J Anim Reprod Biotechnol 2022;37:266-275
pISSN: 2671-4639 • eISSN: 2671-4663
https://doi.org/10.12750/JARB.37.4.266

JARB
Journal of Animal Reproduction and Biotechnology
Check for updates

Original Article

Heat stress effects on fertility and reproductive health problems of dairy cows in a selected area of Bangladesh

Rifat J. Sumi[1], Ziban C. Das[1], Mohammad N. Hoque[1], Abu N. M. A. Rahman[1], Mohammad T. Islam[2] and Anup K. Talukder[1,*]

[1]Department of Gynecology, Obstetrics & Reproductive Health, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh
[2]Department of Pathobiology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

Received October 18, 2022
Revised December 6, 2022
Accepted December 6, 2022

***Correspondence**
Anup Kumar Talukder
E-mail: anupbau@bsmrau.edu.bd

Author's Position and Orcid no.
Sumi RJ, Livestock extension officer,
https://orcid.org/0000-0002-6529-8237
Das ZC, Associate professor,
https://orcid.org/0000-0002-2413-0526
Hoque MN, Associate professor,
https://orcid.org/0000-0002-4861-0030
Rahman ANMA, Professor,
https://orcid.org/0000-0002-7678-7829
Islam MT, Associate professor,
https://orcid.org/0000-0002-6245-808X
Talukder AK, Associate professor,
https://orcid.org/0000-0001-6904-8801

ABSTRACT The impact of heat stress (HS) on reproductive performance and its problems in cows remains to be investigated in Bangladesh. The study was, therefore, aimed to evaluate the effect of HS on fertility and reproductive health problems of dairy cows in a selected area of Bangladesh. A total of 1,095 cows from 500 farms were included in this study. The climate-related data were recorded daily basis for every month in a year and temperature-humidity index (THI) values were calculated to determine the level of HS. Concurrently, data on fertility parameters [number of services per conception (NSC), conception rate (CR) and calving to the first service interval (CFSI)], and reproductive problems were collected through a pre-defined questionnaire. The results show that crossbred [Native x Holstein-Friesian, (HF)] cows were more vulnerable ($p < 0.05$) to a magnitude of HS effects considering physiological parameters of cows [age, body condition score (BCS), parity and milk yield]. Regarding fertility, HS had no effect on NSC, CR and CFSI in both native and crossbred cows ($p > 0.05$). The findings on the reproductive problems indicate that HS had significant influence on the prevalence of anestrus ($\chi^2 = 21.814$, $p < 0.05$) and retained placenta ($\chi^2 = 24.632$, $p < 0.05$) in cows. Of note, the prevalence of repeat breeding syndrome was 2.5 folds higher in stress condition than in no stress condition. Abortion and dystocia were not influenced by HS. In conclusion, HS does not influence the fertility parameters of cows studied; however, anestrus and retained placenta are likely to occur under HS conditions in cows.

Keywords: Bangladesh, cows, fertility, health problems, heat stress, reproductive

INTRODUCTION

Heat stress (HS) can be defined as the point in which the animal cannot dissipate adequate quantity of heat to maintain body thermal balance (Samal, 2013). Animals are exposed to HS when the body temperature is higher than the optimal range specified for the normal activity because the total heat load is greater than the capacity for heat dissipation. There are many different climatic zones around the world which are highly affected by latitude, altitude, water area, oceans, winds or evaporative conditions. Mammals, including humans and livestock,

are living in such variable environmental conditions. Climatic factors that influence the degree of HS include temperature, humidity, radiation, and wind etc. HS affects both productive and reproductive performances of dairy cows (Bohmanova et al. 2007; Dash et al., 2016). In most mammalian species including cattle, HS has deleterious effects on nutritional, physiological and reproductive functions (Takahashi, 2012). Global warming seems to increase temperature, especially in subtropical and tropical regions. The average ambient temperature changes rise up 1.53℃ over the period 1850-1900 to 2006-2015 (Arneth et al., 2019). Dairy cattle in many subtropical, tropical, and semi-arid regions are under the influence of high ambient temperatures and relative humidity for long periods. Exposure of animals to a hot environment causes an increase in body temperature, decrease growth, milk production, and fertility in mammals, including domestic animals (Dash et al., 2016). Multiple reproductive processes are impaired, including oocyte competence, embryonic growth, gonadotropin secretion, ovarian follicular growth, steroidogenesis, development of the corpus luteum, and uterine endometrial responses (Wolfenson and Roth, 2019). The effect of HS on the reproductive performance is multidimensional through several mechanisms ether direct reproductive effects or indirect metabolic and nutritional effects (De Rensis et al., 2017). The direct effect of HS on the cow with altered endocrine regulation due to impairment of hypothalamic-pituitary-ovarian axis (Ozawa et al., 2005). The direct effect on ovarian activity concerning steroid hormone synthesis or steroidogenesis reduces concentration of estradiol (Wolfenson and Roth, 2000; Bridges et al., 2005; Li et al., 2016) and alters progesterone concentration (Youllas et al., 1992; Ronchi et al., 2001). Consequently, HS reduces estrus-related behaviors and continuingly affects fertility such as prolonged day open and low conception rate (CR) (Schüller et al., 2017). High ambient temperature also causes a decrease in the length and intensity of estrus by disturbing ovarian functions as well as decreasing pregnancy rate after artificial insemination. The indirect effect would be an adaptation of cow during HS by reduced feed intake (Ozawa et al., 2005; Soriani et al., 2013). Moreover, negative energy balance (NEB) would be occurred due to the fact that cows have increased feed requirement and hepatic metabolism, in which the NEB can decrease fertility (Shehab-El-Deen et al., 2010; De Rensis et al., 2017). Furthermore, HS is associated with occurrence of diseases and disorders during pregnancy, parturition, and post-partum period in cattle (Mellado et al., 2019). Postpartum reproductive diseases are major stressors that contribute to impaired and reduced fertility in dairy cattle (Crowe and Williams, 2012). Retained placenta, metritis, and clinical endometritis are the three major diseases encompassing after calving. Several risk factors are associated with the development of reproductive diseases. Parity, dystocia, abortion, gender of calf, twinning, stillbirths, prolapsed uterus, body condition score, NEB, hypo-calcemia, and other stressors can predispose cows to a greater risk of developing reproductive disease (Dubuc et al., 2010). Reproductive disease has negative effects on fertility and reproductive performance of dairy cattle (LeBlanc et al., 2002; Gilbert et al., 2005; McDougall et al., 2007). Besides reduced fertility, reproductive diseases are also associated with decreased milk production and an increased risk of being culled from the herd (Rajala and Gröhn, 1998; Dubuc et al., 2011). Therefore, it is important to unveil the effects of HS on reproductive functions and diseases/disorders in order to improve the production of dairy cows and farm income. Bangladesh is a tropical country where HS is very important. To the best of our knowledge, impacts of HS on fertility parameters and reproductive health problems (diseases and disorders) of dairy cows remains to be investigated in Bangladesh. Therefore, the study was conducted to evaluate the effect of HS on fertility-related parameters and reproductive health problems of dairy cows under Bangladesh condition.

