CHAPTER I

INTRODUCTION

Dairy farming is the most promising and potential agricultural sector in Bangladesh. About 85% of the total populations of the country are partially engaged in agricultural and livestock sector (Raha, 2000).According to DLS, (2019) livestock population of Bangladesh is about 24.23 million cattle, 1.47 million buffaloes, 26.27 million goats and 3.54 million sheep. Among the total cattle population 6 million are milking cow. Cattle population in Chattogram division is about 4.21 million (BBS, 2018). About 85% of the total cattle of Bangladesh are of indigenous and non-descriptive in origin with low productivity as compared to other existing exotic breeds and their crosses (DLS, 2015). The available crossbreds and pure breeds cattle in Bangladesh are mostly Sindhi, Sahiwal, and Holstein Friesian breeds (Miazi *et al*., 2007). About 24.3 million people of the country are directly involved in agriculture of which 3.4 million people from Chattogram depend on their agricultural income (BBS, 2018). About 38.21% of total family incomes come from agricultural sector and 14.18% of which based on livestock (BBS, 2018). In the year 2018–2019, livestock sector contributed 1.47% to the national GDP and the GDP growth rate in livestock was 3.47% (DLS, 2019). In Bangladesh, total milk production was 99.23 Lakh Metric Ton (LMT) in the year of 2015-2016. However, the milk requirement was estimated as 152.02 LMT (Considering the World Health Organization recommendation 250 ml/day/head) and the per capita availability was 167ml/head/day (DLS, 2019). In Bangladesh, cows are main source of milk. 90% of the produced milk in the country comes from cows, 8% from goat, and the remaining 2% from buffalo (DLS, 2013).

Chattogram is considered as the second milk pocket of Bangladesh with its growing modern dairy farms. It is the second largest division of Bangladesh consists of 28 million people (BBS, 2017). The estimated demand for liquid milk is about 187725000 liters/day in Chattogram as per the recommendation of WHO. The available commercial dairy farm of Chattogram can fulfill 15% of total demand of the people of the district (Rahman *et al*., 2009). The number of registered commercial dairy farm up to 1st April/2012 was 1136 of which 896 is in operation (DLS, 2012).

Bangladesh is an agricultural based country and agriculture is always vulnerable to the unfavorable climatic conditions and events. Though the Bangladesh Government has earned astronomical technological progress, climatic condition is still the key determinants for agricultural productivity and sustainability (Ahmed and Shibasaki, 2000). Bangladesh located in the north eastern part of South Asia, that's in between 20°24' and 26°38' north latitude and 88°01' and 92°41' east longitude. The county composed of low, flat and fertile land apart from the hilly regions in northeast and southeast. The mean average annual temperature is 26°C with an extreme range between about 4 and 43°C. The average rainfall varies from 1429 to 4338 mm annually of which 80% occurs in Monsoon covering the months from July to October (Kamal, 2010). The country has been facing higher temperatures over the last three decades (Sarker *et al.*, 2012). Moreover, it is projected that the annual mean temperature will rise by 1.0°C, 1.4°C and 2.4°C by 2030, 2050 and 2100, respectively. The average temperature for the winter season (December, January and February) is likely to increase by 1.1°C by 2030, 1.6°C by 2050 and 2.7°C by 2100. The prediction for the monsoon months is 0.8°C, 1.1°C and 1.9°C by 2013, 2050 and 2100 respectively (Agrawala *et al*., 2003).

Climatic conditions of Bangladesh are such that the hot and humid season is relatively long, there is intense radiant heat for an extended period, and there is generally the presence of high relative humidity. So heat stress is chronic in nature especially for animal (West, 2003). Elevated environmental temperature, solar radiation, and relative humidity leads to hyperthermia or heat stress (Thatcher *et al.*, 2010). Heat stress is defined as any combination of environmental conditions that will cause the effective temperature of the environment to be higher than the temperature range of the animal's thermal neutral zone. A number of physical changes occur in the animals in response to heat stress like elevated body temperature (> 102.5 ºF), respiration rates (>70-80/minute), blood flow (Pereira *et al.*, 2008). High-yielding cows are particularly affected by heat stress, because the heat tolerance decreases with increasing milk yield and dry matter intake (Kadzere *et al.*, 2002; West, 2003). As milk yield of dairy cows is expected to further increase the negative impact of heat stress will become more important (Hansen, 2000; Van Arendonk and Liinamo, 2003). There is a trend in the dairy industry toward fewer and larger dairy farms housing more cows under one roof (Winsten *et al.*, 2010), which might increase the risk of suboptimal climate conditions (Wagner-Storch and Palmer, 2002). Heat stress has substantial negative effects on dairy productivity through direct reductions on dry matter intake and milk yield (Collier *et* al., 2006). This decreases the low intake of energy for productive functions such as milk production markedly hampered by negative energy balance. An increased loss of sodium and potassium is results of heat stress, this result in shift the acid base balance and result in a metabolic alkalosis. Dry matter intake decreases for short term or long term depending on the length and duration of heat stress. Due to heat stress body temperature may increase up to 102.5°F in the hot and humid climate that leads the animal to serious discomfort (Pereira *et al.,* 2008). If ambient temperature states approach body temperature, the only remaining viable route of heat loss is evaporation; if ambient conditions exceed the body temperature, heat flow will reverse and affected animal becomes a heat sink (Collier *et al.,* 2006).

Heat stress directly and indirectly affects nutrition, productivity, physiology, health, and behavior of lactating dairy cattle, in turn negatively affecting farm profitability (Cook *et al*., 2007; Tucker *et al*., 2008; Rhoads *et al*., 2009). Heat stress is associated with the Temperature Humidity Index (THI). Temperature Humidity Index (THI) is a measure that has been used since the early 1990s. It accounts for the combined effects of environmental temperature and relative humidity and is a useful and easy way to assess the risk of heat stress. A THI is a single value representing the combination of air temperature and humidity associated with the level of thermal stress. THI index is widely used in the hot area of worldwide to know the effect of the heat stress on dairy cow. Lactating cows are thought to experience no stress when THI is less than 72 and severe stress when THI exceeds 88 (Tailor and Nagda, 2005).

Heat stress is adversely associated with dairy characters including milk yield and therefore is a considerable financial burden in many milk producing areas of the world (St. Pierre *et al.,* 2003). High ambient temperature reduces milk production and cause change in milk composition. When the environmental temperature is above the body temperature, the cows countenance the risk of heat stress and milk production can be decreased by as much as 50% (Salem and Bouraoui, 2009). Weak heat stress can reduce up to 10% of milk production and in case of higher heat stress as high as 25% milk production can be hampered (Pennington and Devender, 2006). Higher milk production from the crossbred cattles was obtained during winter season in comparison with summer seasons (Boor *et al*., 1998; Prejit *et al*., 2007; Könyves *et al*., 2017). Fat and protein is the major components of milk in terms of commercial use. Milk in general high in fat and protein content during the season of winter season and lowest during the spring and summer seasons. This variation is associated mainly to change in climatic conditions and feeding regime. When a lactating Holstein cow is transferred from an air temperature of 18 to 30ºC. Milk fat and milk protein percentage decreased 39.7 and 16.9%, respectively (Kadzere *et al.,* 2002). Protein percentage and fat percentage can lower upto 9.9% in summer month in compared to winter in case of Holstein Friesian cattle (Bertocchi *et al.*, 2014).

Acclimation involves changes in hormonal signals as well as alteration in target tissue responsiveness to hormonal stimuli. Hormones are also implicated in acclimatory responses to thermal stress and altered by photoperiod. These include thyroid hormones, prolactin, somatotropin, glucocorticoids, and mineralocorticoids. The hypothalamic-pituitary-adrenal axis including corticotropin-releasing hormone, adrenocorticotropic hormone (corticotrophin), cortisol, and aldosterone are also altered by thermal stress and are involved in acclimatory responses to thermal stress (Collier *et al.,* 2006). The maintenance energy requirement may increase by 20-30% in animals under heat stress. Low energy diet has detrimental effect on reproduction.

Heat stress directly affect estrous period and also increase the incidence of anestrous and silent heat in dairy animal (Singal *et al.*, 1984; Kadokawa *et al.*, 2012; Singh *et al.*, 2013). It increases ACTH and cortisol hormone secretion (Singh *et al.*, 2013), and blocks the estradiol-induced sexual behavior (Hein and Allrich, 1992).Heat stress reduces the growth and maturation of oocyte thus reduces fertility (Singh *et al.*, 2013). In addition 80% of heat signs become unrecognized during summer season, this also play role for infertility (Rutledge, 2001). Conception rate of the dairy animal is lower from 55% to 33% in last sixty years throughout the world (Lucy, 2001). The most important factor for the scenario is heat stress. Increase level of prolactin during summer results acyclicty and infertility (Alamer, 2011; Singh *et al.,* 2013). The THI of 73 was the most likely threshold for the influence of heat stress on conception rate (Schüller *et al.,* 2014). Endometrial function and embryo development are hampered by low progesterone synthesis (Wolfenson *et al.,* 2000; Khodaei Motlagh *et al.,* 2011). Cows that calved during the warm season were open an average of 24.42 days longer than those calving during the cool season (Du Bois and Williams, 1980).

Along with adverse affect on dam and heat stress during late gestation is also related to lower birth weight of calves, which suggests lower fetal growth (Collier *et al.*, 1982). In case of heifer environmental stress can delay puberty and age at first calving (NRC, 2001).A period of high-temperature results to increase secretion of endometrial PGF-2α, thereby threatening pregnancy maintenance leads to infertility (Bilby *et al.*, 2008). Incidence of reproductive disorders such as dystocia and abortion were higher in summer period than winter season. Fetal loss rate was significantly increased from 17.1 % at low THI to 24.9 % at high THI (El-Tarabany and El-Tarabany, 2015).

