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Feeding and Managemental Strategies for Dairy Animals During Era of Climate Change

Deep Narayan Singh[1], Ranjana Sinha[2], Manmohan Kumar[3], Suchit Kumar[4], Mamta[5], Ajay Kumar[6]

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Abstract

Animal environment is affected by climatic factors that include temperature, humidity, radiation and wind movement. Dairy animals generate heat from two sources viz. the environmental temperature and humidity, and their internal body metabolism and digestion. Within the thermo-neutral zone, the production and loss of heat from animal's body is about equal. Within this zone, animals are able to maintain a normal body temperature of 38.5-39.3°C relatively easily. When more heat accumulates than the animal can dissipate, heat stress occurs. Extreme climatic conditions can alter energy transfer between the animal and its environment and might have deleterious effect on growth, production and reproduction in dairy animals. Animals mostly suffers from heat stress condition so warm & humid climatic conditions are highly detrimental effects on animals performances. One of the major contributors of milk in India is buffalo and crossbred cattle, but they are highly susceptible to hot, humid and cold climate. To unwind the effect of climatic stress, the mechanism of thermoregulation takes place within the animal body to reduce the detrimental effects on reduced milk production, milk fat content, impaired reproductive performance and making the animal more susceptible to various health problems (Naqvi *et al*., 2012).[8] Feeding and management interventions in terms of nutritional modification, housing arrangement may curtail the adverse effect of climate change on growth, productive & reproductive performances in dairy animals. In Indian subcontinent, heat stress is the most important climatic stress. Heat stress adversely affecting productive and reproductive performance of livestock, and hence reducing the total area where high yielding dairy cattle may be economically reared. The livestock sector which will be a sufferer of climate change is itself a large source of methane emissions contributing about 18% of total enteric methane budget.

Keywords: Homeostasis; THI; TNZ; LCT; UCT and VFA.

Author Affiliation: [1]Associate Professor, Department of Livestock Farm Complex, [2-4]Assistant Professor, Department of Livestock Farm Complex & Livestock Production and Management, Bihar Veterinary College, Bihar Animal Sciences University, Patna 800014, Bihar, India, [5,6]Assistant Professor, Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, UP Pandit Deen Dayal Upadhyaya pashu Chikitsa Vigyan Vishwavidyalaya Evam Go Anusandhan Sansthan, Mathura 281001, Uttar Pradesh, India.

Corresponding Author: Deep Narayan Singh, Associate Professor, Department of Livestock Farm Complex, Bihar Veterinary College, Bihar Animal Sciences University, Patna 800014, Bihar, India.

E-mail: drdeep25@gmail.com

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INTRODUCTION

Animal environment is affected by climatic factors that include temperature, humidity, radiation and wind movement. Thermoneutral zone is the range of environmental temperatures from lower critical temperature (LCT) to upper critical temperature (UCT) where normal body temperature is maintained and heat production is at the basal level (Singh *et al.*, 2014).[18] Thermoneutral zone depends on the age, breed, feed intake, diet composition, previous state of temperature acclimatization, production, housing and stall conditions, tissue (fat, skin) insulation and external (coat) insulation and the behaviour of the animal (Gaughan, 2015 and Singh *et al.*, 2008).[4,16] Dairy cattle experience heat stress or cold stress when environmental temperature is not within the thermoneutral zone and thereby there is a decrease in milk production under such stress conditions. The physiological responses of the animals maintained under open sky has elevated physiological parameters (Singh *et al*., 2007 & 2009).[14,9] Moreover, high temperature and humidity alter the balance of endocrine profiles in dairy cattle, leading to lower intensity of estrous behavior, anestrus, embryonic death, and subsequent infertility (Bell *et al*., 2011).[2] The bovine thermal comfort zone is -13ºC to 25ºC. Within this temperature range, the animal comfort is optimal, with a body temperature between 38.4ºC and 39.1ºC.