MATERIALS AND METHODS

Study location and period

The present study was conducted in different locations of Bhuapur Upazila (24.4583°N 89.8667°E) of Tangail District in the Division of Dhaka, Bangladesh (Fig. 1) during the period from July 2020 to June 2021. A total of 1,095 cows from 500 farms were included in this present study.

Design of the investigation

An experimental outline of the present investigation was illustrated in Fig. 2. This investigation was planned to work on the dairy farms for one year in which climate-related data (temperature and humidity) were recorded daily basis. From temperature and humidity, temperature-

Fig. 1. Location of the study area (Source: https://en.wikipedia.org/wiki/Bhuapur_Upazila).

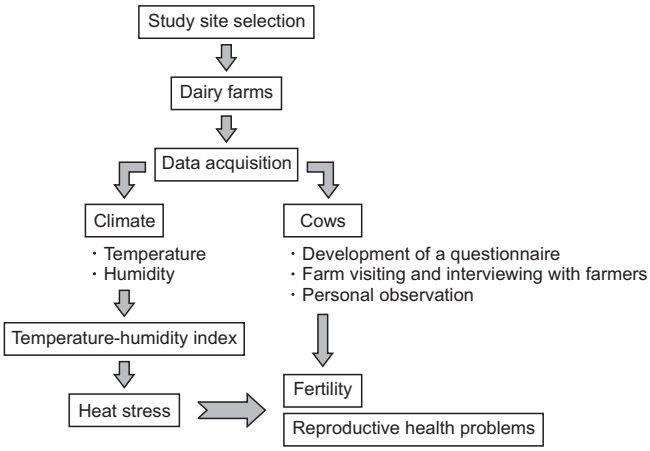

Fig. 2. An experimental outline of the current investigation.

humidity index (THI) values were calculated to determine the level of HS. Simultaneously, data on the fertility-related parameters and reproductive problems of cows were collected from the dairy farms through farm visit, personal observation or from farm registers using a pre-defined questionnaire. The data were then analyzed to observe the effect of HS on reproductive performance (fertility) and problems of cows.

Determination of THI and HS

THI value was calculated following the formula provided by National Research Council (1971).

THI = (1.8 × T + 32) - (0.55-0.0055 × RH) × (1.8 × T -26.8) where, T is the temperature in ℃ and RH is relative humidity in %. This THI formula was selected because it has been associated with thermal stress in dairy cattle and is designed to indicate the level of HS for outdoor cattle (Bohmanova et al., 2007).

Table 1. Classification and symptoms of THI

THI	Classification of HS	Symptoms
< 72	None	Optimum productive and reproductive performance
72–78	Mild	Dairy cows seek for shade, increase in respiration rate and dilation of blood vessels
79–88	Moderate	Increase in respiration rate and saliva secretion. Reduction in feed intake and water consumption. Body temperature is increased and reproductive performances are severely affected in cattle
89–98	Severe	There is rapid increase in respiration and excessive saliva production. The reproductive performances in animals are significantly decreased

Grouping of HS

HS was categorized into four different groups (Table 1) such as none (no stress), mild, moderate, and severe HS as described in previous studies (Armstrong, 1994; Dash et al., 2016).

Data acquisition

1. Development of a questionnaire

A pre-defined questionnaire (Supplementary Table 1) was developed according to the objectives of the investigation and was designed in a simple way so that farmer could understand easily. The questionnaire includes information about climate data (temperature and humidity), farms identity, housing, and individual cow's data related to fertility such as NSC, CR, and calving to the first service interval (CFSI). Data on the reproductive health problems (anestrus, repeat breeder, abortion, stillbirth, retained placenta, pre-mature birth, dystocia, puerperal metritis, and others) were also considered in the study.