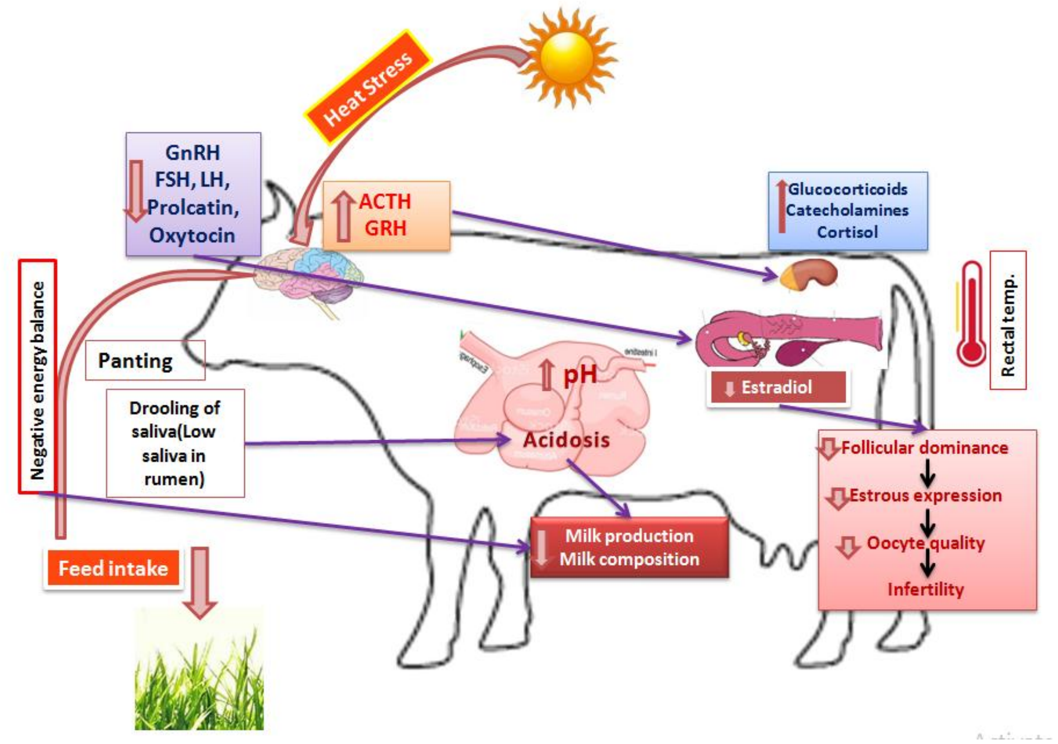

Figure 1: Schematic presentation of adverse affect of heat stress on dairy animal [Obtained from (Jimenez, 2013; Singh *et al.*, 2018)].

However, the aim of the present study was to determine the effect of heat stress on commercial dairy farms in Chattogram having different farming management in particular housing facilities. Following objectives were considered for the study:

- To determine the THI inside the barn at different farming management in the view point of housing condition.
- To determine the effect of heat stress on productive performances of different genotypes of crossbred cattle.
- To determine the effect of heat stress on reproductive performances of different genotypes of crossbred cattle.

CHAPTER II

REVIEW OF LITERATURE

2.1 Introduction:

Climatic conditions of Bangladesh are such that the hot and humid season is relatively long, there is intense radiant energy for an extended period, and there is generally the presence of high relative humidity. So heat stress is chronic in nature especially for animal (West, 2003). Elevated environmental temperature, solar radiation, and relative humidity leads to hyperthermia or heat stress (Thatcher *et al.,* 2010). Heat stress is defined as any combination of environmental conditions that will cause the effective temperature of the environment to be higher than the temperature range of the animal's thermal neutral zone. A number of changes occur in the animals as a result of heat stress like elevated body temperature (>102.5 ºF), respiration rates (>70-80/minute), blood flow (Pereira *et al.,* 2008). Heat stress is associated with the Temperature Humidity Index (THI). THI index is widely used in the hot area of worldwide to know the effect of the heat stress on dairy cow (Thom., 1998). Lactating cows are thought to experience no stress when THI is less than 72 and severe stress when THI exceeds 88. Heat stress has detrimental effect on the productive and reproductive performances of cattle and buffaloes (Tailor and Nagda, 2005).

Stress condition of the animal leads to severe hormonal imbalance that subsequently hampers the milk production as well as bring drastic change in the milk compositions (butter fat, milk protein).

The stress condition causes the release of ACTH from the anterior pituitary which stimulates release of cortisol and other glucocorticoids from the adrenal cortex. Glucocorticoids inhibit the release of luteinizing hormones. (Singh *et al.,* 2013) That leads to irregular estrous cycle and infertility. Heat stress during dry period can affect endocrine system that may cause fetal abortions, shorten the gestation length, lower calf birth weight, and reduce follicle and oocyte maturation (Collier *et al.,* 2006). The rising ambient temperature from 12.5°C to 35°C was accompanied by decline of CR (conception rate) in cattle from 40 to 31% (Zewdu *et al.,* 2014).

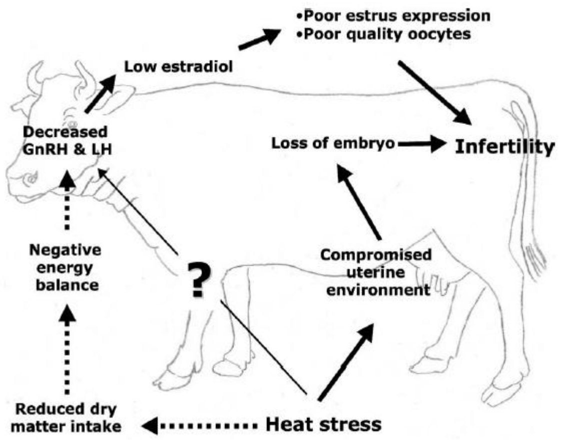

Figure 2: Effect of heat stress on reproductive performance (De rensis, 2003)

2.2 Livestock of Bangladesh:

Livestock is the part and parcel of the complex farming system in Bangladesh as it serving as the source of protein (meat), milk and also act as a major source of farm power services as well as the earning source for a large number of rural populations. Farming becoming a popular and profitable business in urban areas among the educated individuals.

Table 1: Livestock population (in lakh) overview from 2015-2018 (DLS, 2018)

Livestock Species	2015-16	2016-17	2017-18
Cattle	237.85	239.35	240.86
Buffalo	14.71	14.78	14.85
Sheep	33.35	34.01	34.68
Goat	257.66	259.31	261.00
Total Ruminant	543.57	547.45	551.39

About 20% of the total population of Bangladesh directly depend on livestock sub-sectors as their full time employment and 50% involved in part-time employment. (Begum *et al*., 2011).

Table 2: Contribution of Livestock in the National Economy of BD (DLS, 2018)

Contribution of Livestock in Gross Domestic Product (GDP) (Constant Prices)	1.54%
GDP growth rate of Livestock (Constant Prices)	3.40 %
GDP volume (Current prices) (Million Taka)	396246
Share of Livestock in Agricultural GDP (Current prices)	13.62%

As per the national health strategy, Bangladeshi people should have 250 ml of milk daily, which leads the national milk demand to 14.02 million tons (Hamid and Hossain, 2002). With the gradual increase of the income of the people, population growth, urbanizations and change in the dietary habit consumption of milk and milk products has been swelling dramatically (Anon, 2008). This is also assumed that milk, daily products and meat consumption will expected to increase three in South Asia from 1965 to 2030 (Anon, 2008).

Table 3: Estimated Demand, availability and deficit% of milk from 2015 to 2030 in Bangladesh:

Year	**Demand (Million Metric Ton)**	**Availability (Lakh Metric Ton)**	**Deficit%**
2015	14.5 (250ml/head/ day)	3.44 (59.3l/head/day)	76%
2020	15.5 (250ml/head/day)	4.8 (77.6ml/ head/day)	69%
2025	16.4 (250ml/head/day)	8.67 (132ml/head/day	47%
2030	17.5 (250ml/head/day)	15.6 (225ml/head/day)	11%

Considering the population growth rate of 1.6%, per capita milk consumption at 120 ml, about 9.09 million tons of liquid milk production will be obligatory in the year 2025 in Bangladesh. The total yearly concern will be 19.02 million tons if per capita daily milk consumption rose to 250 ml in the year 2025 in Bangladesh (Anon, 2008).

2.3 Global climate and seasonal overview:

Climate is simply the weather which is dominant or normal in a specific region; the term climate possess of temperature, rainfall and wind patterns. Geography, global air and tree cover, sea currents, global temperatures and other associated factors influence the climate of an area, which explains the local weather (Williams, 2002).

Since the industrial revolution in around 1750, one of these greenhouse gases, carbon dioxide, has increased excessively by over 30% and is now remains at a greater concentration in atmosphere than it has been for many thousands of years. Chemical analysis of the carbon manifests that this increase is due largely to the burning of fossil fuels - coal, oil and gas (Houghton, 2005).

Industry and transportation consumed the fossil fuels and produce a large amount of carbon dioxides and together with other greenhouse gases said as nitrous oxide and methane which are also produced by various human activities are thickening the actual greenhouse layer. This therefore leads to a warming of the earth, commonly known as "Global Warming" (Williams, 2002).Latest IPCC predicted from their 4th Assessment Report that for the upcoming twenty years warming at a rate of 0.2˚C per decade is expected to be increased. Which means by the year 2100 the global temperature will increase between 1.8˚C to 4˚ C, although it could possibly be as high as 6.4˚C (Dore, 2005).

Incidence of heavy rainfall will become more frequent, and this is likely to ravage farm incomes by increased soil erosion, and water logged soil will decrease fertility of the soil and reduce the crop production. Drinking water supply may also be contaminated by the incidence, which can cause outbreak of various water borne illnesses (Brouwer *et al*., 2007).