Effect of Climate change

Effects of heat stress in dairy animals are direct or indirect which include:

i. ***Feed intake decrease***: At the temperatures of 25-26ºC feed intake in dairy animal begins to decline and drops more rapidly above 30ºC. At 40ºC, dietary intake may decline by as much as 40%. Heat stress in high producing lactating dairy cows results in considerable reduction in appetite, roughage intake and rumination. This may be due to elevated body temperature and gut fill as these animals have a lower rate of feed passage and reduced gut motility (Singh *et al*, 2014a).[18] Heat stress affects rumen fermentation adversely and the total volatile fatty acid (VFA) production is decreased even when the feed intake is same. During heat stress, DMI (dry matter intake) or nutrient intake declines whereas nutrient requirement for maintenance and active cooling processes like panting increases (Singh *et al*., 2007a).[19] Therefore, offering more forage to animals will cause more heat production in animal's body, adding on to the heat stress problem. On the other side blood flow to internal organs like the mammary gland is reduced delivering fewer nutrients to these organs for metabolism. Thus, fewer nutrients are available for milk production during heat stress. In case of dry cows, off-feed or decrease in DMI during the heat stress can lead to more health problems at parturition and potentially reduce milk production during the subsequent lactation.

Besides these the following impacts of heat stress on feed intake or digestion have been observed:

- Increased feed refusals
- Increased feed sorting
- Reduced natural buffering capacity due to reduced saliva production and increased carbon dioxide expiration
- Increased loss of minerals due to sweating, panting, and urination
- Increased metabolic disorders (acidosis)

Metabolism is reduced due to reduction in thyroid hormone secretion, plasma growth hormone concentration and secretion rate, ruminal pH and gut motility in heat stressed cattle. Major changes in dietary electrolyte balance (Na+, K+, CL^{-} and the buffer HCO_3^{-}) and acid/base balance associated with heat stress takes place.

ii. ***Water intake increase***: The total body water is estimated to range between 75 and 81% of the body weight for lactating dairy cows. Milk contains 87% water and large concentrations of the electrolytes Na, K, and Cl. Water and macro-mineral need increases heavily under heat conditions to maintain homeostasis and homeothermy. Under thermal stress cows tend to have increased water content in the rumen as a result of an accelerated water turnover rate. Moreover, there is need to compensate additional evaporative water loss. Heat stress increases water consumption by at least five times than normal level in temperate weather and three times more in tropical weather.

iii. ***Effect on the Milk yield & Composition:*** During hot and humid weather conditions, there is reduction in intake of the nutrients in dairy cow which are otherwise necessary for production of milk as well as for body maintenance. It has been established that reduction in milk yield during heat stress is mainly, due to less feed intake on one hand and increased maintenance requirement, which reduce feed efficiency on the other hand. Milk yield usually reduce 10-15%

or more during this period. The lactating cows are affected more with heat load due to increased metabolically derived heat associated with milk production, increased rate of respiration and rectal temperature leads to hyperthermia and milk production is reduced proportionately. This may also be explained by the negative effect of heat stress on the secretory function of the udder. There is reduction in daily output, lactation peaks, milk fat production, casein composition, milk component levels and increase in SCC levels. Similarly, higher environmental temperature during last three months of gestation alters blood flow and prolonged hyperthermia interferes with normal placental growth and endocrine function, which results in lower calf birth weight and hormonal alterations affect mammary development and lactogenesis. Reduced hormonal activity particularly T4 during pregnancy affects metabolic state of the dam at parturition and thus reduce mammary development prior to the initiation of lactation which ultimately leads to poor milk production.

