Impact of climate on feeding, production and reproduction of animals-A Review


College of Veterinary Science & Animal Husbandry, Junagadh Agricultural University, Junagadh-362 001, India.

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ABSTRACT

Changes in the climate are due to global and environment warming lead to the heat stress. This heat stress can have large effects on most aspects of health, production and reproductive function in mammals. These may lead to poor production of feed crops and alter the feeding ability and digestion in the animals. Also include disruptions in spermatogenesis and oocyte development, oocyte maturation, early embryonic development, foetal and placental growth and lactation. These deleterious effects of heat stress are the result of either the hyperthermia associated with heat stress or the physiological adjustments made by the heat-stressed animal to regulate body temperature. Many effects of elevated temperature on gametes and the early embryo involve increased production of reactive oxygen species. Genetic adaptation to heat stress is possible both with respect to regulation of body temperature and cellular resistance to elevated temperature.

Key words: Climate, Health, Feeding, Production, Reproduction.

INTRODUCTION

Each species, breed or animal category, correlated with its physiological state, has a comfort zone, in which the energy expenditure of the animal is minimal, constant and independent of environmental temperature. Outside of this zone, the animal experiences stress to maintain homeothermy. This requires extra energy to thermo regulate, so that less energy is available for production processes (Bianca, 1976). The animal modifies its behaviour, especially feeding, physiological and metabolic functions and the quantity and quality of its production. When an animal is for a medium/long period outside of its zone of thermo neutrality it activates mechanisms of acclimatization, whereas population of animals experiencing significant climatic changes can adopt, by genetic adaptation, modifying genetic and phenotypic features over generations. The more the impact of the climatic conditions on the animal varies in magnitude and length, the more difficulties the organism has to maintain homeothermy. The United Nations climate change conference-2010 in Canan, Mexico highlighted the major challenges and opportunities associated with climate change. Rise in temperature due to climate change is likely to affect livestock production and health (Srivastava, 2010).

Impact of climatic changes could be in four ways: heat-related diseases and stress, extreme weather events, feed grain forage availability and price and adaptation of animal production systems to new environments and emergence or reemergence of infectious diseases, especially vector-borne diseases critically dependent on environmental and climatic conditions.

Some of the adverse effects of heat stress reported in bovines are decrease in the efficiency of nutrient utilization, dry matter intake, milk production, the length and intensity of the estrus period and conception (fertility) rate, underdeveloped ovarian follicles (decreased size and growth), large bovine population mostly fed on inferior crop residues and bio-wastes. This is atrocious and more out of ignorance with respect to the animal production systems and the factual gas emission data in India. The livestock sector in India as per 2003 census contributed 11.75 mt of methane constituting 11.9 percent of global methane production. Enteric fermentation and manure accounted for approximately 91 and nine per cent. Dairy buffalo and indigenous dairy cattle together contributed 60 per cent and the rest came from other livestock (Bindya, 2011). Many of infectious diseases especially those are vector borne have seasonal pattern and a geographic range that are influenced by environmental variables like land cover, public health etc.

India is often accused for global warming in recent years, for the high rates of methane gas emission from its...*Corresponding author e-mail: hhsavsani@jau.in.
increased risk of early embryonic deaths, decreased fetal growth and underweighted new born calves. Both milk production and reproductive functions of cattle and buffalo shall be adversely affected by projected temperature rise of 0-2-6 °C over existing temperatures for time slice of 2070-2099. The decline in milk production will be higher in cross breeds followed by buffalo and indigenous cattle. Effects are going to be relatively large on high producing genotypes than the well adapted indigenous breeds. Also effect of climate showing the effect on growth of the animals (Padodara and Jacob, 2012).

Impact of heat stress on animal nutrition: High temperature and humidity have a two-fold impact on dairy animal nutrition.

(i) A direct effect on DM intake
• Animal have been shown to voluntarily reduce intake by 9-13% in hot conditions.
• Factors reducing feed intake include panting, which reduces cud chewing, slows the breakdown of feed, and reduces the amount of water and buffers from saliva reaching the rumen.
• Standing in the shade to keep cool also restricts grazing time and decreases intake.
• Any form of stress, including heat stress, can slow rumen contractions, which in turn slows digestion.