2.4 Climatic critique of Bangladesh:

Bangladesh is primarily a low-lying plain of about 144,000 sq. km, situated on deltas of large rivers flowing from the Himalayas. Except the hilly southeast, most of the country is a low-lying plain land. Geographically, it extends from 20°34'N to 26°38'N latitude and from 88°01'E to 92°41'E longitude. It has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, moderately warm temperatures, and high humidity.

Table 4: Seasonal Temperature, Rainfall and Humidity (BBS, 2017)

Season	Temperature (°C)	Rainfall (mm)	Humidity (%)
Pre Monsoon	22.4-32.6	453	74
Monsoon	25.5- 31.5	1733	86
Post Monsoon	21.4-30.5	210	80
Winter	13.9-26.5	44	73

According to Rashid (1977),there are three distinct seasons can be recognized in Bangladesh out of climatic point of view: (i) the dry winter season(December to February, (ii) the pre-monsoon Summer season (March to June) (iii) the rainy monsoon season (July to September), and (iv) the post-monsoon autumn season(October to November).

According to Ahmed and Schaerer, (2004) there are four meteorological seasons are recognized as- pre-monsoon (March, April and May), monsoon (June to September), post-monsoon (October and November) and winter (December, January and February).

The general characteristics of the seasons are as follows:

- Winter is relatively cooler and drier, with the average temperature ranging from a minimum of 7.2 to 12.8°C to a maximum of 23.9 to 31.1°C. The minimum occasionally falls below 5^{o}C in the north though frost is extremely rare. There is a south to north thermal gradient in winter mean temperature; generally, the southern districts are 5^{o}C warmer than the northern districts.
- Pre-monsoon is rather with an average maximum of 36.7°C, predominantly in the west for up to 10 days, very high rate of evaporation, and erratic but occasional heavy rainfall from March to June. In some places the temperature occasionally rises up to 40.6°C or more. The peak of the maximum temperatures is observed in April, the beginning of pre-monsoon season. In pre-monsoon season the mean temperature gradient is oriented in southwest to northeast direction with the warmer zone in the southwest and the cooler zone in the northeast.

- Monsoon is both hot and humid, brings heavy torrential rainfall throughout the season. About four-fifths of annual rainfall occurring during monsoon. The mean monsoon temperatures are higher in the western districts compared to that for the eastern districts. Warm conditions generally prevail throughout the season, although cooler days are also observed during and following heavy downpours.
- Post-monsoon is a short-living season characterized by withdrawal of rainfall and gradual lowering of night-time minimum temperature.

Bangladesh is one of the most disaster-prone countries in the world. High spatial and temporal climatic variability, extreme weather events, high population density, high incidence of poverty and social inequity, poor institutional capacity, inadequate financial resources, and poor infrastructure have made Bangladesh highly vulnerable to disaster(Ahmed and Kim,2003).

According to Shahid (2010), the average temperature of Bangladesh ranges from 17 to 20.6ºC during winter and 26.9to 31.1ºC during summer. The average annual rainfall of the country varies from 1,329 mm in the northwest to 4,338 mm in the northeast). The gradient of rainfall from west to east is approximately 9 mm/km. The western part of Bangladesh experiences an average areal rainfall of approximately 2,044 mm, which is much lower than that of other parts of the country.

Climate is still key determinants for agricultural productivity and sustainability (Ahmed and Ryosuke, 2000). This erratic and unevenly distributed pattern of the climatic parameters frequently produces extreme events, i.e. floods and droughts, which have significant harmful effects on main crops especially on livestock production. Drought in the northern part of the country has also become a growing concern in the recent years. The country experienced eight droughts of severe magnitude in last forty years (Shahid, 2008; Shahid and Behrawan, 2008).

Climate change has a noticeable impact on the climatic parameters like temperature and rainfall pattern and also the seasonal pattern of the country (Basak *et al*., 2013). Over the last three decades, the country has been facing higher temperatures over the last three decades (Sarker *et al*., 2012). Moreover, it is projected that the annual mean temperature will rise by 1.0ºC, 1.4ºC, and 2.4ºC by 2030, 2050 and 2100 respectively.

The average temperature for the winter season (December, January, and February) is likely to increase by 1.1ºC by 2030, 1.6ºC by 2050 and 2.7ºC by 2100. The prediction for the monsoon months is 0.8°C, 1.1°C and 1.9°C by2013, 2050 and 2100 respectively (Agrawala *et al*., 2003).

According to the above projections the country is likely to face more hot days and heat waves, longer dry spells and higher drought risk which will adversely affect the production of different crops. Similarly, monsoonal rainfall is projected to increase, and the rainfall variability may significantly increase causing more intense rainfall and longer dry spells. Based on the estimation of climate models, the precipitation will increase during the season of summer monsoon (Mirza, 1997; Ahmed and Alam, 1999).

2.5 Temperature humidity index (THI):

Temperature Humidity Index (THI) is a measure that has been used since the early 1990s. It accounts for the combined effects of environmental temperature and relative humidity and is a useful and easy way to assess the risk of heat stress. A THI is a single value representing the combination of air temperature and humidity associated with the level of thermal stress. The THI was developed as a weather safety index to monitor and reduce heat stress-related losses. Utilizing both humidity and temperature is important compared with utilizing temperature alone to evaluate heat stress. The water vapor concentration of the air is important since it can drastically reduce the ability of the animal to use evaporative heat loss through the skin and lungs. Cattle can tolerate much higher temperatures at lower relative humidity because they are able to dissipate excessive heat more effectively by sweating (Basak s*et al*., 2013).

However, during hot and especially humid conditions, the natural ability of cattle to dissipate heat is compromised due to the lowered ability to utilize evaporative cooling. As previously explained above, the Temperature-Humidity Index (THI) lets you know when your cows are becoming heat-stressed and to what degree so you can use appropriate cooling methods.

There are several THI indices that have been used in studies across varying climatic conditions due to the differences in sensitivity to ambient temperature and amount of moisture in the air among species.

THI can be measured by different ways.

$THI_1 = (1.8 \times Tdb + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times Tdb - 26.8)]$ (NRC, 1971);

$THI_2 = Tdb + 0.36 \times Tdp + 41.2$ (Yousef, 1985);

$THI_3 = (0.35 \times Tdb + 0.65 \times Twb) \times 1.8 + 32$ (Bianca, 1962);

$THI_4 = (0.55 \times Tdb + 0.2 \times Tdp) \times 1.8 + 32 + 17.5$ (NRC, 1971);

$THI_5 = (0.15 \times Tdb + 0.85 \times Twb) \times 1.8 + 32$ (Bianca, 1962);

$THI_6 = [0.4 \times (Tdb + Twb)] \times 1.8 + 32 + 15$ (Thom, 1959);

$THI_7 = (Tdb + Twb) \times 0.72 + 40.6$ (NRC, 1971)

$THI_8 = (0.8 \times Tdb) + [(RH/100) \times (Tdb - 14.4)] + 46.4$ (Mader *et al.*, 2006).

2.6 Heat stress of dairy animal:

Heat stress is caused by the combination of temperature, relative humidity (RH), solar radiation, air movement along with precipitation. The majority of studies on heat stress in livestock focus on the two main environmental stressors: temperature and relative humidity (RH). Heat stress was defined as combined external forces on a homoeothermic animal that acts to destabilize body temperature, to an extent where the animal cannot dissipate enough metabolically produced or absorbed heat to maintain thermal equilibrium (Bernabucci *et al*., 2014).

Heat stress directly and indirectly affects nutrition, productivity, physiology, health, and behavior of lactating dairy cattle, in turn negatively affecting farm profitability (Cook *et al*., 2007; Tucker *et al*., 2008; Rhoads *et al*., 2009).Physiologic mechanisms for coping with heat stress include, increased respiration rate, sweating, and reduced milk production and reproductive performance (Fuquay, 1981; St-Pierre *et al*., 2003; West, 2003; Polsky and Keyserlingk, 2017).

The Thermoneutral Zone *(*TNZ) may define as, "The range of ambient temperature within which metabolic rate is at a minimum, and within which temperature regulation is achieved by non evaporative physical processes alone". The lower critical ambient temperature range point and the upper critical ambient temperature point indicate the limits of the TNZ. The ambient temperature below, which the rate of heat production of a resting homeotherm increases to maintain thermal balance, is the lower critical temperature (LCT). The upper critical temperature (UCT) may be defined as the ambient temperature when increased metabolic rate, increased evaporative heat loss, minimal tissue thermal insulation (Silanikove, 2000). At the below and above these recommended temperature limits heat production increased. According to the age, species and breed width of the thermoneutral zone may vary. It is also depending on level of nutrition, previous state of temperature acclimation or acclimatization, level of productivity, housing conditions, insulation, and behavior etc (Yousef, 1985). According to (Silanikove, 2000) TNZ subdivided into a zone of thermal well-being which is most suitable to describe the relationship between an animal and its surrounding environment.

