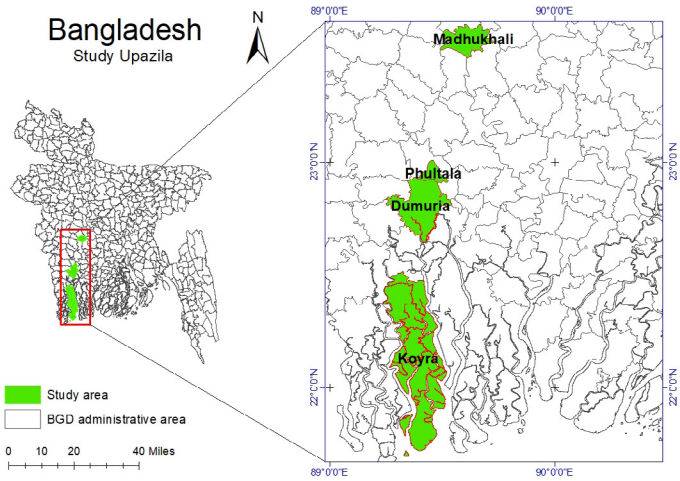

Figure 1: Study area map. The green color marked areas indicated four upazila of Bangladesh where the study was conducted.

Study Period

The data collection was continued from August 2022 to May 2023.

Study Animals

A total of 710 animals, comprising local breeds and crosses of Holstein Friesian and Sahiwal, were randomly selected for this study. The animals that were healthy, with no apparent disease conditions and showing regular estrous cycles, were selected. The animals those came to estrous in the study area and attended by our selected AI technicians, were included in this study after recording of information of farmers and the animals according to the prescribed questionnaire.

Data Collection Procedure

The data were collected using a structured questionnaire. The questionnaire was supplied to different AI technicians in the study area and they collected the information according to the questionnaire during the time of AI. All the required information of the questionnaire was explained in details with the AI technicians while delivering it to them. They were also practically trained how to note the information by directly participating in data collection procedure at

the field during the time of AI. After 35 days or more from the AI, the owner informed the AI technician on the status of the animal regarding conception and tentative diagnosis was made by non-return to estrous. After 90 days or more, confirmatory diagnosis was made by using rectal palpation technique.

Estrus Detection and Artificial Insemination

Estrous detection of cows was basically done by the respective farmers. They observe the cows frequently during taking care of them. When the farmers found the cows in estrous by observing estrous sign such as redness and swelling of vulvar region, restlessness, frequent urination and drooling of mucous, they call for their preferable AI technician and informed the time of estrous signs. The AI technician confirm the estrous stage by palpation of reproductive tract through rectal examination, including the uterine horn tone, mature follicle on the ovarian surface and standing to be mounted. Then, the AI technician selected a reasonable time slot to visit the client and, upon visiting, reexamined the clinical symptoms either through behavioral signs of the cow or by rectal palpation.

Determination of Parity of Cows and Heifers

Parity was recorded by taking history of the cows from the owner. Heifers were recorded as zero parity, and parity 1, 2, 3, 4, 5, 6, 7, 8 was recorded by respective calving numbers.

Determination of Age of Cows and Heifers

The age was determined by both taking history from the owner and using dental formula as previously explained by Banerjee (2010).

Conception Rate

The CR is the percentage of cows pregnant divided by the number of cows inseminated. The conception was determined by non-return to subsequent estrous or more than 35 days after the first AI and by rectal palpation after 90 days or more.

$$Conception\ rate = \frac{Total\ no.of\ heifer/cows\ conceive}{Total\ no.of\ heifer/cows\ receiving\ AI} \times 100$$

Statistical Analysis

The collected data were recorded and coded in MS Xcel sheet. The rate is expressed as a percentage (%). The analysis of variance (ANOVA) was done by using SPSS 26 statistical software for interpreting the CR between different breed of cows with the using different type of semen. Differences has been considered significant at P<0.05 and highly significant at P<0.01. Descriptive and Chi-squared test was done for all data. A multivariable Logistic regression model was used for identifying the probability of a binary outcome while facilitating easy interpretation using odds ratios. This analysis also helps to isolate the true relationship between independent and dependent variables by reducing bias.