(ii) A direct effect on forage quality
• Humidity and high temperatures increase plant growth rate which increases the neutral detergent fibre (NDF) content of plants and reduces potential intake.

Impact on metabolism: At thermal equilibrium the difference between heat production and heat loss of the animal is zero. If heat production exceeds heat loss from radiation, convection, evaporation, and conduction, heat is stored and hyperthermia results in an increased body temperature. In farm animals with only a few sweat glands or none at all (poultry, swine), evaporation through rapid air exchange (panting) is one of the most important mechanisms for cooling the body. It is well known, that rectal temperature is a good indicator of internal body temperature. For this reason rectal temperature and respiratory rate are the usual indicators of heat stress even in cattle (Brown-Brandl et al., 2001; Kadzere et al., 2002).

Animals respond to an unfavorable ambient temperature in a very complex manner. In a hot environment, when the air temperature is above the upper critical temperature, the ability to lose heat is limited; therefore, farm animals reduce their feed intake and thus the heat increment in order to keep the thermal equilibrium. Studies have reported a strong negative correlation between rectal temperature and feed intake in pigs, poultry, and dairy cows at the time of heat stress. High ambient temperature causes hyperthermia in the body, which reduces the activity of the appetite center in the medulla oblongata. Thus it is the higher temperature that triggers the reduction of feed intake, in proportion to the increase of the ambient temperature. In order to lower the heat production, farm animals reduce their physical activity as well (Collin et al., 2001) and spend less time with eating (Brown-Brandl et al., 2001).

The lower feed intake results in a poorer nutrient supply, which obviously compromises the production performance and parameters. This loss of performance, however, is usually more than what would be justified by the reduced feed intake. The cause of the lower efficiency of nutrient and energy utilization is partly the higher energy use of animals due to heat stress, and partly the altered electrolyte balance of body fluids that may impair the protein metabolism (Patience, 1990). The changes in the protein metabolism are then clearly affecting the milk production, egg production and growth of the animals. As discussed earlier, above the upper critical value the respiratory rate linearly increases with the ambient temperature. The enhanced respiration results in a higher CO$_2$ emission, which may cause respiratory alkalosis. The CO$_2$ concentration in the body fluids is a metabolite with significant acidic properties playing a significant role in the acid/base balance. The shift in the acid/base balance can be compensated for by the electrolytes fed in the diet. The results of a large number of studies with birds, dairy cattle and lactating sows show the benefit of changing the dietary electrolyte balance (DEB) during heat stress in order to avoid any loss of performance when compared to animals kept in a thermoneutral environment (West et al., 1991; Dove and Haydon, 1994; Sayer and Scott, 2008). The optimal temperature for fast growing, lean genotypes is lower than that for the unimproved animals or conventional hybrids (Brown-Brandl et al., 2001), since heat production related to the maintenance processes is linearly related to muscle mass. The underlying problem is the genetic selection for rapid growth rate, high egg or high milk production results in a high metabolic heat production by the animals without a significant increase in their ability to lose heat (Renaudeau et al., 2010). It follows from the foregoing that intensive genotypes tolerate global warming much less than the extensive or semi-intensive breeds.

**IMPACT OF CLIMATE ON ANIMAL PRODUCTION**

**Impact on milk production in cattle:** The links between animal production and climate change are complex and multi-directional. On the one hand, animal production has an influence on climate change, with mainly ruminants generating emissions of greenhouse gases. In particular, animal production is a very important source of methane and nitrous oxide released into the atmosphere.
Changes of temperature and relative air humidity during a hot summer the effects of selected microclimate parameters have been assessed based on the THI (temperature-humidity index) in relation to milk production (Herbut and Angrecka, 2012). The research revealed that the animals suffered from thermal stress which resulted in decreased milk production.