The stage of lactation is also an important factor affecting dairy cows' responses to heat. Johnson *et al.* (1998) observed that the mid-lactating dairy cows were the most heat sensitive compared to their early and late lactating counterparts.[7] In fact, mid-lactating dairy cows showed a higher decline in milk production (−38%) when the animals were exposed to heat (Thoroton *et al.*, (2022) and Upadhyay *et al.* (2007) observed the extent of decline in milk yield were less at mid lactation stage than either late or early stage and decline in yield varied from 10-30% in first lactation and 5-20% in second or third lactation in Murrah buffaloes.[20,21] Milk production traits in ewes seem to have a higher negative correlation with the direct values of temperature or relative humidity than THI. The values of THI, above which ewes start to suffer from heat stress, seem to be quite different among breeds of sheep. Solar radiation seems to have a lesser effect on milk yield, but a greater effect on yield of casein, fat and clot firmness in the milk of ewes (Sejiana *et al.*, 2013).[10,11]

iv. ***Effect on Reproductive Efficiency:*** Adverse effects of heat stress on reproduction include reduction in estrous activity, estrous duration, heat detection, follicular development, oocyte quality, semen quality, conception rate, pregnancy rate, uterine function, multiple ovulations and twinning, suppressed intensity of oestrus, a reduction in the strength of the preovulatory LH surge, a decreased secretion of progesterone, altered follicular development, decreased embryo development as well as fetal growth and reduced fertility (Gaughan and Cawsell-smith, 2015).[4,5,6] It is clear that heat stress has many effects on the reproductive axis, some are direct effects on the hypothalamus, the anterior pituitary gland, the uterus, the follicle and its oocyte and the embryo itself; other effects are indirect, probably mediated by change in the metabolic axis in response to reduced dry matter intake.During this period, lower pregnancy rates occur either due to higher rate of fertilization failure or early embryonic death or low sperm output and poor semen quality due to inability of bull to maintain optimal scrotal and testicular temperature. Conception rate declined from 61 to 45% when rectal temperature 12 h post breeding increased 1°C.

Besides these some other impacts of heat stress on reproduction has been observed:

- ❖ Decreased uterine blood flow
- ❖ Increased embryonic death
- ❖ Reduced placental mass
- ❖ Reduced fetal tissue growth
- ❖ Reduced mammary tissue growth
- ❖ Early calvings
- ❖ Light, weak or dead calves
- ❖ Lower colostrum immunoglobulin (IgG)
- ❖ Lower colostrum protein, fat, and lactose
- ❖ Lower calf blood protein levels
- ❖ More "quiet heats"
- ❖ Unsynchronized ovulations
- ❖ Fertility failure
- ❖ Decreased growth, size and development of ovarian follicles
- ❖ Abortion and retained placenta cases are more for cows calving during the summer.
- ❖ Cows calving during hot months show longer calving to conception intervals, more services per conception
- ❖ Heat stress during the dry period may

alter the development of the placenta.

v. ***Oxidative Stress:*** Heat stress generally increases the production of free radicals, leading to oxidative stress. In dairy cows, oxidative stress has a negative impact on immune and reproductive functions: increased mastitis frequency and higher somatic cells counts in milk, decreased fertility, increased embryo mortality, post-partum retained placenta, and early calving, with consequences on the calves live weight, mortality and health.

vi. ***Effect on Health of Dairy cows:*** During hot and humid weather conditions, the animals become more vulnerable to diseases. There is an increase in the somatic cell counts (SCC) and a higher incidence of mastitis and increase in number of flies during summer aggravates the situation. There will be suppressed immune function, increased incidence of mastitis, increased chances of retention of placenta, higher ketone & NEFA levels at the time of calving and higher risk of acidosis, this is mainly due to decreased DM intake with lower proportion of forage and higher levels of fermentable carbohydrates, decrease in rumination, saliva in gut and buffering power due to increased CO_2 expelled. Additionally, the decreased rumen pH impairs fibers digestion efficiency as rumen fibrolytic bacteria is affected due to drop in rumen pH (below 6.0). Acidosis is found to affect the animals overall health status, fertility and longevity.