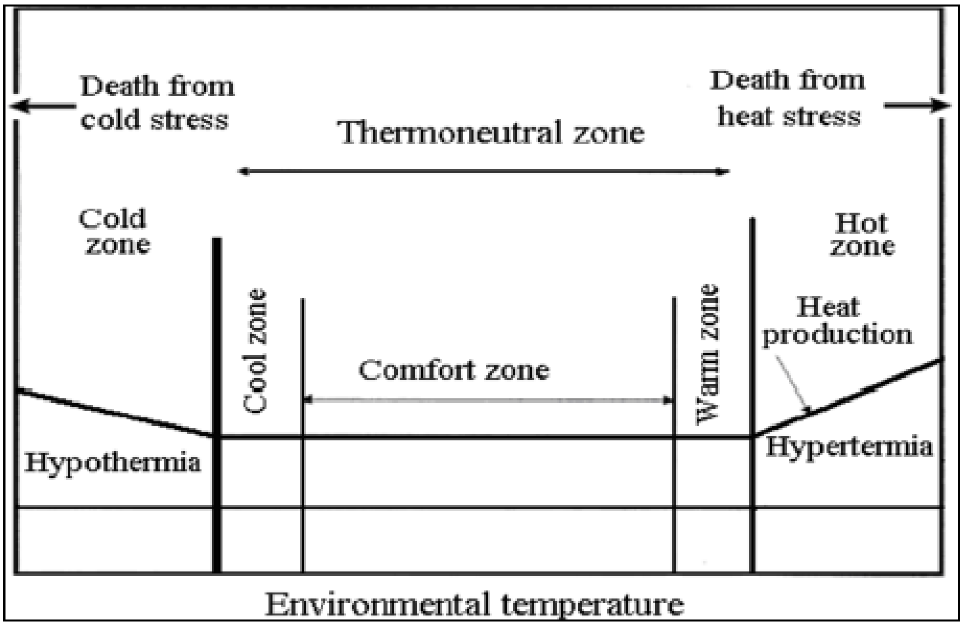

Figure 3: Schematic figure of thermoneutral zone and comfort zone.

Table 5: Lower and upper critical temperature of dairy animal.(Aggarwal and Upadhyay, 2012)

Animal	Upper Critical Temperature (UCT) (°C)	Lower Critical Temperature (LCT) (°C)
Buffalo	36	10
Indigenous Cattle	32-34	10
Crossbred Cattle	24-26	6-8
Jersey Cattle	24-26	2
Holstein Friesian Cattle	22-24	-10 to -20

A number of changes occur in the animals as a result of heat stress like elevated body temperature (> 102.5 ºF), respiration rates(> 70-80/minute), blood flow (Pereira *et al., 2008*) But significant changes in physiological processes were not occurring within the range of 5–25°C (McDowell, 1976). The maintenance energy requirement may increase by 20-30% in animals under heat stress. Low energy diet has detrimental effect on reproduction. This decreases the low intake of energy for productive functions such as milk production. An increased loss of sodium and potassium is results of heat stress. This result in shift the acid base balance and result in a metabolic alkalosis. Dry matter intake decreases for short term or long term depending on the length and duration of heat stress.

The best methods of calculating heat stress in the temperature humidity index (THI).

Table 6: Effect of heat stress on dairy cattle at different THI

THI	Stress level	Response of Dairy cattle
Upto 72	None	
72-79	Mild	• Seeking shed • Increase reparation and dilated blood vessels • Milk production slightly hampered
80-89	Moderate	• Salivation increased and increased respiration • Lower feed intake and higher water intake • Increase rectal temperature • Milk production and reproduction decreases
90-98	Severe	• Very uncomfortable • Panting and excessive salivation • Milk production and reproduction decreased significantly
Above 98	Danger	• Potential cow death may occur

2.7 Effect of heat stress on core body temperature of cattle:

The normal core body temperature range given for adult cattle living in temperate climates is between 36.7 and 39.1°C' (Cunningham, 2002). At this temperature, cellular and other biochemical activities remains most effective. Lower and higher temperatures alter metabolism. Increase in metabolic activity, increase heat production that further causing increased metabolic activity. Uncontrolled metabolisms and directly heat exposure result in to *''run-away hyperthermia'* leading to death (Sparke *et al.,* 2001). With body core temperatures above 42°C there is a risk of this phenomenon developing (Sparke *et al.,* 2001). Normal body temperature of the cow is about 38.5°C (101.3°F) and a cow that as a rectal temperature of 39°C (102.2°F) or higher during the afternoon, and it is not sick, is possible to be heat stressed (Chanda *et al.,* 2017).

According to (Wise *et al.*, 1988), Respiration rate and the body temperature is the indicator of stress in animal. By measuring the rectal temperature along with physical appearance such as panting, excess salivation and increased respiration confirmed the animal suffering from heat stress.

Pereira *et al.,*(2008) find that due to heat stress body temperature may increase up to 102.5°F in hot and humid climate. This leads the animal to serious discomfort.

Bouraoui *et al.,*(2002) study indicates that significant rectal temperature increase from spring(38.36°C) to the summer (38.86°C).Increase rectal temperature also reported in other studies when animal remain in temperature higher than the thermoneutral zone. (Roman-Ponce *et al.*, 1977; Mohamed *et al.,* 1985; Wisem*et al.,* 1988). In the study of (Srikandakumar and Jhonson, 2004) rectal temperature increased in case of Australian milking zebu, Jersey and Holstein cattle was 0.38°C, 0.70°C and 0.47°C respectively. Which indicates Jersey cattle was the poor heat tolerable cattle breed according to this study.

There are also some other studies where it clearly indicates that higher THI index increase the core body temperature and animal prefer to remain in standing position due to higher temperature (Zahner *et al.*, 2004; De Palo *et al.*, 2005; Provolo and Riva, 2009). When THI reached upto 68, then the core body temperature increased and duration of the cows lying down decreased. (Allen *et al.,* 2015).

2.8 Effect of heat stress on dry matter intake (DMI):

During cool climatic condition had minor effects on dry matter intake. During the hot period, the increase THI and air temperature had the greatest impact on dry matter intake (West *et al.*, 2003).

According to (Mc Guiren *et al.*, 1989) extreme environmental condition directly affect the dry matter intake. In Holstein Friesian cattle DMI decreased to 11.5 kg/day from 15.1 kg/day due to compromise environmental comfort. A distinct decrease of 9% dry matter intake found in the study of (Nonaka*et al.*, 2008) when temperature reached 33°C from 28°C in HS cattle. (Silanikove, 2000) reported that the appetite decrease caused by increased body temperature could be related to gut fill. Feed intake initially decreases when temperatures reach 25°C, declining more rapidly over 30°C, with decreases up to 40% at 40°C.
At 32.2 C the majority of the responses showed clear changes in the first week of each period. Evaporation from body surface increased markedly at 32.2 C, with the water coming mostly from a 28% increase in consumption and a 33% decrease in fecal water. Which also decrease the urine production (Mc Dowell *et al.*, 1969).

Daily dry matter intake declined from 17.8 kg when in thermal comfort with the decrease in 12.5kg in the heat stress condition (Lough *et al.*, 1990). This clearly indicates heat stress affect the DMI. Dry matter intake was affected by THI when ambient temperature was ≥21°C at the day of data collection. Results shows DMI increased up to THI 35, reached a pick and dropped, when THI exceeded 60. When THI was 70, DMI had a slight peak (Gorniak *et al.*, 2014). Feed intake of lactating cow is declined when ambient temperature reached 25-26°C and more rapidly declined above 30°C (Rhoads *et al.*, 2013). According to (Eastridge *et al.*, 1998) dietary intake may decline upto 40% at the temperature of 40°C. Increase in ambient temperature results increase in rectal temperature decrease dry matter intake (Rhoads *et al.*, 2009). The mean levels for acetic, propionic, and total VFA were found 94.4, 37.6, 153.1; 94.7, 33.3, 147.9; and 47.2, 10.6, 66.3 mEq/liter of rumen fluid for 1.6°, 18.2°, and 37.7° C, respectively (Kelley *et al.*, 1967).

Severe heat stress condition also alters the ruminal environment (Weldy, 1964). When Holstein cow exposed to 90° F, some distinct physiological change observed in terms of rumen pH, blood glucose levels. Gut motility, ruminal contraction and rumination reduce due to increase environmental temperature and decrease appetite in ruminant animal (Yadav *et al.,* 2013). Changing of rumen pH occurred by heat stress that reduces the production of volatile fatty acid (VFA) with individual animal variation (Yadav *et al.,* 2013). Rumination also hampered by the heat stress (Aganga *et al.,* 1990; Soriani *et al.,* 2013). In heat stressed animal production of lactic acid in the rumen is higher that cause ruminal acidity by decreasing ruminal pH (Mishra *et al.,* 1970). High ambient temperature also cause gastrointestinal hormonal imbalance that reduce gut motility and ruminal contraction (Grovum, 1981).

2.9 EFFECT OF HEAT STRESS ON PRODUCTIVE PERFORMANCES OF CATTLE:

2.9.1 Milk production:

(Heck *et al.,* 2009) collected bulk milk samples from seventeen milk plants in Netherlands from February 2005 to February 2006. In their study, they observed a higher milk yield in the winter months than summer months. (Larsen *et al.*, 2010) reported that in indifferent parts of Sweden variation in milk production and fat percentage during the different seasons. They attributed both these differences due to feed changes.

Seasonal variation of the quality and the effect of the two feeds on the seasonal variation were also studied by (Boor *et al.*, 1998). The results of the physio-chemical parameters of the milk obtained from cows fed on two varieties of feed in the months of November, January and March (autumn-winter season) and in the months of May, June and September (spring-summer season). They observed a higher milk production in the winter months than summer months. The variation in milk yield is because of the diet given to the cows along with the variation of the season. Effect of seasonal variation of milk yield is also studied by (Prejit *et al*., 2007; Könyves *et al*., 2017). They found variation of milk yield in different seasons (summer, rain and winter) obtained from the herd of Jersey x Red Sindhi x Local crossbred-bred cows. The results showed that milk production was higher in winter and lower in summer season. Higher milk production in winter compare to the summer season is observed in most of the studies (Oleggini *et al*., 2001;Nardone *et al.,* 2010).

Večeřa *et al.,* (2013) found the significant influence of season on milk production. Higher amount of milk was obtained in spring season from the cow (29.28 kg) than autumn season (24.58 kg). Weak heat stress can reduce upto 10% of milk production and in case of higher heat stress as high as 25% milk production can be hampered (Toufer and Dolejs, 1996; Pennington and Devender, 2006).

A study conducted in Egypt by (Nasr and Tarabany, 2017) with production records from multiple herds over a 4-year period were separated into low medium and high THI groups based on average monthly THI. Milk yield decreased by 14.29% from low to high THI groups.