The optimal ambient temperature for dairy cows is between 5 to 15°C. Over 15°C the animals start to sweat, although they are still able to maintain the equilibrium between heat production and heat dissipation. Heat dissipation by sweating gradually increases and although it becomes quite intense above the upper critical temperature (25°C) the cow is no more able to maintain the heat balance at such high temperatures. Kadzere et al. (2002) found that on days of heat stress the amount of water lost through evaporation may be up to or even exceed the amount of water excreted in the milk. The high rate of water loss stresses the importance of water supply for dairy cows at high temperatures. The efficiency of body cooling by evaporative water loss, however, decreases with the increase of humidity. The use of the Temperature-Humidity Index (THI) is suggested as an indicator of the thermal climatic conditions (THI = 0.72(W + D) + 40.6, where W is wet bulb and D is dry bulb temperature in °C). When the THI is in the range of 72-80, 80-90 or 90-98, the corresponding heat stress is mild, medium or severe. Both the increasing ambient temperature (from 25 to 32°C), and the increasing THI (from 73 to 82) have a negative impact on the dry matter intake and milk production of cows (Lopez et al., 1991). The relevant data show, that the shorter the animal is exposed to heat stress, the better they can tolerate it, although even a moderate heat stress will impair their production performance. As mentioned earlier, there are other environmental factors besides temperature and humidity that affect thermal sensation. According to the results of a model simulation the critical ambient temperature that can compromise the respiratory response of a 600 kg live-weight Holstein cow is largely dependent on the daily milk yield, coat depth, exposed surface area, air velocity and water vapor pressure (Berman, 2005) and in varying environmental conditions the upper critical temperature of the animals can fluctuate in a wide range (8 to 42°C).

The higher the milk yield of a cow the higher her feed intake. This basic principle conflicts with the fundamental behaviour of heat-stressed animal, which reduces feed intake to reduce heat gain. Among farm animals, a high yielding dairy cow represents one of the extreme cases of this difficult situation. At the peak of lactation a cow of 700 kg body weight (BW) with a milk yield of 60 kg/day, produces about 44171 kcal/day (25782 kcal/day at the end of lactation, with a milk yield of 20 kg/day (Nardone et al., 2006). The annual loss in milk production due to combined thermal stress and global warming on cattle and buffalo in 2020 are likely to about 3.4 million tones costing more than Rs. 5000 crores in India (Upadhyay et al. 2009).

Decreased intake accounts for approximately 36% of the decrease in milk production due to shifts in post absorptive metabolism and nutrient partitioning (Rhoads et al., 2009). Heat stress increases loss of body fluids due to sweating and panting and results in an altered water balance of the body and the osmolarity of cells. Enhanced respiration associated with a higher rate of CO₂ loss leads to an altered blood pH and respiratory alkalosis. An increased urinary pH can help to overcome alkalosis caused by the high excretion of bicarbonate (HCO₃⁻) (Kadzere et al., 2002); however, these processes have energetic and thermoregulatory consequences. Excretion of sodium in the sweat and urine increases during heat stress, at the same time the level of Na available in the body determines, even if indirectly, the milk fat content. NaHCO₃ acts as a key buffering agent in the rumen, alleviating the low-fat milk syndrome. Several studies have shown significant increases in the milk production of heat-stressed dairy cows when fed higher than recommended (NRC, 2001) concentrations of sodium (NaHCO₃) and potassium (i.e. KCl) (Silanikove et al. 1997).

A reduction in feed intake precedes a decrease in milk production when cows are subjected to heat stress (Rhoads et al., 2009). Spiers et al. (2004) showed that feed intake decreased within 1 day after initiation of heat stress, while milk yield decreased after day 2 of heat stress. Collier et al. (1981) demonstrated that maximum decrease in milk yield during heat stress occurs 48 hours after the initiation of the stress. Prolonged thermal stress negatively impacts somatotropin (growth hormone or GH) secretion from the anterior pituitary (Mitra et al., 1972). Depressed GH concentrations result in slower growth rates, reduced nitrogen retention, and contribute to decreased lactation performance in dairy cattle (Mitra et al., 1972).