2. Visiting the farms and interviewing with farmers

Each farm was visited in person and farmer were kindly requested to take part in the interview for research purpose of the present study. The data were then collected

and recorded for direct interviewing of the farmers.

3. Personal observation

The housing-related data of individual farm were collected by personal observation. Then, individual cow data were collected by taking history directly from farmers and also from farmers register book. The age and parity of the cow were also determined by interviewing the farmer and by noticing from farm register. Breed and body condition score (BCS) of cows were confirmed by personal investigation. The general farm management was observed by visual inspections and asking questions to farmers. The ventilation system was also noticed as it is an important aspect to reduce HS.

Statistical analysis

The data were initially entered into Microsoft Excel Worksheet and then transported to the SPSS software version 14.0 (NY, Chicago, USA) for further analyses. Kruskal-Wallis H test was applied to reveal association of HS with cow traits (age, BCS, parity, milk yield). Student's *t*-test was performed to compare mean difference between two groups (native vs crossbred). One-way analysis of variance (ANOVA) was carried out to compare mean among three groups or more (different categories of HS-none, mild, and moderate groups). Chi-square (χ^2) test was used to examine the effect of HS on prevalence of reproductive health problems. p-values < 0.05 were considered statistically significant difference.

RESULTS

Climate-related data in the study area over the study period

During the period from July 2020 to June 2021, the whole field work was conducted in Bhuapur Upazilla of Tangail District, Bangladesh. The data of temperature and relative humidity were collected from the Akurthakur para (Tangail) weather station. The whole data of temperature and relative humidity were categorized on daily basis and the mean ± standard deviation (SD) value of each month was presented in the Fig. 3. To evaluate the effect of HS, THI was also calculated and illustrated in Fig. 3 as described earlier by Dash et al., (2016). THI is a single value depicting the integrated effects of air temperature and humidity associated with the level of HS and extensively used in hot regions across the world. The lowest temperatures were found in December (24 ± 2.1℃) and January (24 ± 1.4℃), while the highest temperatures were observed in April (34 ± 1.4℃) and May (34 ± 2.0℃). The relative humidity was the lowest in April (47 ± 5.0%) and it was the highest in June (71 ± 10.7%), July (71 ± 7.3%), and September (71 ± 5.9%). The lowest values of THI were 72.0 ± 3.1 and 72.0 ± 1.8 in December and January, respectively, representing none to mild stress conditions of HS during these two months. In the month of February, the mean THI value was recorded 74 ± 2.0 which represents mild stress conditions of HS. In November, THI value of 79 ± 2.4 was found, indicating either mild or moderate stress conditions of HS. On the other hand, THI values were between 80.0 and 84.0 representing the moderate stress conditions during rest of the eight months (Fig. 3). No conditions of severe HS (THI ≥ 89.0, Dash et al., 2016) were observed in the present study.

Association of HS with cow traits

The negative effect of HS on individual animal production is one of the major problems in livestock production. The HS effects on age, BCS, milk yield, and parity between the native and crossbred cows are presented in Fig. 4. The results showed that crossbred cows were more vulnerable to a magnitude of HS effects considering all four parameters analyzed. For instance, the mean age was

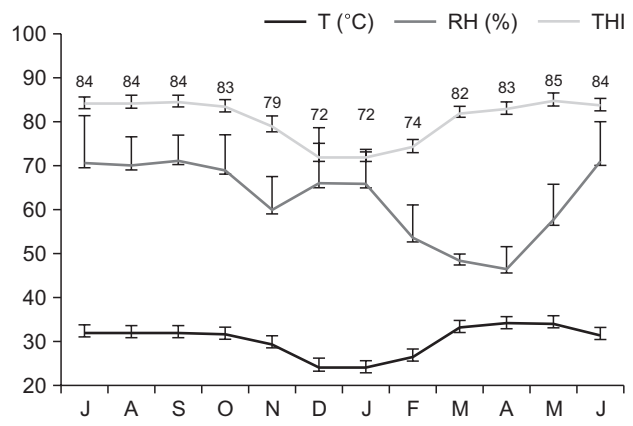

Fig. 3. The temperature-humidity index (THI) of study area. The values at the top of graph indicate the numerical values of THI. The graphs are presented as mean ± standard deviations. T, temperature; RH, relative humidity; J, July; A, August; S, September; O, October; N, November; D, December; J, January; F, February; M, March; A, April; M, May; March, and J, June, respectively.