In the chamber experiment of (Schneider *et al.,* 1988) cows that exposed to heat stress usually ate less and produce lower amount of milk about 18% than cows remain in thermoneutral environment. When cows remain in heat stress for 4 consecutive days, DMI decreased about 48% followed by 53% decreased in milk production.

Rhodes *et al*., (2009) conducted that cow usually reduce the synthesis of milk during high ambient temperature. Reduce DMI leads the cattle to negative energy balance (Dash *et al.,* 2016). This negative energy balance and less DM intake going to reduce milk production (Tao *et al.*, 2018).

Johnson and Vanjonack (1976) reported that 3-10% of the change in milk production was caused by climate factors. In another study (Wheelock *et al*., 2010), said that on mid-lactation heat stressed cows, DMI accounted for only 50% of the drop in milk production, proposing that other factors influenced the remaining reduction. Additionally, severely heat stressed cows experienced a higher drop in milk yield than a pair-fed group consuming the same amount of feed (Baumgard and Rhoads, 2012; Cowley *et al*., 2015).

2.9.2 Milk composition:

Milk in general high in fat and protein content during the season of winter and fall months and lowest during the spring and summer seasons. This variation is associated mainly to change in climatic conditions and feeding regime. During spring, the green pastures usually provide low fiber in diet, which reduces the fat and protein percentage in milk. During summer months, heat stress declines the dry matter intake following in decrease of fat and protein percent (Looper, 2014). Apart from diet and hot weather, lactation stage, calving patterns, humidity, photoperiod, somatic cell count, etc., also contribute to variation in milk composition. Hence, It is combined with various factors, so very difficult to find out the single cause (Fox *et al.*, 2004).

Bernabucci *et al.*,(2002) studied the variation of milk composition with regard to the environmental temperature for two seasons: spring and summer. The study comprised of 40 mid lactating Holstein cows in central Italy. The findings of the study were the fall of milk production in summer was 10% lower than the milk production in winter. There were also changes in milk composition, 9.9% less protein yield found in summer than spring season. Casein percentage also decreased.

Bertocchi *et al.*,(2014) investigated annual, seasonal, and monthly variations in milk characteristics (somatic cell count, total bacterial count, fat, and protein percentage) and thermal humidity index (THI) -milk characteristics relationships over a seven-year period(2003-2009) in Holstein dairy farms in Po Valley, Italy. They found high somatic cell count, total bacterial counts, lower fat, and protein percentage in summer months. However, they reported that the THI - milk characteristics study suggested that heat stress was not the main factor contributing to fat and protein decrease. They concluded that the photo-period and also lactation stage might be the contributing factor.

In the study of Azad *et al.*,(2007) at baghabarighat milk shed area milk shed shows the higher amount of fat, protein and SNF found in the milk during winter season than the summer period.

Sargeant *et al*., (1998) studied the effect of seasonal variation in milk composition on dairy fouling. The milk that was supplied to the Fontera Research Center showed the production of milk in early February, 2007 to mid-April, 2008. The reading shows that there is a change in the production of milk in two different times and this change has an effect on the dairy fouling of milk. The change in the composition of milk is attributed to the feeding behavior of the cows. During drought period the production of the milk is reduced. Lactation is also seen to influence the composition as observed by the authors.

2.10 EFFECT OF HEAT STRESS ON REPRODUCTIVE CHARACTERISTICS:

2.10.1 Estrous period and follicular growth:

Heat stress directly affect estrous period and also increase the incidence of anestrous and silent heat in dairy animal (Singal *et al.,* 1984; Kadokawa *et al.,* 2012; Singh *et al.,* 2013). It increases ACTH and cortisol hormone secretion (Singh *et al.,* 2013), and blocks the estradiol-induced sexual behavior (Hein and Allrich, 1992). Roth *et al*., (2000) revealed that developed follicles become damaged and non-viable when the core body temperature exceeds 40°C.

Reduced the granulosa cells aromatase activity and viability also responsible for poor estradiol secretion (Wolfenson *et al.,* 2000; Ozawa *et al.,* 2005). Low estradiol secretion resulting suppressed signs of estrus, ovulation, gonadotropin surge, transport of gametes that cause reduced fertilization (Wolfenson *et al.,* 2000). In Indian buffalos poor estradiol production in heat stressed condition resulting poor expression of heat (Upadhyay *et al.,* 2009).

2.10.2 Fertility:

Various factors are associated with the fertility of dairy animal. Depending on the magnitude of heat stress fertility can be affected. Heat stress reduce the growth and maturation of oocyte thus reduce fertility (Singh *et al.,* 2013). Increase level of prolactin during summer results acyclicty and infertility (Alamer, 2011; Singh *et al.,* 2013).

In addition 80% of heat signs become unrecognized during summer season, this also play role for infertility (Rutledge, 2001). A period of high-temperature results to increase secretion of endometrial PGF-2α, thereby threatening pregnancy maintenance leads to infertility (Bilby *et al.,* 2008).

Oocytes of cows that exposed to thermal stress usually lose their ability for fertilization (Gendelman and Roth, 2012a) and development to the blastocyst stage (Gendelman and Roth, 2012b). Along with these heat stress cause infertility by reducing the quality of oocyte and early stage embryo (Gendelman and Roth, 2012b).

2.10.3 Embryonic growth and development:

Early embryonic death also caused by heat stress due to interference of protein synthesis in embryo stage (Edwards and Hansen, 1996), oxidative cell damage

(Wolfenson *et al.,* 2000), reducing interferon- tau production for signaling pregnancy recognition (Rutledge, 2001) and expression of stress-related genes associated with apoptosis (Fear and Hansen, 2011). Endometrial function and embryo development are hampered by low progesterone synthesis (Wolfenson *et al.,* 2000; Khodaei Motlagh *et al.,* 2011).

Exposure of lactating cows to heat stress on the 1st day after estrus reduced the ratio of embryos that developed to the blastocyst stage on the 8th day after estrus (Ealy*et al.,* 1993).Exposure of post-implantation embryos (early organogenesis) andfetus to heat stress also leads to various teratologies (Wolfenson *et al.,* 2000). The deleterious effects of heat stress in the embryo are most evident in early stages of embryo development (Demetrio *et al.,* 2007).This events result in lower pregnancy rate due to embryonic loss at day 30-45 (Demetrio *et al.*, 2007).

2.10.4 Calf birth weight:

Exposure to heat stress increases the maintenance energy requirements while suppressing appetite, resulting in smaller fetuses and slower rates of growth after birth (NRC, 1981).However, ewes with restricted nutrition in early pregnancy birth heavier lambs compared with those with unrestricted nutrition (Funston *et al.,*2010). In addition to nutrition, other prenatal stressors, such as environmental stress, psychological stress, and social stress, lead to compromised fetal development and postnatal immunity (Merlot *et al.*, 2008; Reynolds *et al.*, 2010). Heat stress cause adverse affect on dam and heat stress during late gestation is also related to lower birth weight of calves, which suggests lower fetal growth (Collier *et al.,* 1982).

According to Tao *et al.,* (2012) calf born from the heat stressed dam obtained lower birth weight and weaning weight than calf born from unstressed dam. Heat stress in ruminant limits fetal blood flow during late pregnancy that results lower glucose and amino acid supply to the fetus (Reynolds *et al.*, 2006) and lower oxygen diffusion to the fetus (Dreiling *et al.,* 1991). Thus, the heat stress and fetal hyperthermia may account for the other 67% (4 kg) of decreased fetal growth in heat stress calves relative to calves from cows that were in thermoneutral environment.

2.10.5 Conception rate:

The conception rate during the hot season can range from 20 to 30%lower than that in winter (Badinga *et al.,* 1985). Conception rate of the dairy animal is lower from 55% to 33% in last sixty years throughout the world (Lucy, 2001). The most important factor for the scenario is heat stress which reduces conception rate upto 23% (García-Ispierto *et al.,* 2007). High yielding varieties are more affected by heat stress due to high production and negative energy balance. Disturbances in hormonal balance include decreased serum estradiol concentration (Wilson *et al.,* 1998a; Wilson *et al.,* 1998b), decreased plasma concentration of LH, and decreased progesterone secretion (Wolfenson *et al.,* 2000). Furthermore, oocyte quality (Ferreira *et al.,* 2011; Gendelman and Roth, 2012b), embryo development (De Rensis *et al.,* 2003; Gendelman *et al.,* 2010; Silva*et al.,* 2013), and embryo survival (Wolfenson *et al.,* 2000) are impaired by heat stress. These processes lead to a decrease in CR in the subtropical are as during the hot season at 90 and 135 days postpartum(33% and 62%) ranging between 20% and 30% compared with the winter season (46% and 76%) De Rensis *et al.,* (2003). Thus, heat stress is one impacting factor responsible for extensive economic losses to the dairy industry (Collier *et al.,* 2006).

Heat stress during the day of breeding readily decreases the conception rate (García-Ispierto *et al.,* 2007; Morton *et al.,* 2007). Therefore, negative effects of heat stress have been observed from 42 days before to 40 days after insemination (Jordan, 2003).Conception rate of lactating dairy cows in the moderate climate was highly affected by heat stress. The THI of 73wasthe most likely threshold for the influence of heat stress on conception rate (Schüller *et al.,* 2014).

2.10.6 Post partum heat period and days open:

There is a widely observed decrease in the fertility of postpartum dairy cows inseminated in the summer compared to cows inseminated in winter (De Rensis and Scaramuzzi, 2003). Higher non return rate was obtained in the study of Al-Katanani *et al.,* (1999) in cooler month of the year and lowest in the summer months.