RESULTS AND DISCUSSIONS

A total of 710 cows were selected for this study. Local breeds, crosses of Holstein Friesian and Sahiwal were included. Both cows and heifers were included in the study. The age of these cows/heifers were categorized as 18-24 months, 25-48 months, 49-72 months, and 73-156 months. Different parity of cows was also included in the study. The overall CR of the animals was 70.28%, which relates to the findings of Biswas *et al*. (2022) who found 70.0% CR and Howlader *et al*. (2019) who also found and 72.0% CR. Strength of association between different potential factors was measured by Correlation-coefficient. A multivariable Logistic regression model was used for correcting potential confounders was conducted to test the main effect on CR.

In the present study effect of age, parity, BCS, milk yield of animals, breed of bull semen, breed of animals, semen percentage, season, time between estrus sign and AI, study area and experience of AI technician on CR was measured. Among them, milk yield of animals, breed of bull semen, breed of animals, semen percentage, season, study area and experience of AI technician had less effect on CR while age, parity, BCS and time between estrus sign and AI had significant effect on CR (Table 1). It was found that animals in earlier age and parity had significantly higher CR than other older groups.

Animals within the age range of 18-24 months and of 1st parity had 74.00% and 74.90% CR respectively (P<0.01). This finding partially correlates with Chebel *et al*. (2004), who found highest (55.2%) CR in nulliparous animals and Miah *et al*. (2004) who interpreted that the CR was increased up to 2nd parity and then decreased up to last parity 5th parity and Khatun *et al*. 2014 who also found that Cows at parity-1 had highest CR (73%) and cows at parity 6 had lowest CR (25%). Older animals are more susceptible to experience calving difficulties or other periparturient problems, while younger animals have a lower chance of such issues. The animals of BCS-3 also had significantly higher CR than BCS-2 and BCS-4 (P<0.01). The result contradicts Potdar *et al*. (2016), who investigated and found that body condition has no significant effect on CR study. On the contrary, this study is partially in agreement with Hossain *et al*. (2016), who explained that heifers having BCS 3.0-3.5 had highest (53.8%) CR while those having BCS 2.0 had lowest (48.5%) CR. So, adjusting the nutritional management to obtain desired body condition at different stages of production is necessary to enhance production efficiency.

Table 1: Effects of different univariable on CR of cows/heifers during the study period.

Variable	Value	No. of cows inseminated	No. of cows conceived	CR %	Chi-square (χ^2) value	P-value
Age of animals (Months)	18-24	192	142	74.00	9.63	0.02*
	25-48	276	195	70.70		
	49-72	182	130	71.40		
	73-156	60	32	53.30		
Parity	0	211	158	74.90	13.24	0.02*
	1	157	109	69.40		
	2	151	108	71.50		
	3	94	65	69.10		
	4	58	41	70.70		
	5-11	39	18	46.20		
BCS	2	337	212	62.90	17.04	0.00*
	3	356	275	77.20		
	4	17	12	70.60		
Milk yield (Liter/day)	0	213	160	75.10	6.33	0.10
	1-5	253	164	64.80		
	6-10	201	145	72.10		
	11-32	43	30	69.80		
Breed of bull semen	HF	606	422	69.64	0.05	0.39
	SW	104	77	74.04		
Breed of animals	HF cross	503	359	71.40	2.42	0.30
	Local	96	61	63.50		
	SW cross	111	79	71.20		
Semen percentage	62.5	34	24	70.60	3.29	0.51
	75	274	185	67.50		
	87.5	63	42	66.70		
	93.75	14	9	64.30		
Season*	Rainy	119	89	74.80	5.08	0.08
	Winter	125	78	62.40		
	Summer	466	332	71.20		
Time between estrus sign and AI (hours)	11-14	96	78	81.20	13.14	0.01*
	15-20	378	265	70.10		
	21-24	186	129	69.40		
	25-30	34	20	58.80		
	31-48	16	7	43.80		
Study area	Dumuria	435	303	69.70	6.29	0.10
	Phultala	127	91	71.70		
	Koyra	98	76	77.60		
	Madhukhali	50	29	58.00		
Experience of AI Technician (Year)	2-6	229	157	68.60	0.94	0.62
	7-9	181	132	72.90		
	>9	300	210	70.00		

* Rainy: August to October; Winter: November to February; Summer: March to May.