vii. ***Effect on Vectors:*** The epidemiology of many diseases are based on transmission through vectors such as ticks, lice, mites, mosquitoes and flies, the developmental stages of which are often heavily dependent on temperature and humidity. Changes in rainfall and temperature regimes may affect both the distribution and the abundance of disease causing vectors, as can changes in the frequency of extreme events (Thornton *et al.* 2009).[22] High temperature with high humidity and rainfall leads to the seasonality of Foot and Mouth (FMD) disease in cattle in hyper-endemic areas of India.

viii. ***Effect on Pathogens:*** Higher temperatures resulting from climate change may increase the rate of development of certain pathogens or parasites that have one or more life cycle stages outside their animal host. This may shorten generation times and, possibly, increase the total number of generations per year, leading to higher pathogen/parasite population sizes. Conversely, some pathogens are sensitive to high temperatures and their survival may decrease with climate warming. Pathogens and parasites that are sensitive to moist or dry conditions may be affected by changes to precipitation, soil moisture and the frequency of foods.

ix. ***Effects on hosts:*** Climate change may bring about substantial shifts in disease distribution, and outbreaks of severe disease could occur in previously unexposed animal populations (possibly with the breakdown of endemic stability) (Thornton *et al.* 2022).[22] Endemic stability occurs when the disease is less severe in younger than older individuals, when the infection is common or endemic and when there is lifelong immunity after infection. Certain tick-borne diseases of livestock, such as anaplasmosis, babesiosis and cowdriosis, show a degree of endemic stability (Basu *et al.*, 2004).[1]

x. ***Impact on bio-diversity:*** Climate has continue to change rapidlyleads to agricultural and farm communities will deteriorate further while we lose more genetic diversity among crops and farm animals, biodiversity will decline faster rate as terrestrial and aquatic ecosystems are damaged. Harmful exotic species will become ever more numerous.

Ameliorative Measures of heat stress Reduction

As discussed, heat stress is a burden for the cow's performance and health that costs the dairy industry millions every year. Implementation of herd management techniques as early as possible is beneficial at production level. In order to prevent the effects of heat stress, economically feasible heat stress relief techniques can be used which include the use of fans, shades, foggers, misters, desert coolers, air conditioners, water bathing and adequate air circulation. Modifications in feeding strategies by either dietary fiber adjustment or the use of high-quality forage, supplemental protected fat and feeding at cool hours can greatly help in reducing the negative effect of heat stress on productive and reproductive performance.

PHYSICAL PROTECTION

- ❖ Trees are an excellent natural source of shade on the pasture and cools the surrounding air.[13]
- ❖ Solar radiation is a major factor in heat stress can be blocked by use of properly constructed shade structures alone increases milk production remarkably. Two options are available: permanent shade structures and portable shade structures. Shade permits reduction of more than 30% of all the heat radiated on cattle and is the single most important contribution for lowering heat stress.[15,17]

Besides these some of the protective measures are

- ✓ Avoid overcrowding
- ✓ Do not keep the animals in the holding area for long time. The holding area is a very crowded and poorly cooled area in many farms.
- ✓ The air flow over the cow housing area should be 4-5 mph.

Air Temperature Reduction Measures

Air temperature of micro-environment can be lowered by air conditioning or refrigeration but the expenses of such types of air cooling make these impractical.[3] The evaporative cooling pad (corrugated cardboard or similar material) and a fan system which uses the energy of air to evaporate water is a more economically feasible method to cool the micro-environment. Several cooling measures may be utilized to get rid of heat stress are mentioned below:

- Fine mist injection apparatus
- The cooler at very high rates. This system is effective in arid climates.
- High pressure foggers
- Misters
- Cooling in hot and humid climates emphasizes shade, wetting the skin and forced drying of the cow's coat to maximize the cooling effect.
- Milking parlors with adequate holding pens can employ the use of subsequent sprinkling and forced air in the pens.
- In dairies with adequate drainage and housing, evaporative cooling can be provided above the feed bunks in addition to or instead of in the holding pen.
- Upper body sprinkling followed by forced air ventilation reduces body temperature, increase feed intake and milk yield.
- Sprayers in parlour exit lanes.