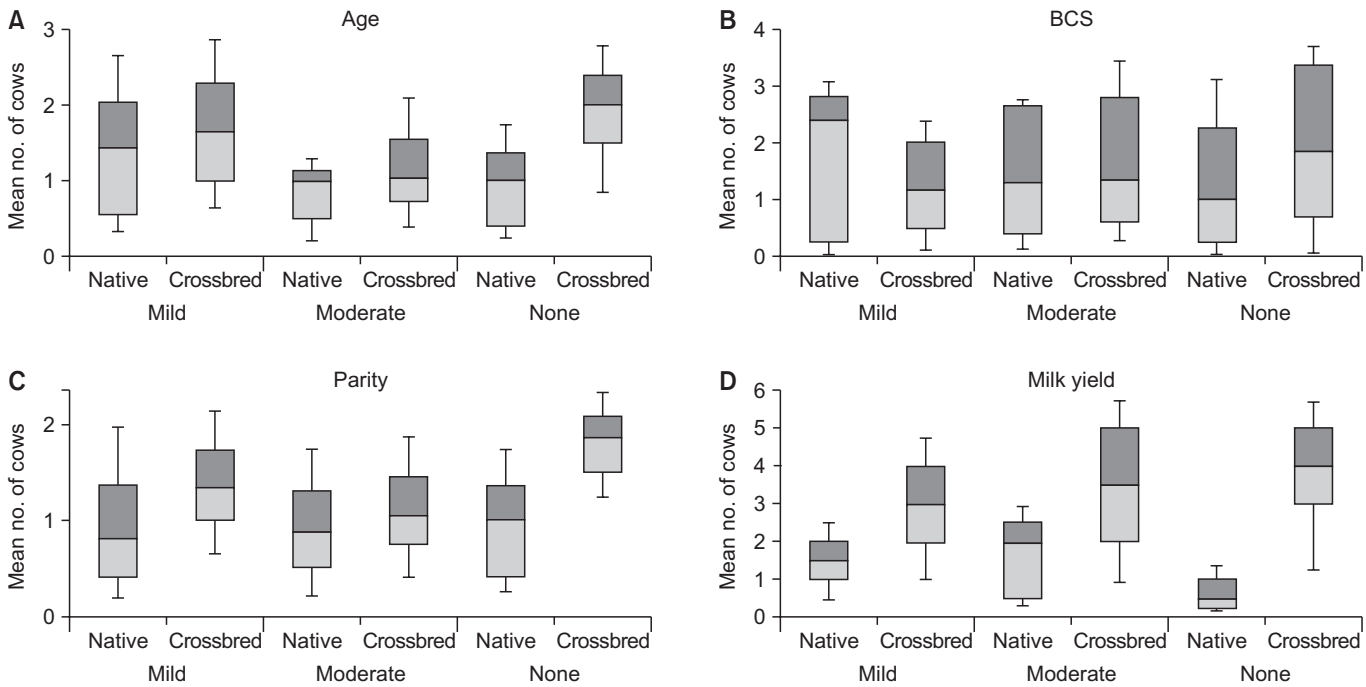

Fig. 4. Relationship of HS conditions with age, BCS, parity, and milk yield of native and crossbred cows. The graphs are presented as mean ± standard deviations.

found to be varied across mild, moderate, and none categories of HS ($p < 0.05$, Kruskal-Wallis H test). The crossbred cows having a mean age of ≥ 2.0 years were more prone to mild and moderate forms of HS, and this trend was consistent with cows not suffering from HS (none) (Fig. 4A). The discrepancy in the association of HS with BCS of the cows was also evident between the cow groups (native vs crossbred). Native cows with an average BCS of ≥ 2.9 were more prone to mild form of HS than crossbred cows (mean BCS ≥ 2.0). Conversely, the crossbred cows having an average BCS of ≥ 2.85 were more prone to moderate form of HS than native cows (mean BCS ≥ 2.7). Similarly, crossbred cows with a mean BCS of ≥ 3.4 showed more resilience to HS (none) than their native counterpart (mean BCS ≥ 2.3) (Fig. 4B). The parity of the cows had significant association with HS effects between the native and crossbred cows. The crossbred cow having a parity of ≥ 1.7 were more susceptible to mild and moderate forms of HS than the native cows (average parity ≥ 1.4). This difference was more evident among the cows of none HS groups, and crossbred cow with an average parity of ≥ 2.2 showed more negative association with HS than native cows (average parity ≥ 1.4) (Fig. 4C). In this study, marked differences ($p < 0.001$, Kruskal-Wallis H test) was observed between the two cow groups regarding their association with HS in terms of milk yield. The crossbred producing an average of ≥ 4.0 L per day were more vulnerable to both mild and moderate forms of HS, and this differences in milk yield was also corroborated with crossbred cows (mean milk yield ≥ 4.0 L per day) that were not subjected to none HS (Fig. 4D).

Effect of HS on fertility-related parameters in cows

The effect of HS on the different fertility parameters such as NSC, CR (%), and CFSI is shown in Table 2. The NSC was recorded 1.8 ± 0.8 in none, mild, and moderate stress conditions in native cows, while it was recorded between 1.8 ± 0.8 and 1.9 ± 0.8 in crossbred cows in none, mild and moderate stress conditions. The results showed that HS has no effect on NSC in both native and crossbred cows ($p > 0.05$) (Table 2). The CR in native and crossbred cows were 64.4 ± 8.0% and 67.6 ± 9.1%, respectively, in none stress condition. Similarly, in mild categories of HS, CR was 66.9 ± 9.0% and 67.4 ± 9.0% for native and crossbred cows, respectively. The CR were recorded as 65.7 ± 9.7% and 65.8 ± 9.7% in native and crossbred cows, respectively, in moderate stress conditions. The HS had no effect on CR depending on the breed under all conditions of HS ($p > 0.05$). Calving to the first service interval during none, mild, and moderate stress conditions

Table 2. Effect of HS on number of services per conception, conception rate (%) and calving to the first service interval (days) in native and crossbred cows

Fertility parameters	Categories of HS	Native	Crossbred
No. of services per conception	None	1.8 ± 0.8 (n = 9)	1.9 ± 0.8 (n = 120)
	Mild	1.8 ± 0.8 (n = 11)	1.8 ± 0.8 (n = 160)
	Moderate	1.8 ± 0.8 (n = 55)	1.8 ± 0.8 (n = 740)
Conception rate (%)	None	64.4 ± 8.0	67.6 ± 9.1
	Mild	66.9 ± 9.0	67.4 ± 9.0
	Moderate	65.7 ± 9.7	65.8 ± 9.7
Calving to the first estrus interval (days)	None	68.1 ± 3.3	68.5 ± 3.6
	Mild	68.6 ± 3.7	68.6 ± 3.6
	Moderate	68.1 ± 3.2	68.1 ± 3.2

Table 3. Effect of HS on the prevalence of anestrus

Categories of HS	Anestrus
None	9.3% (11/129)
Mild	11.0% (17/171)
Moderate	27.4% (171/795)
Total	18.2% (199/1095)

χ^2 = 21.814, p = 0.000.

