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Review Article

THE POTENTIAL IMPACT OF HEAT STRESS ON PRODUCTION AND REPRODUCTION OF DAIRY ANIMALS: CONSEQUENCES AND POSSIBLE SOLUTIONS: A REVIEW

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Abstract: Climatic change is the big problem in recent time. Climate changes affect a range of factors associated with production, reproduction, work capacity and adaptability of the animals. Global climate change is expected to alter temperature, precipitation, atmospheric carbon dioxide Animal husbandry sector depends upon the climatic conditions where it mainly affected by the temperature and humidity. Environmental stress reduces the productivity and health of livestock resulting in significant economic losses. Climate changes, could impact the economic viability of livestock production systems worldwide. Heat stress affects animals performance and productivity of dairy animals in all phases of production. Heat stress has a direct effect on oestrus behavior in dairy animals. They display the most remarkable sexual activities in morning and midnight but the lowest activity was reported at noon time during high ambient temperature. The outcomes include decreased growth, reduced reproduction, increased susceptibility to diseases, and ultimately delayed initiation of lactation. Productive and reproductive success in livestock is essential for the economic livelihood of producers. Housing, feeding, management improved cooling system and many other new technologies are available through which climatic impacts on livestock can be reduced.
Keywords: Heat, environment, temperature, production, reproduction.

Introduction

The livestock sector accounts for 40% of the world's agriculture Gross Domestic Product (GDP) and employs about 1.3 billion people. The agriculture and animal husbandry is the main source of farmers and directly affects the economic conditions of farmers. Global climate change is exerting profound effects on productive life of animals by changes in biological function of the body High ambient temperature directly affects production and reproduction of dairy animals (Sere *et al., 2008*). If today's level of greenhouse gases held steady, the average temperature of the earth will increase by 0.6°C by 2100. The

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Intergovernmental Panel on Climate Change (IPCC) projections for the concentration of atmospheric CO_2 in the year 2030 range from 400 to 480 ppm. Animal's environment is affected by many climatic factors that include temperature, humidity, radiation and wind (Gwazdauskas, 1985). Surrounding environmental conditions directly affects the mechanisms and rates of heat gain or loss by all animals (NRC,1981). Increase of temperature will lead to influence of etiologic bacteria and parasites around the animals environment. Many other important effect of climate change is production of poor quality of feed and fodder, forages, grain. Designing strategies to reduce negative effects of fertility; such as enhanced cooling, ration adjustments, and reproductive protocol changes, will improve dairy farm profitability. Many housing and management technologies are available through which climatic impacts on livestock can be reduced. Improved cooling is still the most profitable and effective way to improve both milk production and reproduction during the summer months. The important role of rational manipulation and use of modern technologies are important for profitability of the livestock enterprise.

Animal environment and environmental stress

Many environmental factors directly or indirectly causes decrease in milk production in animals. Singh *et al.,* (2012) reported that climate change directly affects the productivity and reproductively of animals about 58.3 % and 63.3 %. 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, 1972). The maintenance energy requirement may increase by 20-30% in animals under heat stress. According to Lee, (1993) 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.

Temperature humidity index (THI) and assessment of animal stress

Heat stress is associated with THI as the primary environment factor that produce heat stress are temperature and humidity. Body temperatures beyond 45–47°C are lethal in most of the animals. Exposure of animals to the hot conditions evokes a series of changes in the biological functions that include depression in feed intake, efficiency and utilization, disturbances in metabolism of water, protein, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites. THI index is widely used in the hot area of worldwide to know the effect of the heat stress on dairy cow. THI was created by Thom, (1998) for the human and later it was observed that it is very important for dairy cows. Determined THI values were used to identify heat stress seasons. THI is calculated according to NRC, (1971) by following equation-

$$THI = 0.72\ (Tdb + Twb) + 40.6$$

Where, Tdb is Dry bulb temperature in ºC, Twb is Wet bulb temperature in ºC

The mean and maximum THI may calculate by following formulae (Hahn *et al*., 1969; McDowell *et al.,* 1979, Thom, E.C. 1959)

Mean THI = (0.8 x mean T + mean RH (%)/100 x (mean T – 14.4) + 46.4)

Maximum THI = (0.8 x mean T + minimum RH (%)/100 x (mean T – 14.4) + 46.4)

Where, T is temperature and RH is the relative humidity.

When THI exceeds 72, IT will result in heat stress to the animal (Johnson, 1980). Many previous studies reported that milk yield of cows in to be negatively correlated with temperature-humidity index (Shinde *et al.,* 1990; Mandal *et al.,* 2002).

Effects of climatic change on livestock productivity

All climatic variables accounts for variation in production and composition in milk. Previous experiment indicated that increase heat stress causes low milk production in dairy cow and buffalo (Marai *et al., 2002*). This illustrates that winter season is the most favorable season for milk production of lactating animals (Barash *et al., 2001).* Milk constituents are greatly affected by heat stress during summer. The protein fractions showed a reduction in percentages of casein, lactoalbumin, IgG and IgA. Heat stress results in reduction on dry matter intake and feed conversin efficiency which directly affects the body condition of animals result in low milk yield (Wilson e*t al.,* 1998). This causes low circulating Immunoglobulin (Ig) concentration in summer born calves. High temperatures during late pregnancy and the early post-partum period markedly modify colostrum composition. In Holstein cows at 30°C, milk fat, solids-not-fat, and milk protein percentages decreased (McDowell *et al.,* 1976). Friesian cows maintained less than 38°C showed lower averages of total solids, fat, protein, ash and lactose yields than when the same animals were maintained under thermo neutral environmental temperatures. Averages of phosphorus and magnesium values were also found to be less in summer. Citric acid and calcium contents decreased during early lactation, while potassium decreased in all lactation stages at high temperatures (Kamal *et al., 1962*).