**Impact on beef production in cattle:** In beef cattle the unfavorable meteorological conditions directly affect the animals and their physiology as discussed in the above section for dairy cows. Extreme weather conditions diminish the growth performance (weight gain, feed intake and feed conversion potential) of beef calves, particularly of those kept outdoors. Slower growth and smaller slaughter weight however are reflected in the quality of meat as well, since animals of the same age but smaller body weight have less muscle fat and also the taste panel traits of juiciness and
tenderness are poorer (Keane and Allen, 1998). The predicted climate changes not only weaken the performance of livestock per se, but also compromise the conditions for production by reducing the quality of feedstuffs, as earlier discussed in this chapter. Increasing mean temperatures and declining precipitation reduce the dietary crude protein and digestible organic matter content of grass; it is unlikely, however, that any future increases in precipitation would compensate for the declines in forage quality following from the projected temperature increases (Craine et al., 2009). Aridity, water deficiency may lead to a drop in groundwater levels, alteration and thinning of pasture flora, and in consequence to a decline in feed supply, besides aggravating the problems of water supply (Babinszky et al., 2011).

As a result, cattle are likely to experience greater nutritional stress in the future with the two options of either accepting the loss of performance or being prepared to provide supplemental nutrition to the extensive beef sector as well. Feeding concentrate to beef cattle increases the costs of beef production, and it may also affect the nutritive and health value of meat. In respect of fatty acid composition, numerous publications suggest that the meat of grass fed cattle contains more n-3 fatty acids and conjugated linoleic acid than meat from their concentrate fed peers (Scollan et al., 2006; Nuernberg et al., 2005). These fatty acids play an important role in maintaining health and preventing diseases (i.e. cardio vascular diseases, cancer) and consumers are increasingly aware of these functional components of foods. In addition to the above-mentioned problems, extreme weather may result in respiratory disease, immune suppression and thus higher mortality of the animals, which further reduces the profitability of beef production.

Impact on egg and meat production in poultry: There is a large number of reports on the effects of high ambient temperature and humidity on poultry production, since the poultry industry is concentrated in hot climate areas of the world, mainly in Asia and South America (Daghir, 2009). However, their higher production performance and feed conversion efficiency make today’s chickens more susceptible to heat stress than ever before (Lin et al., 2006). The thermoregulation characteristics of poultry differ to some extent from those of mammals due to their high rate of metabolism associated with more intensive heat production and low heat dissipation capacity caused by their feathers and lack of sweat glands. Evaporative cooling is achieved exclusively by panting. In the first days of their life pouls need hot climate (32-38°C), but the optimal temperature decreases rapidly with age by 2.5-3.0°C per week (FASS, 2010). After feathering birds prefer mean ambient temperatures between 18-22°C for their growth performance and egg production although the optimal temperature for feed efficiency is higher. The crucial temperature for poultry is 30°C, because up to this point birds, through a better feed conversion rate and lower basal metabolic rate, are able to compensate for the energy loss caused by the lower feed intake (Daghir, 2009). Above 30°C the feed and energy intake declines to such an extent that birds are no more able to compensate for it, production declines rapidly and the rate of mortality increases.

The reduction of feed consumption in response to high temperatures is closely associated with the severity and duration of exposure. In broilers the rate of feed refusal during heat stress increases with age (Gonzalez-Esquerra and Leeson, 2005) and can be as high as 50%.

Accordingly, layers reduce their feed intake by approximately 30-50% in severe heat stress (34-35°C). In addition, several studies reported that high ambient temperatures decrease the digestibility of nutrients in poultry likely due to a reduced activity of trypsin, chymotrypsin, and amylase (Hai et al., 2000). Consequently, the lower and by most probability insufficient nutrient supply limits egg production and egg mass in layers, and the growth rate in broilers. During heat stress birds lose a large amount of carbon dioxide by panting; CO₂ however, is essential for Ca-carbonate in eggshell formation. Therefore, in addition to an insufficient nutrient supply, the compromised egg shell formation limits the egg production further (egg/day or egg production/number of birds), which can be very substantial as the egg production percentage might decline from 80-90% to 50-60%, with a 10 g lower egg weight on average (Mashaly et al., 2004). Furthermore, the lack of carbon dioxide results in decreasing eggshell thickness and an increasing number of broken eggs that further aggravates the profit losses in hens kept in a hot environment.