Table 4. Effect of HS on the prevalence of repeat breeding syndrome

Categories of HS	Repeat breeding syndrome
None	10.9% (14/129)
Mild	11.1% (19/171)
Moderate	21.5% (121/795)
Total	14.1% (154/1095)

χ^2 = 3.214, p = 0.201.

were 68.1 ± 3.3, 68.6 ± 3.7, 68.1 ± 3.2 days, respectively, in native cows. On the other hand, it was 68.5 ± 3.6, 68.6 ± 3.6, 68.1 ± 3.2 days for none, mild, and moderate HS conditions, respectively, in crossbred cows. No significant difference ($p > 0.05$) was found among the HS conditions and between the breeds (Table 2).

Effect of HS on reproductive health problems in cows

1. Anestrus

The effect of HS on the occurrence of anestrus is shown in Table 3. In this study, a total 199 anestrus cases were recorded. The overall prevalence of anestrus in cows was 18.2% (199/1095) in the study area. Under no HS condition (none HS), the percentage of anestrus cows was 9.3%, which gradually increased to 11.0% and 27.4% during mild and moderate HS conditions, respectively. These results indicate that HS had significant effect on anestrus in cows (χ^2 = 21.814, $p < 0.05$). However, other factors such as breed, age, parity, and milk yield of cows might be involved which requires further investigations. Cows exhibit a distinct seasonal change in displaying estrus and calving rate. With the onset of summer (April), breeding efficiency in both young and adult cow is reduced, reaching a nadir in the dry hot months of May and June when approximately 80% of non-pregnant cows have quiescent ovaries.

2. Repeat breeding syndrome

The effect of HS on repeat breeding syndrome is shown in Table 4. A total 154 repeat breeding syndrome cases in cows were observed during the study period. The overall prevalence of repeat breeding syndrome was 14.1% in cows. The percentage of repeat breeding syndrome was 10.9% under no stress condition, which gradually inclined to 11.1% and 21.5% during mild and moderate stress conditions, respectively (χ^2 = 3.214, $p < 0.05$). Even though these variations were not significant, the highest (21.5%) prevalence of repeat breeding during moderate HS conditions warrants farmers to take this into considerations.

3. Abortion

Heat stress can affect reproductive performance in a dairy herd, although it will generally cause conception problems rather than abortions. While there is some evidence to suggest that a very sudden increase in environmental temperature may result in abortions, there is little evidence to support HS as a common cause of abortions. The effect of HS on abortion is presented in Table 5. In this study, a total 47 abortion cases were found in cows during the study period. The overall prevalence of

Table 5. Effect of HS on the prevalence of abortion

Categories of HS	Abortion
None	7.0% (9/129)
Mild	4.7% (8/171)
Moderate	3.8% (30/795)
Total	4.3% (47/1095)

χ^2 = 2.846, p = 0.241.

Table 6. Effect of HS on the prevalence of retained placenta

Categories of HS	Retained placenta
None	24.0% (31/129)
Mild	19.3% (33/171)
Moderate	36.9% (293/795)
Total	32.6% (357/1095)

χ^2 = 24.632, p = 0.000.

abortion was 4.3%. The proportion of abortion was 7.0%, which gradually decreased to 4.7% and 3.8% during mild and moderate HS conditions, respectively (χ^2 = 2.846, p > 0.05). These results are inconsistent and might be related to the breed, age, parity, and milk yield of cows.

4. Retained placenta

Retained placenta is a common complication of bovine parturition. The incidence in healthy dairy cows is 5-15%, whereas the incidence in beef cows is lower. The effect of HS on retained placenta is shown in Table 6. A of total 357 retained placenta cases were found during the study period. The overall prevalence of retained placenta was 32.6%. The percentages of retained placenta were 24.0% in no HS conditions, which slightly decreased to 19.3% in mild HS and increased to 36.9% in moderate HS condition (χ^2 = 24.632, p < 0.05).

5. Dystocia

The effect of HS on the prevalence of dystocia is presented in Table 7. In the present study, a total of 207 dystocia cases were found in cows. The overall prevalence of dystocia was 18.9% in cows. Under no HS condition, the percentage of dystocia was 20.9%, which decreased to 17.0% in mild HS and 19.0% in moderate HS conditions (χ^2 = 0.772, p > 0.05). Several predisposing factors are associated with dystocia such as calf birth weight, gestation length, cow age at calving, climate, nutrition, management, genetics, and infection. Among the mentioned predisposing factors, climate has a significant role in occurrence of dystocia. The dystocia rate is higher in the winter than in the summer, however, the exact definition of these seasons differs. An easier access to a pasture in summer, more physical exercises, longer days, and closer observation by owner in winter are suggested factors of seasonal differences.