According to Lewis *et al.,* (1984) heat stress during prepartum affected the sensitive measures of the postpartum reproductive function, although it did not alter days to first estrus, days open (102.3±13.1) or services/conception (2.5±0.3). During the heat stress period the size of the dominant follicle become lower that cause delayed post partum heat and increase days open (Shehab-El-Deen*et al.*, 2010).The number of days open was influenced both by abnormal postpartum period and season of calving. Cows having retained placenta and metritis were open an average of 31.69 days longer than cows with normal postpartum periods. Cows that calved during the warm season were open an average of 24.42 days longer than those calving during the cool season (DuBois and Williams, 1980)

2.10.7 Maturity of heifer:

The age at attainment of sexual maturity in case of Holstein heifers ranges from 9 to 11 months, 14 to 16 months of age is the breeding age, weighing in between 400 and 430 kg (Tučková and Filipčík, 2019). Compared to lactating cows, heifers generate far less metabolic heat, have greater surface area relative to internal body mass and would be expected to suffer less from heat stress (Nonaka *et al.*, 2008). The conception rates for heifers do not decline until 35 °C (Cavestany *et al.*, 1985). However, environmental stress can delay puberty and age at first calving (NRC, 2001). Colditz and Kellaway (1972) reported that high environmental temperature decreases feed intake by only 14%in Friesian heifers, whereas daily weight gain fell by 50%. The growth rate, serum concentration of thyroxin and glucose of Friesian calves were found to be significantly lower in summer than in winter (Marai *et al.*, 1995). Maternal heat stress during the dry period limits heifer calf grain intake and growth during the pre weaning period (Monteiro *et al.*, 2016).

2.10.8 Heat stress on reproductive diseases (abortion, retained placenta and dystocia):

Stressed animal tends to eat less, this low dry matter intake drives the animal to malnutrition which cause fetal death, abortion and dystocia (Wu *et al.*, 2006). The incidence of retained placenta and postpartum metritis was 24.05% during the period of May through September compared to 12.24% the rest of the year. The gestation period of cows calving during the warm season was an average of 2.82 days shorter than that of the cows calving during the cool season. Heat stress resulting in early parturition was the probable cause of this increased incidence of retained placenta and postpartum metritis (DuBois and Williams, 1980). Furthermore, their fetal loss rate was significantly increased from 17.1 % at low THI to 24.9 % at high THI (El-

Tarabany and El-Tarabany, 2015).In study of Ahmadi and Mirzaei, (2006) the effect of heat stress on the incidence of retained placenta in dry and hot weather of Shiraz, 542 Holstein cows were examined. The study found that incidence of retained placenta was 6.92%, 18.3%, 13.23% and 7.58% in spring, summer, fall and winter, respectively. The average temperature- humidity index (THI) was 73.2 in summer, indicating that the cows were remaining under heat stress. It that heat stress increased the incidence of retained placenta in Holstein cows.

2.11 Conclusion:

Chattogram is one of the most dairy developed cities in Bangladesh in the aspect of commercial dairy farming. Chattogram is facing a lot of problem regarding quality and quantity of milk production. The problems of dairy industry are hindered due to poor management, high ambient temperature and humidity, poor nutrition, lack of good breeds, infertility, reproduction disorders, animal diseases and the poor marketing system for the milk and milk products. Economic profitability of a dairy farm is based, in part, on the calving interval of the cows. The optimal interval is 365 days. To achieve this, the cow needs to be pregnant within 85 days post partum. But in the environmental condition like Bangladesh, exotic cross bred dairy cattle always remain under heat stress which cause the hormonal imbalance leads to delayed puberty to other reproductive disorders. For obtaining profitable farming operation, farmers have to give the cow comfortable environment. In this context of profitable farming, present effect of heat stress need to be studied and possible remedies should bring to light.

Chapter III

Materials and Methods

3.1 Study area:

Chattogram consists of an area of about 168.07 square kilometer (64.89 sq mile). This city is known for its hilly terrain that stretches throughout the district. The location of the city is 22°22'0" N 91.98°E on the bank of Karnaphuli river. Sikalbaha is the area under Karnophuli upazilla which is situated to the south bank of Karnaphuli river next to the Chattogram metropolitan area (CMA). Commercial dairy farms of CMA and Sikalbaha were selected for the study.

3.2 Study period:

This study was conducted during the period of December 2018 to June 2019.

3.3 Selection of farm:

Three commercial dairy farms were selected for the study. Liza Dairy Farm (Farm A) located in CMA, Azizia Dairy Farm (Farm A) and Shahanaz Dairy Farm (Farm B) were located in Sikalbaha.

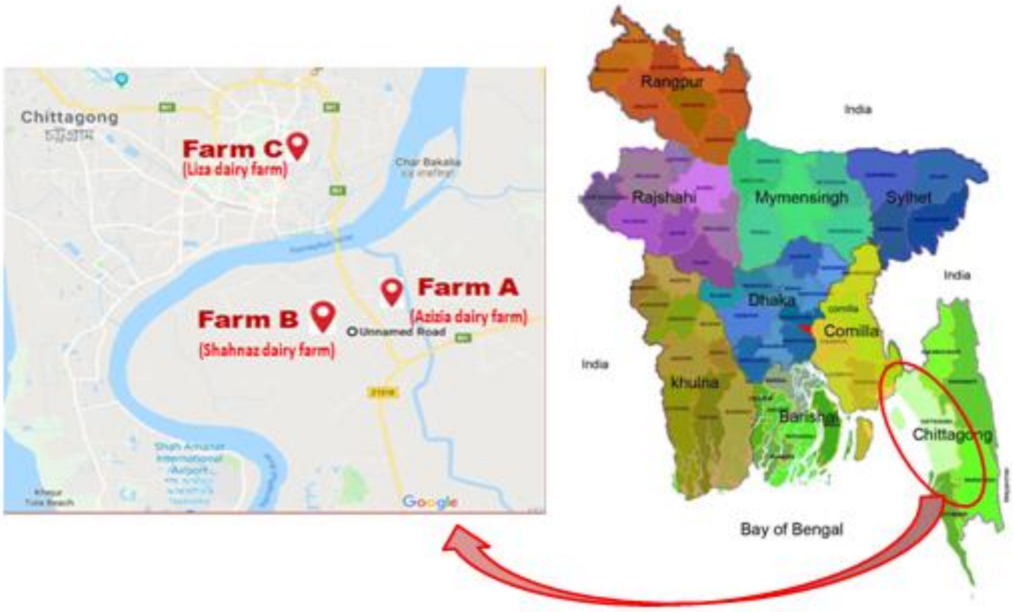

Figure 4: Location of selected farms.

3.3.1 Criteria for farm selection:

For the selection of the commercial farms from the study areas following categories were considered in terms of housing management.

- Height of the shed
- Ventilation system
- Roof materials and insulation materials
- Stocking density
- Provided fan type and density
- Surrounding areas

As per observations of the housing managements three types of farms were selected for the study. These were categorized as good, moderate and poor housing condition.

3.4 Animal Selection:

For the production related study (milk production and composition) a total of 27 (9 from each farm)crossbred dairy cows of HF50%×L50%, HF50%×S50% and HF75% × L25% of 3rd lactation were selected. The genetic composition, number of lactation, milk yield records in previous lactation and month of calving were the main criterion to select dairy cows.

Table 7: Animal selection for production record.

Genotype	Farm A	Farm B	Farm C	Total
G_1 (HF50%×L50%)	3	3	3	9
G_2 (HF75% × L25%)	3	3	3	9
G_3 (HF50%×S50%)	3	3	3	9
Total	9	9	9	27

For the reproductive related informations, total 173 milking cow, dry cow and heifers of genotypeG_1 (HF50%×L50%), genotype G_2 (HF75%× L25%) and genotype G_3 (HF50%×S50%) were observed throughout the study period.

3.5 Animal management:

3.5.1 Cleaning of shed:

Animal shed were cleaned twice a day with disinfectant. Droppings of cow were removed by the farm attendant.

3.5.2 Deworming:

All experimental animals were checked for any kind of external parasitic infestations and deworming was done by using broad spectrum anthelmentic.

3.5.3 Vaccination:

Proper vaccination schedule was maintained during study period.

3.5.4 Washing of animal:

Animals were washed by cold water 3-4 times daily in summer season and 2 times in the winter.

3.5.5 Milking management:

Cows were milked twice daily by hand milking (morning and evening) and recorded every day in the course of trial period.

3.5.6 Feeding management:

A single ration was formulated for each group of cows and offered for each period of trial. Cows were fed 2 times a day with mixed concentrate rations and four times green grass & rice straw through manual distribution to the selected genotypes as mentioned in table 9,10 and 11.