Broilers were observed to respond to high ambient temperatures by a decreased protein synthesis and increased protein breakdown (reviewed by Lin et al., 2006). This appears to be supported by trial findings that report lower body protein and muscle tissue protein plus higher fat levels in heat stress (Gonzalez-Esquerra and Leeson, 2005; Aksit et al., 2006). The deterioration of meat quality is not limited to the altered protein/fat ratio, as the mobilization of minerals and vitamins from tissues due to heat stress (Sahin et al., 2009) further compromises the nutritive value of eggs and meat (Sahin et al., 2002). The prevalence of other deficiencies of meat quality, such as high drip loss, too pale color (Aksit et al., 2006), and PSE (pale, soft and exudative) meat also
TABLE 1: Effect of temperature on composition and quality of meat in broilers.

<table>
<thead>
<tr>
<th></th>
<th>Yield</th>
<th>Meat nutrient composition</th>
<th>Meat quality¹</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Carcass(%)</td>
<td>Breast(%)</td>
<td>Moisture(%)</td>
</tr>
<tr>
<td>Control</td>
<td>73.8ᵃ</td>
<td>29.9ᵃ</td>
<td>74.7ᵃ</td>
</tr>
<tr>
<td>28-22°C</td>
<td>72.9ᵇ</td>
<td>29.5ᵇ</td>
<td>74.4ᵇ</td>
</tr>
<tr>
<td>34°C</td>
<td>71.5ᶜ</td>
<td>28.4ᶜ</td>
<td>72.4ᶜ</td>
</tr>
<tr>
<td>SEM</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>P-values</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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Control: temperature was maintained at 22°C; 28-22°C: temperature was 28°C from 1000 h to 1700 h and at 22°C from 1700 to 1000 h; 34°C: temperature was kept at 34°C from 3 to 7 weeks of age¹ L*: lightness; a*: redness, b*: yellowness² ³ means in the same column with no common superscript differ significantly at P≤0.05 level SEM: Standard Error of the Mean.

In summary, high ambient temperatures impair egg production by decreasing the number and weight of eggs as well as by reducing the eggshell quality, whereas in meat-type chickens lower growth rates and higher feed per gain ratios are predominant. The deterioration of meat quality traits due to heat stress occurs mainly in consequence of the associated higher rate of lipid peroxidation and the altered electrolyte balance.

**Impact on pig performance and pork quality:** The climate change with rising mean temperatures may cause a permanent stress load for pigs, especially in continental summer or warmer climate areas. The upper critical temperature for pigs from nursery to adult ages is 25-26°C; however, some research data suggest that the optimal temperature decreases with the increase in body weight. The heavier an animal, the less ability it has to lose heat due to the relative small surface area compared to its body weight. In consequence feed refusal increases with body weight at high ambient temperatures (Close, 1989; Quiniou and Noblet, 1999).

In case of sows kept at high ambient temperatures (29°C Vs 18°C) the feed intake over the entire lactation period may fall back by more than 50%, resulting in a loss of body condition far exceeding the optimum and also leads to poorer growth of the piglets.

The condition of the sows is also in close correlation with the number of days to oestrus and the reproductive performance. Studies with pair fed sows showed that the energy metabolism and hormonal status of the animals changed during heat stress and the lower milk production is not exclusively explained by the reduced feed intake (Prunier et al., 1997; Messias de Bragança et al., 1998). Renaudeau et al. (2003) suggests, that the apparent inefficiency of the sow mammary gland in hot conditions could be attributed to an increased rate of blood flow irrigating the skin capillaries in order to dissipate body heat and this in turn results in a lower blood flow to the mammary gland cells. Feeding high fat diets (125 g fat per kg of dry matter) to the sows during lactation in order to alleviate hyperthermia leads to decreased heat production, which may reduce the feed refusal of the sows kept at high ambient temperatures (Babinszky, 1998). Feeding high fat diets also improves the energetic efficiency of milk production when compared to sows fed high starch diets (with low dietary fat levels). From the aspect of energetic efficiency milk fat production is more efficient from dietary fat than from dietary carbohydrates because it is converted more directly (Babinszky, 1998).