Table 7. Effect of HS on the prevalence of dystocia

Categories of HS	Dystocia
None	20.9% (27/129)
Mild	17.0% (29/171)
Moderate	19.0% (151/795)
Total	18.9% (207/1095)

χ^2 = 0.772, p = 0.680.

DISCUSSION

Heat stress (HS) has deleterious effects on fertility and reproductive diseases and disorders in dairy cows in tropical and sub-tropical countries. It has been known that along with other stressors, HS could induce several physiological changes in animals (Hwang et al., 2021; Kang and Kim, 2021). However, the impact of HS on these aspects of dairy cows remains to be investigated in Bangladesh. The present study was, therefore, aimed to evaluate the effect of HS on fertility-related parameters, and also to observe the effect of HS on reproductive health problems of dairy cows in a selected area of Bangladesh.

The HS has adverse effects on production, fertility, and health of dairy cattle. Heat stress in dairy cattle results in economic losses due to reduced feed intake, milk production and reproduction performance and increased lameness, disease incidence, days open and death rates (Polsky and von Keyserlingk, 2017). The decrease in conception rates during summer seasons can range between 20 and 30%, with evident seasonal patterns of estrus detection (De Rensis et al., 2015). Elevated environmental temperatures negatively affect the cow's ability to display natural mating behaviour, as it reduces both the duration and intensity of estrous expression (Polsky and von Keyserlingk, 2017). A reduction in estrus behaviour has been argued to be the result of reduced Dry matter intake (DMI) and the subsequent effects on hormone production (De Rensis et al., 2015; Polsky and von Keyserlingk, 2017). The conception rate of lactating dairy cows is highly affected by heat stress. Earlier, NSC was reported 1.8 ± 0.8 under mod-

erate HS conditions (Ghavi Hossein-Zadeh et al., 2013), which resembles to our current observations. The CR of crossbred cows under moderate stress conditions (67.4 ± 9.0%) of the present study corresponds to the finding of Ghavi Hossein-Zadeh et al. (2013). The lower percentages of CR were reported with higher THI values (Ghavi Hossein-Zadeh et al., 2013; Mellado et al., 2019).

The HS increases the likelihood of anestrus, and thus it has negative impacts on fertility of cows (Rao and Sreemannarayana, 1982; Chauhan et al., 1984). Infertility as manifested by anestrus is still remained a major problem for reducing reproductive efficiency in dairy cows. Anestrus in cows is a multifactorial problem mainly caused by inadequate nutrition, environmental stress, uterine pathology, and improper management practices etc. Nutrition, season of calving, parity, management practices, and abnormal parturition were found to influence the frequency of postpartum anestrus in cows (El-Wishy, 2007). Although native cows are well adopted in hot and humid climate, the ovarian activity is greatly reduced by HS and manifested in the form of anestrus (Singh et al., 2000). Ovarian inactivity is more frequent in summer (41-46%) than in other seasons (7-33%) calvers (Rao and Sreemannarayana, 1982; Chauhan et al., 1984). Silent estrus is also more common in the hotter months than from August to January and it takes longer for ovarian cyclicity to resume after calving in the summer (80 additional days) (Singh et al., 2000). There was a distinct seasonal variation of anestrus condition in cows with spring and early summer (January to June) as the low breeding season and July to December as the active breeding season (Devkota and Bohora, 2009). Repeat breeding syndrome is one of the major problems affecting reproductive efficiency and is a major source of economic loss in dairy herds (Bartlett et al., 1986; Yusuf et al., 2010). Our findings on the effect of HS in repeat breeding syndrome are similar with that of Ghanem and Nishibori (2015). Retention of the fetal membranes is an important contributor to bovine infertility (Noakes et al., 2019). Many factors have been implicated in the production of retained placenta such as breed, year, season, induction, dystocia, hypocalcemia, twins, length of gestation, age, abortion, heredity, deficiency of vitamin A/E, selenium, and iodine, and general nutrition (Laven and Peters, 1996). The highest incidence of retained placenta was recorded in summer ($p < 0.05$) as compared to spring and winter was observed by others (Ahmadi and Mirzaei, 2006) is resembled to this study.

Heat stress is a major contributing factor to the reduced reproductive performance and disorders including dystocia in dairy cows. The findings of the present study suggest that the prevalence of dystocia reduces when the THI value increases, which is resembled to the finding of others (Gaafar et al., 2011; Atashi et al., 2012). Several predisposing factors are associated with dystocia such as calf birth weight, gestation length, cow age at calving, climate, nutrition, management, genetics, and infection. Among the mentioned predisposing factors, climate has a significant role in occurrence of dystocia. The risk of dystocia in Holsteins was 15.0% higher in winter (October-March) than in spring and summer (April-September) (Johanson and Berger, 2003). Cold weather (Air and wind chill temperatures of approximately -5 and -10℃, respectively) during the last trimester has been associated with increased dry matter intake, increased thyroid hormone concentration, increased blood and nutrient flow to the uterus, increased gestation length, and reduced plasma oestradiol concentrations leading to increased birth weight and dystocia (McClintock, 2004).

CONCLUSION

The study concluded that Crossbred (Native x HF) cows were more vulnerable to a magnitude of HS effects considering all parameters analyzed such as age, BCS, parity, and milk yield of cows. Surprisingly, HS did not influence fertility parameters studied such as NSC, CR, and CFSI in dairy cows. Importantly, HS had significant effect on occurrence of anestrus and retained placenta in cows. Of note, repeat breeding syndrome is likely to occur in moderate stress condition. To understand these mechanisms, we think that further study is required to investigate the markers for HS directly in cows' body by measuring cortisol level in blood plasma and/or heat shock proteins (HSP70 and HSP90).