Nutritional Dietary Manipulation

Evaporative heat loss through sweating, frequent urination and panting is the primary mechanism for heat loss at high environmental temperatures. Besides this following manipulations in feed and feeding system can help to reduce the heat stress

- Increasing the amount of feed available during the cooler period of the day, early morning or late evening. Feeding 60 to 70 percent of the ration between 8 p.m. and 8 a.m. has successfully increased milk production during hot weather.
- Feeding fish meal as bypass protein.
- Increase the amount of concentrate by adding an energy rich feedstuff such as maize, or other cereal, and reduce the amount of fiber in the diet.
- Fat Supplementation
- Minimize drastic change in ration.
- During heat stress rumen degradable protein should not exceed 61 percent of CP.
- Management of the dietary electrolyte balance is based on adding essential body salts and electrolytes to the drinking water and feed.
- Adding water to diets may help DMI during summer months. Water will soften fiber feeds and reduce dustiness and dryness of the diet increasing palatability and DMI. A three to five percent addition of water is recommended.
- To reduce rumen acidosis high energy, more palatable diets, with high quality, highly palatable forages should be provided. On the other hand feeding of live yeast *Saccharomyces cerevisiae* CNCM I-1077, improves rumen pH as a result reduce acidosis risk, improve fiber digestion and nitrogen utilization, increased feed efficacy, help in rumen microflora stabilization and helps in milk production.
- A well balanced (Total mixed ration) TMR will allow diets to be formulated at minimum fiber levels encouraging DMI and minimizing rumen fermentation fluctuations and pH

declines.

- Use of anti-oxidants such as selenium enriched yeast (Alkosel® R397) help reducing the impact of heat stress on the oxidative balance, resulting in improved milk quality, immune and reproductive functions, prevention of retained placenta and reduced somatic cells.
- Vitamin A, Vitamin E, niacin and selenium should be supplemented in diet during this period. Sometimes zinc and biotin may also play important role.
- Provision of fresh and cooled water all the time is most important. Water tanks should be located close to the feeding area to encourage both DMI and frequent drinking.
- An increase in the levels of deficient nutrients sodium (0.4 to 0.5%, Sodium bicarb or Sodium sesquicarbonate), potassium (1.5%, potassium carbonate, potassium sulfate/magnesium sulfate and potassium chloride) and magnesium (0.3 to 0.35%, magnesium oxide, magnesium sulfate) and decrease in chloride (go down to .25-.30% in heat) may be helpful.

Besides the importance of providing shade, cooling measures and nutritional modification the following measures should also be taken into consideration as ameliorative measures.

- Reduce parlor walking distance.
- Reduce time in holding area.
- Improve ventilation.
- In areas of extreme heat, it is even more important for cows to give birth in good body condition because after parturition their dry matter intake will be lowered by heat stress, as well as the usual low intake immediately after calving.
- Fly control.
- Under these conditions dairy farmers must go for artificial insemination rather than using natural service of heat stressed bulls.
- Teat dipping with germicidal dips is recommended.
- Handling cattle can elevate their body temperature by as much as 3.5°F. Therefore avoid handling during intense heat.

CONCLUSIONS

Global demand for Animal products is expected to double by 2050, mainly due to improvement in the worldwide standard of living & scientific interventions in livestock rearing. Meanwhile, climate change is a threat to livestock production because of the impact on quality of feed crop and forage, water availability, animal and milk production, livestock diseases, animal reproduction, and biodiversity. Climate change is a major threat to the farming community as well as for the sustainability of livestock systems globally. Consequently, adaptation to, and mitigation strategies against the detrimental effects of extreme climates has played a major role in combating the climatic impact on livestock. As livestock is an important source of livelihood, it is necessary to find suitable solutions not only to maintain this industry as an economically viable enterprise but also to enhance profitability and decrease environmental pollutants by reducing the ill-effects of climate change.

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