In case of effect of time spent between estrous sign and AI, it was observed that, when the time was between 11 to 14 hours from the estrous sign and AI the CR was highest (81.20%) followed by less CR with increasing time gap. This is completely in agreement with Miah *et al.* (2004) who found highest CR, when insemination was done between 11-14 hours and partially in agreement with Islam *et al.* (2021), Howlader *et al.* (2019) and Mollah *et al.* (2015) whose findings summarize the fact that CRs increase when insemination is done between 12 to 18 hours and markedly declines after 24 hours of the onset of estrous. Delaying AI declines the CR because oocyte moves fast from the ovulation site to the fertilization site in the oviduct, and each oocyte's viable lifespan is short (Bombardelli *et al.*, 2016). Oocytes that are expected to develop into normal, healthy embryos must usually be fertilized within ten hours of ovulation. On the other hand, Sperm cells must remain in the female reproductive system for six to eight hours before they can fertilize an oocyte (Dalton *et al.*, 2001). Therefore, timely insemination of animals is very much important to attain fair CR at field level.

In this study, semen from two different breeds of bull was used (*viz.* HF and SW) to three different breeds of cow (*viz.* HF, Local and SW). However, corresponding breed of semen have the higher CR compared to any crossing (Table 2). This finding was related with Miah *et al.* (2004) and Khatun *et al.* (2014) who observed no significant difference (P>0.05) in CR among cows inseminated with semen from bulls of different genotypes. However, when the cows of a particular breed were inseminated with the semen from the same breed of bull, the CR was numerically higher than the other. It is difficult to investigate the impact of cow`s genotype on their CR. Environmental and management strategy might have more influence on this factor that requires more intensive study.

Table 2: Effect of bull semen on CR when inseminated with different breed of cow/heifer.

Breed of bull semen	Cow breed	Total number of animals inseminated	Total number of animals conceived	P-Value
HF	HF	503	359 (85.07)	0.12
	Local	86	52 (12.32)	
	SW	17	11 (2.61)	
SW	HF	0	0 (0.0)	0.23
	Local	10	9 (11.69)	
	SW	94	68 (88.31)	

In this study CR was found higher (74.80%) in summer season than rainy (62.40%) and winter (71.20%) seasons. This result agrees with Potdar *et al.* (2016) who commented that CR was higher (45.15%) in the cows which were

inseminated in summer than the cows were inseminated in monsoon (45.07%) and winter (39.51%). On the contrary, Miah *et al.* (2004) found higher CR (53.07%) in the cows which were inseminated in spring than the cows were inseminated in summer (37.89%) and winter (39.42%). This factor can be explained by availability of grasses and fodders in particular area in particular season. The effect of location was not found significant ($p>0.05$) in the present study but the CR varied in different regions of the study area. The highest (77.60%) CR was found in Madhukhali upazila of Faridpur and the lowest CR was found in Koyra (58.00%) upazila of the Khulna. In Phultala and Dumuria the CR was found 71.70% and 69.70% respectively. CR slightly varied in accordance with the experience of the AI technicians but the difference was not found statistically significant in this study ($p>0.05$). The CR achieved by the AI technician having 2-6 years, 7-9 years and 10-11 years of experience was 68.60%, 72.90% and 70.00% respectively. This study partially in agreement with Sepúlveda *et al.* (2020) and Miah *et al.* (2015) who also found higher CR with more experienced technician. However, the present study contradicts this, showing a slightly lower CR (70.00%) for technicians with 10-11 years of experience compared to those with 7-9 years of experience (72.90%). It can be explained by the fact that, in field condition, AI technicians with extensive experience receive numerous calls from farmers, increasing the likelihood of unintentionally delaying insemination in some cases.