Author Contributions: Performed the field work and data collection, R.J.S.; analyzed data and edited the manuscript, Z.C.D. and M.N.H.; edited the manuscript, A.N.M.A.R. and M.T.I.; developed the research concept, A.K.T.; supervised the field work, A.K.T.; analyzed data and edited the manuscript, A.K.T.

Funding: None.

Ethical Approval: Not applicable.

Consent to Participate: Not applicable.

Consent to Publish: Not applicable.

Availability of Data and Materials: All data would be available upon request.

Acknowledgements: None.

Conflicts of Interest: No potential conflict of interest relevant to this article was reported.

SUPPLEMENTARY MATERIALS

Supplementary material can be found via https://doi.12750/JARB.37.4.266.

REFERENCES

Ahmadi MR and Mirzaei A. 2006. Effect of heat stress on incidence of retained placenta in Holstein cows at dry hot weather of Shiraz. J. Appl. Anim. Res. 29:23-24.

Armstrong DV. 1994. Heat stress interaction with shade and cooling. J. Dairy Sci. 77:2044-2050.

Arneth A, Denton F, Agus F, Elbehri A, Erb K, Elasha BO, Rahimi M, Rounsevell M, Spence A, Valentini R. 2019. Framing and context. In: Shukla PR, Skea J, Calvo Buendia E, Masson-Delmotte V, Pörtner HO, Roberts DC, Zhai P, Slade R, Connors S, van Diemen R, Ferrat M, Haughey E, Luz S, Neogi S, Pathak M, Petzold J, Portugal Pereira J, Vyas P, Huntley E, Kissick K, Belkacemi M, Malley J (Eds.), Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems, Intergovernmental Panel on Climate Change, Geneva, pp. 77-129.

Atashi H, Abdolmohammadi A, Dadpasand M, Asaadi A. 2012. Prevalence, risk factors and consequent effect of dystocia in holstein dairy cows in Iran. Asian-Australas. J. Anim. Sci. 25:447-451.

Bartlett PC, Kirk JH, Mather EC. 1986. Repeated insemination in Michigan Holstein-Friesian cattle: incidence, descriptive epidemiology and estimated economic impact. Theriogenology 26:309-322.

Bohmanova J, Misztal I, Cole JB. 2007. Temperature-humidity indices as indicators of milk production losses due to heat stress. J. Dairy Sci. 90:1947-1956.

Bridges PJ, Brusie MA, Fortune JE. 2005. Elevated temperature (heat stress) in vitro reduces androstenedione and estradiol and increases progesterone secretion by follicular cells from bovine dominant follicles. Domest. Anim. Endocrinol. 29:508-522.

Chauhan FS, Takkar OP, Singh M, Tiwana MS. 1984. Influence of season on the incidence of anestrus in buffaloes: Proceedings of 10th International Congress on Animal Reproduction and Artificial Insemination. Urbana: University of Illinois Urbana-Champaign. 2, 28.1-28.2.

Crowe MA and Williams EJ. 2012. Triennial Lactation Symposium: effects of stress on postpartum reproduction in dairy cows. J. Anim. Sci. 90:1722-1727.

Dash S, Chakravarty AK, Singh A, Upadhyay A, Singh M, Yousuf S. 2016. Effect of heat stress on reproductive performances of dairy cattle and buffaloes: a review. Vet. World 9:235-244.

De Rensis F, Garcia-Ispierto I, López-Gatius F. 2015. Seasonal heat stress: clinical implications and hormone treatments for the fertility of dairy cows. Theriogenology 84:659-666.

De Rensis F, Lopez-Gatius F, García-Ispierto I, Morini G, Scaramuzzi RJ. 2017. Causes of declining fertility in dairy cows during the warm season. Theriogenology 91:145-153.

Devkota B and Bohora TP. 2009. Effects of season on pregnancy rates in water buffaloes of Southern Nepal evaluated by using different estrus synchronization protocols during active season and low breeding season. Pak. J. Zool. Suppl. Ser. 9:763-770.

Dubuc J, Duffield TF, Leslie KE, Walton JS, LeBlanc SJ. 2010. Risk factors for postpartum uterine diseases in dairy cows. J. Dairy Sci. 93:5764-5471.

Dubuc J, Duffield TF, Leslie KE, Walton JS, Leblanc SJ. 2011. Effects of postpartum uterine diseases on milk production and culling in dairy cows. J. Dairy Sci. 94:1339-1346.

El-Wishy AB. 2007. The postpartum buffalo. II. Acyclicity and anestrus. Anim. Reprod. Sci. 97:216-236.

Gaafar HM, Shamiah SM, El-Hamd MA, Shitta AA, El-Din MA. 2011. Dystocia in Friesian cows and its effects on postpartum reproductive performance and milk production. Trop. Anim. Health Prod. 43:229-234.

Ghanem ME and Nishibori M. 2015. Effects of season on plasma progesterone profiles in repeat breeding cows. Vet. Med. (Praha) 60:227-234.

Ghavi Hossein-Zadeh N, Mohit A, Azad N. 2013. Effect of temperature-humidity index on productive and reproductive performances of Iranian Holstein cows. Iran. J. Vet. Res. 14:106-112.

Gilbert RO, Shin ST, Guard CL, Erb HN, Frajblat M. 2005. Prevalence of endometritis and its effects on reproductive performance of dairy cows. Theriogenology 64:1879-1888.