Effects of climate in reproductive performance of animals

Reproductive efficiency is the key factor affecting profitability in many livestock production systems. Previous experiments showed that heat stress has detrimental effect on the reproduction of cattle and buffaloes (Tailor and Nagda, 2005). 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) reported that hyperprolactinaemia as a result of thermal stress inhibits the secretion of both FSH and LH at hypophyseal level. The low fertility occurs during heat because the embryo loses its ability to alter prostaglandins synthesis in a manner that favours the maintenance of the corpus luteum. These effects, combined with the other endocrine changes which occur during heat stress, accounts for the more pronounced effect of heat stress on reproduction than is seen with other stressors (Moberg, 2000). The dry period is very important for mammary gland involution and subsequent development, rapid fetal growth, and induction of lactation. 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. Prepartum heat stress may decrease thyroid hormones and placental estrogen levels, while increasing non-esterified fatty acid concentrations in blood; all of these factors alter growth of the udder and placenta, unborn calf growth, and future milk production. Heat stress adversely affects the ability of the dairy cow to ramp up production postpartum. Collie*r et al.,* (2007) reported that dairy cows experiencing heat stress during late gestation had calves with lower birth weights and produced less milk than cows not exposed to heat stress. Oestrus behaviors were more frequent in the normal environment season accompanied by changes in the seasonal pattern of sex hormones (Barkawi *et al., 1989*). Continuous exposure of animals to the heat stress result in adverse effect on the oocytes quality (Roth *et al*., 2001) and increased level of GH and non-sterified fatty acid (Butler, 2001). Thermal stress has an adverse effect on the conceptus and post-partum performance (Gwazdauskas *et al., 1981*). 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% (Ulberg and Burfening, 1967). Zewdu *et al.,* (2014) reported that all the climatic variables exhibited positive and non-significant effect on the dry period and inter-calving period. In the dairy cows infertility is the the significant effect heat stress (Lopez-Gatius, 2003)

Scrotal circumference, size and weight are decrease in hot summer season due to degeneration in the germinal epithelium (Chou *et al.,* 1974). The reaction time (libido) is shorter in summer season and the shortest time is recorded during summer and the longest in autumn. The thermoregulatory mechanism of the testes, sexual desire (libido), live sperm percentage, sperm concentration, ejaculate volume, viability and motility (Gamcik *et al.,* 1979) are negatively affected by high environmental temperature. The studies of Marai *et al.,* (2007) showed that semen-ejaculate volume decreased, while studies of showed remarkable increase with heat elevation.

Heat balance in productive animals

The basic management principal for reducing the effect of thermal stress by physical modification of the animal's surrounding, nutritional management and genetic improvement of beeds. The application of good management practices helps in reducing the heat stress in dairy animals. Animals should be exposed to positive handling and management practices. Many previous experiments showed the differences in heat tolerance capacity among different cattle breeds and crosses (Prayaga *et al*., 2006). There is a number of housing alterations that can be used to reduce the impact of heat stress. The tree shades have proved to be a effective and economic method to reduce heat stress efficient (Hahn, 1969). There are several methods like mist, fog and sprinkling systems which helps in heat loss and maintaining normal body temprature. Use of cooling system help in improvement in fertility of animals (Armstrong, 1994). Sysematic use of cooling and fanning brought more preovulatory LH surges and higher oestrus response in dairy animals. Some more benefits were observed when minerals, vitamin E (Arechiga *et al.,* 1998) and b-carotene were supplemented with cooling and fanning system. Arechig*a et al.,* (1998) reported that timed AI in combination with b-carotene supplementation resulted in improved pregnancy rates during heat stress. The ration manipulation during heat period is very important by increasing energy and protein intake with addition of 3-5% fat, adequate buffers and Sodium and potassium level. An experiment showed an increase in sweating rates and lower core body temperatures when encapsulated niacin was fed to lactating cows than thermal neutral controls (Zimbelman *et al.,* 2007). Administration of GnRH to lactating cows at estrus increased the conception rate from 18 to 29%. (Ullah *et al.,* 1992). Collier *et al.* (2008) suggest that we can improve the heat tolerance through manipulation of genetic mechanisms at cellular level. We should select those animals that already have good heat tolerance (Renaudeau *et al*., 2010). Hansen and Arechiga, (1999) suggested the selection practices for those genes that control the traits related to thermo tolerance without affecting milk yield.

The important traits for heat tolerance are coat color, genes controlling hair length, heat shock resistance in cells.

Conclusion

Climate change could affect the animal's production, reproduction and health. The reduced performance in the animals occurs due to environmental and management factors like animal housing, handling, human-animal relationship, and production system. Some current practices to reduce heat stress in dairy cows, such as shades, sprinklers and ventilation will be suitable for adapting to future climates changes. Improved cooling is still the most profitable and effective method to improve both milk production and reproduction during summer stress. In case of buffalo mainly during summer season allowing for wallowing and water sprinkling are effective step for reduction in heat stress. Selection practices for important heat tolerance traits will helpful for genetic improvement of the animals. Application of new and scientific strategies to reduce negative effects of heat are cooling system, ration adjustments, and reproductive protocol changes, stress reduction, use of buffers, yeast and hormones will improve the economic conditions of dairy farms.

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