To find out the potential confounders among all this factors, logistic regression model was run on the factors that significantly affected the CR like time between heat to AI, BCS of cows, age of animals and parity of animals. After the backward elimination procedure, season of the year, experience of AI technician, breed of semen, number of AI per conception, breed percentage of semen, breed of heifer/cow, milk production, and working area also were not significant variables. Only the time between heat to AI, BCS of cows, age of animals and parity of animals were significant terms and remained in the final model. Therefore, the model contained four independent variables (Table 3). The full model containing all predictors was statistically significant, χ^2 (14, N =710) =70.3, $p<0.001$), indicating the model was able to distinguish among the variable. The model as a whole explained between 5.5% (cox and snell R square) and 7.9% (Nagelkerke R square) of the variance in conception status and correctly classified 70.6% of cases. As shown in Table 3 only two of the independent variables made a unique statistically significant contribution to the model (Time between heat, AI, and BCS). The strongest factor was BCS-3, with an odds ratio of 2.03. This indicated that controlling with all other factors in this model, only BCS-3 can influence at least 2 times to CRs. However, odds ratio 0.48 to 0.16 for times between heat to AI was less than 1, indicating that delay the AI could negatively influence the CR and it was statistically significant, controlling the others factors in the model. The other variables parity and age of animals were not found to be significant predict for influencing CR.

Table 3: Logistic regression model of multiple variables for CR in the study area.

Predictor Variable	Value	Frequency	β	Odds Ratio	95% Confidence Interval for Odds Ratio		Significance P-value
					Lower	Upper	
Time between heat and AI (hour)	11-14h	96		Ref.			
	15-20h	378	-0.736	0.48	0.27	0.85	0.01
	21-24h	186	-0.752	0.47	0.25	0.88	0.02
	25-30h	34	-1.285	0.28	0.11	0.67	0.00
	31-48h	16	-1.847	0.16	0.05	0.52	0.00
BCS	BCS-2	337		Ref.			
	BCS-3	356	0.706	2.03	1.42	2.89	0.00
	BCS-4	17	0.145	1.16	0.39	3.46	0.80
Parity	0	211		Ref.			
	1	157	-0.518	0.60	0.18	1.97	0.40
	2	151	-0.454	0.64	0.19	2.17	0.47
	3	94	-0.735	0.48	0.11	2.00	0.31
	4	58	-0.580	0.56	0.12	2.52	0.45
	5-11	39	-1.505	0.22	0.04	1.38	0.11
Age of animal (Month)	18-24	192		Ref.			
	25-48	276	0.415	1.52	0.46	4.98	0.49
	49-72	182	0.674	1.96	0.49	7.93	0.34
	73-156	60	0.701	2.02	0.36	11.41	0.43
	Constant		1.291	3.64			0.00

CONCLUSION AND RECOMMENDATIONS

In conclusion, the study found that cow/heifer breed, bull semen breed and percentage, season, and AI technician experience had minimal impact on CR. However, time from estrus to AI, BCS, age, and parity significantly affected CR. However, among them only estrus-to-AI timing and BCS were identified as key factors for impact on CR. Farmers should prioritize proper insemination timing and maintaining cow health for better breeding outcomes. The strategic plan should be implemented to improve the CR in crossbred cows in Bangladesh by providing proper guidelines to AI technicians.

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NOVELTY STATEMENT

This study provides novel insights into the factors affecting CRs in cross-bred dairy cows in Bangladesh, particularly emphasizing the importance of timely artificial insemination and body condition score (BCS). The findings offer practical guidelines for improving reproductive efficiency in small-scale dairy farms, which have not been extensively studied in this region.

AUTHOR'S CONTRIBUTIONS

Conceptualization: Dibyendu Biswas.
Methodology: Amit Roy and Dibyendu Biswas.
Formal analysis: Dibyendu Biswas and Ashit Kumar Paul.
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Writing review and editing: Dibyendu Biswas and Ashit Kumar Paul.

Conflict of Interest

The authors have declared no conflict of interest.

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