High temperatures cause loss of appetite in pigs; however, both the upper critical temperature and the rate of feed refusal are influenced by the relative humidity of the air (Collin et al., 2001; Huyhn et al., 2005). With the increase of humidity a 60 – 70 kg pig may lower its feed intake by up to 80-150 g/day (Huyhn et al., 2005). The lower feed intake compromises the daily gain, however, after exposure to hot periods of 30-33°C pigs display compensatory growth, they overcome their heat stress and grow further, but they can’t compensate for temperatures as high as 36°C (Babinszky et al., 2011). There is a curvilinear relationship between the increase of temperature and the average daily gain and feed conversion rate of pigs fed ad libitum (Noblet et al., 2001). The average daily gain reaches its maximum between temperatures of 15 to 25°C in young pigs (up to 30-34 kg) and between 10-20°C in growing and finishing pigs. Both cold and severe heat stress compromise feed conversion; however, during moderate heat stress (2-3°C above the upper critical temperature) pigs have the ability to compensate for the lower feed intake by decreasing their maintenance related heat production. Besides constant heat stress, diurnal high temperatures can also be detrimental to pig performance. The average daily feed intake and the average daily gain decreased by 10 and 20%, respectively, and the feed conversion (feed/gain) increased by approximately 8% when pigs were kept in...
a daily range of 22.5 to 35°C in contrast to the thermoneutral (20°C) temperature (Lopez et al., 1991). In the interest of performance and immune response it is recommended to avoid any higher fluctuations (±12°C) of the mean of 20°C (Noblet et al., 2001).

Recent publications highlight the fact that high temperatures not only impair growth but also change body composition and thus can impair the nutritive value and quality of pork. Prolonged heat stress (30-33°C) reduces the rate of protein deposition in growing and finishing pigs (Kerr et al., 2003; Le Bellego et al., 2002). As seen in the above, the lower protein deposition is probably not just in consequence of the lower nutrient supply. Halas et al. (2004) demonstrated in their model simulation that the rate of protein deposition is sensitive to any changes occurring in the maintenance energy requirement of the body. Heat stress triggers hormonal changes that influence the metabolism of nutrients. Reduced levels of thyroid hormones were consistently observed in swine kept in a hot environment in contrast to a thermo neutral milieu (Messias de Bragança et al., 1998; Renaudeau et al., 2003). Thyroid hormones are responsible for the metabolic rate and thermogenesis besides influencing the protein turnover within the body. Although carcass fatness decreases as a result of lower feed intake during heat stress, the shift of fat distribution from external sites towards internal sites was found to be attributable to a reduced activity of the lipogenic enzyme in back fat and a higher activity of lipoprotein lipase in lean fat (Noblet et al., 2001).

**Impact of climate on animal reproduction:** Heat stress compromises oocyte growth in cows by altering progesterone, luteinizing hormone, and follicle-stimulating hormone secretions during the estrus cycle (Ronchi et al., 2001), as well as impairing embryo development and increasing embryo mortality (Wolfenson et al., 2000). Also has adverse effects on reproductive functions i.e. gamete formation and function, embryonic development, fetal growth and development (Singh et al., 2011). Moreover, HS may reduce the fertility of dairy cows in summer by poor expression of oestrus due to a reduced estradiol secretion from a dominant follicle developed in a low luteinizing hormone environment (De Rensis and Scaramuzza, 2003). In these situations the calving interval is longer, the birth rate is lower and farm milk yield per year can be reduced. Heat stress during pregnancy slows down growth of the fetus (Nardone et al., 2006), although active mechanisms attenuate excursions in fetal body temperatures when mothers are thermally stressed. Semen concentration, number of spermatozoa and motile cells per ejaculate of bulls are lower in summer than in winter and spring (Mathevon et al., 1998). Conversely, Karagiannidis et al. (2000) refer an improvement of semen characteristics of goat bucks reared in Greece during summer and autumn. Prolonged heat stress negatively affected reproduction by increasing estrous cycle length and decreasing duration of estrus (Abilay et al., 1975). A decrease in the frequency of pulsatile release of luteinizing hormone on d 5 of the estrous cycle was observed in heat-stressed cows compared to cooled cows (Wise et al., 1988). Follicular dynamics are altered and follicular dominance is depressed by heat stress (Wolfenson et al., 1995). Furthermore, fetal growth is negatively affected due to decreased uterine blood supply and the insufficiency of the placenta to provide maternal nutrients (Collier et al., 1982).