Table 8: Composition of feedstuffs

Ingredients	DM (g/kg)	ME (Mj/kg DM)	CP (g/kg DM)
Green grass	240	9.0	90.0
Straw	900	6.0	30.0
Rice polish	900	12.0	120.0
Wheat barn	900	12.0	140

Soybean meal	900	9.0	400
Broken Maize	900	12.5	8.5
Mug bran	900	9.0	250
Molasses	850	11.0	25.0

Table 9: Daily feedstuffs consumption per cow of genotype G_1 (HF50%×L50%)

Ingredients	Quantity(kg)	DM(kg)	ME (MJ)	CP(g)
Green grass	16	3.84	34.56	345.6
Straw	2	1.80	10.80	54
Rice polish	2	1.80	21.60	216
Wheat barn	1.5	1.35	16.20	189
Soybean meal	0.375	0.33	3.03	135
Broken Maize	1.2	1.08	13.50	9.18
Mug bran	1.5	1.35	12.15	337.5
Molasses	0.75	0.63	7.01	15.93
Total	**25.32**	**12.19**	**118.86**	**1302.21**

Table 10: Daily feedstuffs consumption per cow of genotype G_2 (HF75%×L25%)

Ingredients	Quantity(kg)	DM(kg)	ME (MJ)	CP(g)
Green grass	20.00	4.80	43.20	432
Straw	2.75	2.47	14.85	74.25
Rice polish	2.25	2.02	24.30	243
Wheat barn	1.50	1.35	16.20	189
Soybean meal	0.75	0.67	6.07	270
Broken Maize	1.50	1.35	16.87	11.47
Mug bran	2.00	1.80	16.20	450
Molasses	1.00	0.85	9.35	21.25
Total	**31.75**	**15.32**	**147.05**	**1690.97**

Table 11: Daily feedstuffs consumption per cow of genotype G_3 (HF50%×S50%)

Ingredients	Quantity(kg)	DM(kg)	ME (MJ)	CP(g)
Green grass	18	4.32	38.88	3499.2
Straw	2.5	2.25	13.5	405
Rice polish	2.1	1.89	22.68	2721.6
Wheat barn	1.5	1.35	16.2	2268
Soybean meal	0.5	0.45	4.05	1620
Broken Maize	1.3	1.17	14.62	124.31
Mug bran	1.8	1.62	14.58	3645
Molasses	0.9	0.76	8.41	210.37
Total	**28.6**	**13.81**	**132.93**	**14493.48**

3.6 Calculation of Temperature humidity index (THI) in the selected farm:

THI of the selected farms were calculated by the following formula of National Research Council (NRC, 1971)

$$THI = (1.8 \times T_{db} + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T_{db} - 26) \text{ (NRC, 1971)}$$

WhereT_{db}= dry bulb temperature (°C);

RH =relative humidity (%).

3.6.1 Recording of temperature and relative humidity:

Environmental temperature and relative humidity was measured by digital thermohygrometer ((Model PH1000, Zeal, England). The digital thermohygrometer was installed in each three farms at the height of 5 feet from the ground.

The temperature and humidity were recorded five times daily throughout the study period at 6.00 am, 9.00 am, 12.00 pm, 3.00 pm and 6.00 pm to calculate THI by above mentioned formula.

3.7 Measuring rectal temperature:

To determine the affect of THI on dairy animals, rectal temperatures were recorded daily by using clinical thermometer. The rectal temperature was recorded in record sheet in each of the farms during evening time (5 PM).

3.8 Collection of milk sample:

Milk sample were collected weekly from the selected animals. Samples were analyzed for milk composition (fat and protein).

3.9 Testing of milk composition:

3.9.1 Procedure for test of fat (%) of milk:

Fat percentage was determined by volumetric method (Gerber method). Ten ml of concentrated sulfuric acid (H_2SO_4) was taken in butyrometer and 10.75 ml of well mixed milk sample was added to it. After that 1 ml of amyl alcohol was added and shaken the butyrometer until the disappearance of white particles. Centrifuge was done at 1100 RPM for 5 minutes and reading was recorded by keeping the butyrometer in vertical position (Kleyn *et al.,* 2001).

3.9.2 Procedure for test of protein (%) of milk:

Protein percentages of the milk samples were measured. Ten ml well mixed milk sample was taken in a conical flask and 0.4 ml potassium oxalate was added to it and kept the mixture for two minutes. 2-3 drops of phenolphthalein indicator was added and titration was done against 0.1 N sodium hydroxide solution upto the appearance of faint pink color.

Two ml formaldehyde solution was added to the mixture and kept for 30 minutes. After adding 2-3 drops of phenolphthalein indicator, titration was done by the same procedure (G. Pyne, 1932).

Total required alkali (NaOH) was recorded and percentage protein was calculated by,

$$\text{Protein percentage} = \text{ml of alkali required} \times 1.70$$

3.10 Data collection:

3.10.1 Production related data:

Daily milk production records of the selected animals were recorded daily from each groups and each farms. Daily total milk yield was obtained by cumulating of morning and evening milk production. Milk composition (fat and protein) data were recorded weekly.

3.10.2 Reproduction data:

3.10.2.1 Conception rate:

During the study period the animals were observed closely for the signs of heat. Animal that attained heat were inseminated artificially and checked for pregnancy which was not returned to heat after 60 days by rectal palpation.

3.10.2.2 Calf birth weight:

The body weights of the new born calves were taken on the day of birth. The weights were recorded in Kg.

3.10.2.3Days open:

After calving the calved cows were observed for the signs of heat. After the insemination the cows were test for pregnancy. The length from calving to conception were calculated and recorded.

3.10.2.4 Reproductive complications:

The pregnant cows and heifers were observed to determine any type of complications such as abortions, still birth, uterine prolapse, vaginal prolapse, dystocia, retained fetal membranes.

3.11 Data analysis:

All productive and reproductive data were included in Microsoft excel 2007 spread sheet to evaluate statistical analysis and analyzed by usingSTATA-2017 (Stata Corp, 4905, Lakeway Drive, College Station, Texas 77845, USA) and Minitab version 16, 2000.

Picture Gallery

Figure5: Animal shed of farm A (Insulated with bamboo slits)

Figure 6: Animal shed of farm B (No insulation and poor ventilation)

Figure 7: Animal shed of farm C (Low shed height and poor ventilation)

Figure 8: Good ventilation of farm A

Figure 9: Very high stocking density in farm C

Figure 10: Optimum stocking density in farm A


Figure 11: Recording rectal temperature of selected cattles


Figure 12: Recording temperature and relative humidity of animal shed

Figure 13: Parturition of cow

Figure 14: Heat stressed cow

Detection of milk fat percentage

Figure 15: Adding Sulfuric acid in butyrometer

Figure 16: Drawing 10.75ml milk sample

Figure 17: Adding amyl alcohol

Figure 18: Digestion of milk constituents

Figure 19: Centrifugation

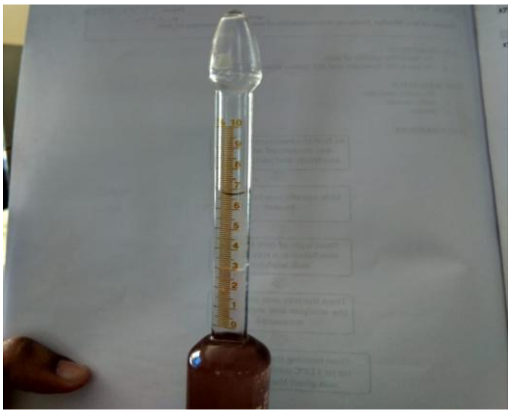

Figure 20: Reading of fat

Detection of milk protein percentage

Figure 21: Drawing milk sample

Figure 22: Adding potassium oxalate

Figure 23: Adding phenolphthalein

Figure 24: Titration against 0.1N sodium hydroxide

Figure 25: Adding formaldehyde

Figure 26: Faint pink color

CHAPTER V

DISCUSSION

This study was intended to determine the effect of heat stress on the productive and reproductive performances of the cross breds cattle of Chattogram raised in three commercial dairy farms having different housing management. From the results, it was found that the highest average THI was found during June and the lowest during December in all three farms. This is might be due to the higher ambient temperature and humidity in the month of June and lower ambient temperature and humidity in the month of December. Reyad *et al.,* (2016) was also found the highest THI in the month of June in Bangladesh Agricultural University dairy farm, Mymensing. These results also supported by Chanda *et al.*,(2017) they also found highest average THI during May 84.49± 0.558 and the lowest in January 68.79± 0.413. Result also reflect that, among the three selected farms the highest THI was 83.58±2.77 observed at farm C and the lowest 82.07± 2.61 at farm A during June. This difference might be due to the differences in housing condition of the farms. The lower shed height (12 feet) along with poor ventilation due to surrounding high rise buildings might be decreased the degrees of air movement to the animal shed, which increased the ambient temperature and humidity in farm C resulting the high THI.

There is a significant difference found in the rectal temperature (RT) of the animals from December to June. The RT obtained from all genotype groups were higher during the months of high THI (>72) as compared to the months having low THI (<72). That indicated that higher THI caused stress condition in animal directly involved in the increased RT (West, 2003). This result also supported by the study of Chanda *et al.,* (2017), they also found higher RT during the month of higher THI. The study of Bouraoui *et al.* (2002) also indicated that significant rectal temperature of dairy cattle increase from spring (38.36°C) to the summer (38.86°C). Increased rectal temperature also reported in other studies when animal remains in temperature higher than the thermoneutral zone (Roman-Ponce *et al.,* 1977; Mohamed *et al.,* 1985; Wise *et al.,* 1988). Among the three groups, RT of genotype G_2 was higher followed by genotype G_3 and G_1 during the hotter months of the study, which indicated that the higher percentage of temperate blood made the animal more prone to heat stress. Chanda *et al.,* (2017) also described the similar change. In the study of

Srikandakumar and Jhonson, (2004) showed that rectal temperature increased in case of Australian milking zebu, Jersey and Holstein cattle was 0.38°C, 0.70°C and 0.47°C, respectively during summer season.

There is a clear negative correlation between THI and milk production performance was seen in this study. The comfortable environmental temperature for dairy cattle ranges between 5 to 25° C which is also known as the thermal comfort zone (McDowell, 1976). Dairy cow experienced no stress when THI remains under 72. At the level of THI 72-79 cows remain in moderate heat stress. When THI exceeds 80, it imposes severe heat stress to the dairy cattle (Moran, 2005). The highest milk production of the animal was found during January and lowest observed in June in all three genotype groups of animals (Table: 16). This indicated that higher THI in June cause lower milk production and lower THI of January favored to increase milk production by providing comfortable environment to the cows. This was might be due to the higher THI caused lower dry matter intake and caused negative energy balance of the dairy animals that directly hampers the milk production physiology (Silanikove, 2000). This finding resembles to the findings of Chanda *et al.,* (2017). Larsen *et al.,* (2010) was also observed higher milk yield in the winter months than summer months. The results reported by Prejit *et al*., (2007) and Könyves *et al*., (2017) also showed that milk production was high in winter and low in summer season. Milk yield increased from July to October in accordance with the decreased THI. It is revealed that a reduction of THI (from 84.95 to 79.57) results the increment of milk yield from 5.12±0.61 l/h/day to 6.10±0.05 l/h/day (Reyad *et al*., 2016).