Hwang JC, Kim HD, Park BJ, Jeon RH, Baek SM, Lee SW, Jang M, Bae SG, Yun SH, Park JK, Kwon YS, Kim SJ, Lee WJ. 2021. Immobilization stress increased cytochrome P450 1A2 (CYP1A2) expression in the ovary of rat. J. Anim. Reprod. Biotechnol. 36:9-16.

Johanson JM and Berger PJ. 2003. Birth weight as a predictor of calving ease and perinatal mortality in Holstein cattle. J. Dairy Sci. 86:3745-3755.

Kang D and Kim D. 2021. Antioxidant effect of Lonicera Caerulea on heat stress-treated male mice. J. Anim. Reprod. Biotechnol. 36:220-229.

Laven RA and Peters AR. 1996. Bovine retained placenta: aetiology, pathogenesis and economic loss. Vet. Rec. 139:465-471.

LeBlanc SJ, Duffield TF, Leslie KE, Bateman KG, Keefe GP, Walton JS, Johnson WH. 2002. Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. J. Dairy Sci. 85:2223-2236.

Li L, Wu J, Luo M, Sun Y, Wang G. 2016. The effect of heat stress on gene expression, synthesis of steroids, and apoptosis in bovine granulosa cells. Cell Stress Chaperones 21:467-475.

McClintock SEJ. 2004. A genetic evaluation of dystocia in Australian Holstein-friesian cattle [Doctoral dissertation, University of Melbourne]. Victorian Government Library Service. https://www.vgls.vic.gov.au/client/en_AU/VGLS-public/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:154954/one?qu=McClintock%2C+Sara+Elizabeth+Juliette+author.&te=ILS&ps=300.

McDougall S, Macaulay R, Compton C. 2007. Association between endometritis diagnosis using a novel intravaginal device and reproductive performance in dairy cattle. Anim. Reprod. Sci. 99:9-23.

Mellado M, Alba V, Gaytán L, García JE, Mellado J. 2019. Effect of age at first calving and heat stress at parturition on reproductive efficiency and postpartum disorders in Holstein heifers. Span. J. Agric. Res. 17:e0405.

National Research Council. 1971. A Guide to Environmental Research on Animals. National Research Council, Washington, DC, pp. 196.

Noakes DE, Parkinson TJ, England GCW. 2019. Veterinary Reproduction and Obstetrics. 10th ed, Saunders, Edinburgh, pp. 500-509.

Ozawa M, Tabayashi D, Latief TA, Shimizu T, Oshima I, Kanai Y. 2005. Alterations in follicular dynamics and steroidogenic abilities induced by heat stress during follicular recruitment in goats. Reproduction 129:621-630.

Polsky L and von Keyserlingk MA. 2017. Invited review: effects of heat stress on dairy cattle welfare. J. Dairy Sci. 100:8645-8657.

Rajala PJ and Gröhn YT. 1998. Effects of dystocia, retained placenta, and metritis on milk yield in diary cows. J. Dairy Sci. 81:3172-3181.

Rao AVN and Sreemannarayana O. 1982. Clinical analysis of reproductive failure among female buffaloes (Bubalus bubalis) under village management in Andhra Pradesh. Theriogenology 18:403-411.

Ronchi B, Stradaioli G, Supplizi AV, Bernabucci U, Lacetera N, Accorsi PA, Nardone A, Seren E. 2001. Influence of heat stress or feed restriction on plasma progesterone, oestradiol-17β, LH, FSH, prolactin and cortisol in Holstein heifers. Livest. Prod. Sci. 68:231-241.

Samal L. 2013. Heat stress in dairy cows - reproductive problems and control measures. Int. J. Livest. Res. 3:14-23.

Schüller LK, Michaelis I, Heuwieser W. 2017. Impact of heat stress on estrus expression and follicle size in estrus under field conditions in dairy cows. Theriogenology 102:48-53.

Shehab-El-Deen MA, Leroy JL, Fadel MS, Saleh SY, Maes D, Van Soom A. 2010. Biochemical changes in the follicular fluid of the dominant follicle of high producing dairy cows exposed to heat stress early post-partum. Anim. Reprod. Sci. 117:189-200.

Singh J, Nanda AS, Adams GP. 2000. The reproductive pattern and efficiency of female buffaloes. Anim. Reprod. Sci. 60-61:593-604.

Soriani N, Panella G, Calamari L. 2013. Rumination time during the summer season and its relationships with metabolic conditions and milk production. J. Dairy Sci. 96:5082-5094.

Takahashi M. 2012. Heat stress on reproductive function and fertility in mammals. Reprod. Med. Biol. 11:37-47.

Wolfenson D, Roth Z, Meidan R. 2000. Impaired reproduction in heat-stressed cattle: basic and applied aspects. Anim. Reprod. Sci. 60-61:535-547.

Wolfenson D and Roth Z. 2019. Impact of heat stress on cow reproduction and fertility. Anim. Front. 9:32-38.

Youllas M, Fuquay JW, Hussain SMI. 1992. Serum cortisol and Estradiol-17β levels in bovine under heat stress. Pak. J. Agric. Sci. 29:203-213.

Yusuf M, Nakao T, Ranasinghe RB, Gautam G, Long ST, Yoshida C, Koike K, Hayashi A. 2010. Reproductive performance of repeat breeders in dairy herds. Theriogenology 73:1220-1229.