**Impacts of climate on animal health:** Most important direct effect could be heat stress and reduced nutrient intake affecting production performance (Mariara, J.K., 2008). The results of impact assessment study in Africa indicate that large livestock farms are more vulnerable to climate change and are likely to lose net revenue while small farms are much less vulnerable and will probably get advantage, at least against the risk of dryness, livestock offer a good substitute for crops (Seo and Mendelsohn, 2007). It is a requisite to mitigate the climatic stresses, if a high producing and less tolerant animal to be reared in harsh environmental situation (Naqvi and Sejian, 2011).

Lameness incidence increases with an increase in ambient temperature (Cook et al., 2007). This coincides with the change of seasons as well; lameness prevalence is lower in cool months as compared to warm months (Sanders et al., 2009). These climatic and seasonal effects are also correlated to mastitis (Dohoo and Meek, 1982; Elvinger et al., 1991). Several trials have reported an increase of disease, particularly reproductive issues, during warmer months of the year due to the acceptable environment for pathogens and vectors (Collins and Weiner, 1968; Silanikove, 2000; Kadzere et al., 2002). Death losses also increase with an increase in THI (Vitali et al., 2009). Livestock diseases are strongly influenced by climate change and transmission of wild borne diseases like FMD and infectious diseases transmitted by ticks, flies, mosquitoes and other arthropods may be of great concern with respect to the changing climate (FAO, 2008 and Pattanaik and Sharma, 2010).

Predictions on all the impacts are difficult but a change in climate can result in changes in species composition of vectors, pathogens and augmenting its spread and even the emergence of new pests and diseases. New transmission modalities and host ranges complicate the epidemiology of some diseases (FAO, 2004). Temperate countries will be more prone to such diseases. Changes in the spatial distribution of
vectors/pathogens, animal populations with little or no immunity would be exposed and suffer major disease impacts (FAO, 2004). Diseases such as Bluetongue have expanded their range due to global warming. Extreme weather events such as heavy rainfall or droughts often trigger disease outbreaks.

**Impact of climate on crop production:** Unfavorable climatic factors may lead to a significant decline, and sometimes to the complete elimination of crops. Efforts to research the adaptive potential of crops are urgently needed to prevent this turn of events. Production technologies adapted to the cropping site conditions and to the requirements of the crops, the increased use of varieties / hybrids that better tolerate drought and the extreme conditions, and the selective breeding aimed at these objectives are of key importance.

Much of the relevant data in literature suggests the necessity of distinguishing between the potential and the actual vegetation periods. A consequence of the higher daily mean temperatures is that the potential vegetation period will be longer. At the same time the higher temperature leads to accelerated growth and this in turn shortens the crop lifecycle, and thus the duration of the actual vegetation period is also shortened. Under such circumstances it is reasonable to either grow varieties having a longer growth season (these usually produce higher yields than varieties with a shorter growth season, and can also be stored better), or to grow after crops. In this latter case the same area can be harvested twice within the same year (Babinszky et al., 2011).

Nutritionists are also going to face a serious challenge. Using the latest results of animal nutrition and its related disciplines (microbiology, immunology, physiology, molecular biology, precision nutrition, information technology, etc.) suggest that they hey are to develop feeding technologies and feed formulas in which the latest feed crop varieties of improved drought resistance are used more extensively. All this should be used in the everyday practice of producing foodstuffs of animal origin besides avoiding any decline in the quality and safety of the product (foodstuffs of animal origin) and alleviating the environmental load of livestock production.