There is a significant difference found in the milk composition of the animals from December to June. The fat and protein percentage of milk obtained from all genotype groups were lower during the months of high THI as compared to the months having low THI (Table 17, 18). The higher fat and protein percentage were observed in December to February and the lowest in month April to June in all genotype groups of animal. This is supported by the similar results in the study of Li *et al.,* (2009) who reported that the fat and protein percentage reduced due to heat stress. Similar lower fat and protein percentage during heat stress period (High THI) were found in some other studies (Looper, 2014; Reyad *et al*., 2016; Chanda *et al.*, 2017). Bernabucci *et al.,* (2002) was also found changes in milk composition, 9.9% less protein yield in summer than spring season.

Among the three genotype groups milk production performances and milk composition of G_2 groups were affected more by the higher THI value followed by G_3 and G_1. Presence of higher amount of temperate blood could be reason behind this significant difference among three groups. Higher temperate blood percentage makes it difficult for the animal to cope with the higher THI. Chanda *et al.*, (2016) also stated the similar findings in their study.

Results of this study also showed the significant effect of heat stress on the reproductive performances of cattle. Conception rate (CR) of the cows were found higher in the cooler months (Dec, Jan, Feb) when THI was lower (Fig: 32) and comparatively lower in the hot months (Mar, Apr, May, Jun) when THI of the barn was found high. This finding suggest that higher THI caused heat stress condition for the cow resulting low CR. CR of genotype G_2 was 62.5% during December which had fallen down to the 30% during June. This might be due to the hormonal imbalance caused by the heat stress. The heat stress condition caused release of ACTH, subsequently reduced the production of estrogen, FSH and LH that results poor estrous expression and delayed ova maturation. Increase level of prolactin during summer season results acyclicity and infertility that also reduced CR (Alamer, 2011; Singh *et al.*, 2013). This result also supported by Roth *et al*., (2000), they also revealed that developed follicles become damaged and non-viable when the core body temperature exceeds 40°C. Similar findings also stated in the study of García-Ispierto *et al.*, (2007), they also found that heat stress reduce conception rate upto 23% in heat stress condition. Schüller *et al.*, (2014) further found that when mean THI was 73 or more, in this period CR decreased from 31% to 12%, this finding stated in favor of the finding of present study. In addition to that other cause of lower CR is due to early embryonic death before implantation in the uterus. Cows that exposed to heat stress condition during 1st day of estrus reduced the ratio of embryos that developed to the blastocyst stage on the 8th day after insemination (Ealy *et al.*, 1993). There is a significant difference found in case of days open in this study. The longer days open recorded during the months with higher THI and the shorter days open recorded during months with lower THI (Fig: 33). This was might be due to ACTH induced hormonal imbalance.

Birth weights of the calf recorded in the selected cows were significantly lower during the month with higher THI than the months with favorable THI for the pregnant cows (Fig: 34). Average calf birth weight of the genotype G_2 was 35.75 Kg during January which fall down significantly to 29.5 Kg during June. This might be due to heat stress which limits fetal blood flow during late pregnancy that results lower glucose and amino acid supply to the fetus (Reynolds *et al.,* 2006) and lower oxygen diffusion to the fetus (Dreiling *et al.*, 1991). Thus, the heat stress and fetal hyperthermia may account fo rthe decreased fetal growth upto 4kg in case of calves that obtained from heat stress cows relative to calves from cows that were in thermoneutral environment. Lower calf birth weight during summer than that of winter was also observed in another study carried out by Tao *et al.,* (2012). The statement of Collier *et al.,* (1982) also resembles to the present finding. The study revealed that heat stress cause adverse affect on dam and heat stress during late gestation is also related to lower birth weight of calves, which suggests lower fetal growth.

Reproductive disorders such as cases of abortion, dystocia and retained fetal membrane were recorded in higher percentage during the month of April, May and June, when average THI value were higher (>72) than the thermoneutral zone of the dairy cows. In the present study 67.6% of the total recorded abortion occurred during April and 33.33% during May, When pregnant animals were in heat stress condition. The reason might be the lower dry matter intake by dam and undeveloped fetal membrane due to heat stress during pregnancy period. The present finding is supported by Wu *et al.,* (2006), who stated that stressed animal tends to eat less, this low dry matter intake drives the animal to malnutrition which causes fetal death, abortion and dystocia. Analogous study carried out by El-Tarabany and El-Tarabany, (2015) reported that fetal loss rate was significantly increased from 17.1% at low THI to 24.9 % at high THI. Incidence of dystocia was higher during the month of May and June. The reason behind could be the negative energy balance and stress condition of the pregnant cow. Stress condition reduces the strength of uterine muscle contraction efficacy which causes the dystocia and difficult parturition. In case of retained placenta 42.85% of cases were found during May. Finding is similar to DuBois and Williams, (1980), who found the incidence of retained placenta and postpartum metritis 24.05% during the period of May through September (Late Spring and Summer) compared to 12.24% the rest of the year. They stated the reason might be due to gestation period of cows calving during the warm season was an average of

2.82 days shorter than that of the cows calving during the cool season. Heat stress resulting in early parturition was the probable cause of this increased incidence of retained placenta. This finding also supported by Ahmadi and Mirzaei, (2006), who found that incidence of retained placenta 6.92%, 18.3%, 13.23% and 7.58% in spring, summer, fall and winter, respectively.

CHAPTER VI

CONCLUSIONS

The summery of the results can be concluded by some following points

- THI is directly related to the housing system. Better housing can reduce THI by increasing degrees of air movement.
- Higher THI negatively affect the productive and reproductive performances of cattle.
- Milk production and milk composition of cattle were significantly low when THI increased during the hotter months of the year.
- Reproductive efficiency was markedly compromised by the higher THI during hot and humid months.
- Among three selected groups genotype groups HF 75%×L 25% was more prone to heat stress, both productive and reproductive behavior shown a dramatic fall in higher THI months compared to months with low THI.

CHAPTER VII

RECOMMENDATIONS

- During construction of stanchion barn proper housing should be ensured by maintaining optimum shed height (at least 20 feet).
- Proper ventilation of the animal shed need to be ensured to increase the degrees of air movement, that helps to reduce ambient temperature and humidity.
- Breed upgrading with exotic breed should closely supervise to ensure optimum production in existing environmental condition of Bangladesh.

CHAPTER VIII

LIMITATIONS

A pretty good number of problems were faced while conducting the research. These could be considered for further study successfully.

1. CVASU don't have own dairy farm. It would be easy task if there is an established dairy farm under university.
2. Milk scanner of dairy science lab was out of order during the study period that is why the quality of different chemical parameters of milk other than fat and protein was not possible to perform.
3. The farms were located far away from CVASU campus. It was difficult to be at the farm in time due to transport difficulties.
4. There was not enough scientific record keeping system on the farm. Due to lack of pedigree record, proper selection of different HF crossbreds was difficult.
5. For the reproductive traits available sample size was small.

CHAPTER IX

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Appendix 1

Questionnaire for farm selection

Section A (General Information)

1. Farm name:
   ……………………………………………………………………………...
2. Address:
   ………………………………………………………………….............
3. Name of the farmer:……………… …………………………………….
4. Contact no:……… ……………………………………………………
5. Educational Background: Illeterate/ Primary/Secondary/Higher Secondary/ Graduate to above
6. Total Income of the farm:…… ………………………………………….
7. Total income of the farmer:… …………………………………………..
8. Main professionof the farmer:… ………………………………………..
9. Composition of the farm:
   a. Milch cow:
   b. Dry cow:
   c. Pregnant cow
   d. Calf
   e. Bull
10. Average Milk Production/cow/day:……………
11. Average feed given: Concentrate: …………….. Green Grass………….
12. Price of milk:………………………………………………………………
13. Place of milk selling:………………………………………………………
14. Vaccination: Yes/No
15. If yes,Name of the vaccine with route and date
    a. ……………………………………
    b. ……………………………………
16. Deworming: Yes/ No

Section B (Housing management)

1. Type of housing: Stanchion barn/ Loose house
2. Shed materials:…………………………………………………………………..
3. Shed height……………ft
4. Insulating materials:……………………………………………………………..
5. Stocking density: Optimum/ High/ Very high
6. Ventilation: Very good/ Good/ Fair/ Poor/ Very Poor

Signature of respondents Signature of Interviewer

Appendix 2

Daily ambient temperature and relative humidity recording sheet

Name of the Farm:………………………………………

Location of farm………………………………………...

Date	6 AM		9 AM		12 PM		3 PM		6 PM	
	Temp. (°C)	Humidity	Temp. (°C)	Humidity	Temp. (°C)	Humidity	Temp. (°C)	Humidity	Temp. (°C)	Humidity

Appendix 3

Milk production, composition and rectal temperature record sheet

Date	Rectal temperature of cow			Milking Time		Total milk production (Liter/Day)	Composition	
	G1	G2	G3	Morning (Liter)	Evening(Liter)		Fat	Protein

Appendix 3

Reproductive performances data sheet

Date	Animal Id	Heat sign	AI	Post Partum heat	Days open	Calf Birth weight	Reproductive complications

BIOGRAPHY

Myself, Avijit Dhar, son of Anil Kumar Dhar and Ratna Dhar. I have born in Chattogram district of Bangladesh. I have successfully completed my S.S.C. from Chittagong Board on 2008 and H.S.C from Chittagong Board on 2010. I have completed my graduation on Doctor of Veterinary Medicine (DVM) from CVASU on 2017. Currently I'm Master's student of Dairy science under the Department of Dairy and Poultry sciences, Faculty of veterinary medicine, Chittagong Veterinary and Animal Sciences University (CVASU).