**Feeding strategies to reduce the impact of hot conditions**

- Take feed to cows, rather than cows to feed in hot weather. Walking to feed increases a cow’s heat load, so reduce their walking during the hottest time of the day.
- Allow greater access to pastures for grazing at night. Cows will do up to 70% of their daily grazing at night time in hot weather.
- High-fibre forages will generate more heat through digestion, compared with concentrate diets. Cows will voluntarily limit forage intake during hot weather, so provide good quality forages during these periods.
- Increase the energy content of the diet with good quality forages and concentrates to make up for the shortfall in reduced intake and to reduce the metabolic heat load.
- Increase the concentration of minerals and vitamins in the diet to compensate for the reduction in feed intake, particularly sodium, potassium, magnesium and niacin levels in the diet.
- Supplementing cows with 1.5–1.6% DM of potassium and 0.5–0.6% DM of sodium will potentially improve milk yield in heat-stressed cows. Include magnesium at 0.35–0.4% DM to help to avoid metabolic problems (grass tetany) when feeding higher amounts of potassium.
- Including niacin (6 g/cow/day) may also be beneficial. It has been reported to reduce skin temperature and increase milk yield.
- Improvement in milk yield has also been reported by feeding 150–200 g/cow/day of sodium bicarbonate during hot weather to help buffer the rumen.

**Management strategies to reduce the impact of hot conditions**

- Provide cool, clean water and ample trough space in close proximity to cows at all times. In hot weather, lactating cows have the capacity to drink >100 L a day.
- Cows may drink 50% of their daily water intake as they exit the dairy. A 200-cow herd may therefore require a supply of up to 5000 L of cool, clean water during the 1–2 hours that cows exit the dairy.
- Allow access to shade throughout the day. Shade can reduce the cows’ heat load from the environment by up to 50%. Provide shade in feed-out areas, grazing areas and over the milking yards.
- Cooling cows at the dairy with shade, sprinklers and/or fans before and after milking will improve their comfort and enhance their capacity to eat.
- Let cows wander home and stand under sprinklers before the afternoon milking. Lowering body temperature will encourage higher feed intake during milking and pasture/ forage intake after milking.
- Queensland trials have shown that 30 minutes of wetting cows with sprinklers can produce an extra 1 L of milk; 60 minutes has produced an extra 1.5 L in hot weather. Sprinklers should deliver large drops to thoroughly wet cows’ skin.

**Feeding strategies to reduce the impact of cool conditions:**

As earlier mentioned, animals consume more feed at low ambient temperatures in order to compensate for the increased energy requirement used in thermoregulation. From the aspect of energy requirements a cold environment is essentially the
equivalent of reduced energy supply, and thus higher feed intakes and higher energy intakes can meet the extra demand of thermogenesis. When the increased feed intake is prevented by the limitations of the animal’s gastro-intestinal system, any means of boosting the dietary energy of the feed may be suitable for maintaining growth, and egg and milk production. Although increasing the dietary energy in a thermo neutral environment is associated with the improvement of feed conversion (the amount of feed required to produce 1 kg of product), in cold ambient temperatures, however, feed conversion may become worse or in the best case does not change with the feeding of high energy density diets due to the higher use of maintenance – i.e. non-productive – energy.

The body attempts to compensate for the excessive heat loss suffered in cold temperatures by a higher rate of heat production, and one component of this is to increase the use of maintenance energy. Heat, however, is also generated in the course of digesting and converting the dietary nutrients (the thermic effect of diet), which helps to maintain body temperature in conditions below the lower critical temperature; accordingly the feeding of diets with a high thermic effect will help the animals cope with the too cold environment. Thus for example, when high fiber diets are fermented by the colon bacteria a relatively high portion of energy is lost as heat; and the oxidation of proteins / amino acids as a form of energy producing process also produces lot of heat. Therefore, feeds containing a high percentage of fermentable fibers or excess protein increase the heat production of the animals. In practical feeding, however, protein overfeeding is not recommended either from the economical or the environmental point of view.

CONCLUSION

In conclusion, heat stress impairs feed intake and performance in the lactating period and in growing and fattening of different animals. The extent of this detrimental effect depends mainly on body weight and the actual temperature and relative humidity of the air. In order to avoid disastrous destroy of global environment and prevent it from further deterioration, it is a vital matter of immediate urgency to keep and control density of greenhouse gases in atmosphere.

REFERENCE


