Environmental constraints in livestock production

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The foremost problem faced by scientists and farmers alike involved in livestock development in tropical and subtropical environments is the constraint imposed by the physical environment. Direct and indirect effects of climatic factors like high temperature, solar radiation, humidity and air movements have a profound effect on the physiology and production of these animals.

Thermal stress has been found to cause deviations in the functioning of respiratory, circulatory, alimentary, endocrine and reproductive systems of the body. There is a vast array of observations indicating changes in respiration rate, pulse rate and rectal temperature due to thermal stress (Thomas and Razdan 1973 a, Sastry *et al.* 1973; Nauheinur - Thoneick *et al.* 1988a, Sreekumar and Thomas, 1990; Thiagarajan and Thomas, 1991, Thiagarajan and Thomas, 1992, Anil and Thomas, 1996.).

Reduction in feed intake near or above the upper critical temperature is the single most important factor affecting performance of heat stressed animals. Under thermal stress, reduction in dry matter intake was observed at various levels (Thomas *et al*, 1969; Thomas and Razdan 1973b). Thomas *et al* (1984) and Nauheimir - Thoneick *et al*, (1988) observed a reduction of around 30% in the gross energy intake at 30°C constant temperature in lactating German HF cows compared to 15°C. The corresponding ME reduction was 32%.

The requirement of ME was calculated from heat production, the energy utilized for milk production and body mass changes. The gross efficiency for milk production did not change due to heat stress. However, the energy balance of the animals was negative under high ambient temperature. The reason was regarded to be the rise in energy requirement for maintenance from 0.495 MJ/Kg$^{0.75}$ to 0.566 MJ/Kg$^{0.75}$ at high ambient temperature (Nauheimer - Thoniek *et al.* 1988b.).

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Several physiological reactions to heat stress are responsible for reduced intake. Foremost is a need to decrease metabolic heat production and is part of the adaptation process mediated through reduced thyroid activity. Additionally, factors like increased respiration rates and water intake (Pal *et al.* 1973), reduced gut motility and rate of passage of ingesta and the direct negative effects of elevated temperatures on the appetite centre of the hypothalamus (Collier *et al.* 1982) also play some role in reducing feed intake.

Page *et al* (1959) noted that heat stress caused a 30% reduction of liver Vit.A concentration. The potential impact of this on reproduction, epithelial cell function and health of animals in warm climates has not been explored.

In naturally heat-stressed livestock, the efficiency of dietary protein utilisation above maintenance was improved (Ames *et al.* 1980). However Thomas *et al* (1969) observed lower crude protein digestibility and nitrogen balance during summer in Sahiwal and Sahiwal x Brownswiss (F1) bull calves. Mitra *et al* (1972) observed that secretion rate of growth hormone of dry Jersey cows exposed to thermal stress was decreased 43% over controls. Similarly thyroid (Yousef and Johnson, 1966) and Glucocorticoid (Bianca, 1965) concentrations were reduced by thermal stress. Low secretion rates or activity of growth hormone, thyroid hormone and glucocorticoids reduce not only metabolic rate and feed intake, but also, growth rate and milk production.

Peripheral vasodilatation and redistribution of blood flow is a basic physiological reaction to thermal stress (Thatcher and Collier, 1982). Thomas and Razdan (1974) observed an expansion of extra-cellular fluid volume and reduction of blood and plasma volume during hot and hot-humid seasons in Sahiwal and Sahiwal x Brown Swiss (F1) bull calves. The reduced blood volume may be a result of increased fluid loss due to enhanced cutaneous and respiratory evaporation. Blood flow to the internal organs, especially uterus (Roman - Ponce *et al*, 1978) is markedly reduced due to heat stress. This can result in lower birth weight of calves (Collier *et al* 1982). They also found that provision of a shade during summer increased the birth weight of calves. Higher birth weight of calves was associated with higher (subsequent) milk yield of their dams (Collier *et al*, 1980). Thus heat stress reduced calf birth weight and indirectly altered the dams' post partum milk yield.

Similar quantification of blood flow to the mammary gland and digestive tract have not been assessed thoroughly. Blood flow to the stomach compartments of sheep was reduced by is to 30% due to heat stress (Englehardt and Hales, 1977).

Effect on growth and milk yield.

Milk yield is found to be affected by thermal stress. Thomas *et al* (1984) reported a decline of 30% and 24% in milk yield during early and late lactation in German Holstein - Friesian cattle when they were subjected to 30°C and 50% RH compared to 15°C and 70% RH. Nauheimer - Thoniek *et al*, (1988) also reported 30.4% reduction of yield in early lactation and 25.9% reduction in late lactation under continuous heat stress of 30°C and 50% RH.

Analysis of the data on milk production and environmental variables like ambient temperature and humidity at 6 stations spread over India, indicated that maximum temperature and vapour pressure considered together accounted for 36 and 14 per cent of the variation in milking averages in Hostein Friesian and Jersey halfbreds from Zebu respectively (Thomas and Acharya, 1981).

Tripathi *et al* (1972) observed that increase in ambient temperature and humidity had an adverse effect on growth in Murrah buffalo heifers and found that an average ambient temperature above 33°C retarded growth in them. Buffalo calves kept sheltered and sprinkled with water gained 15% more during summer. Thomas *et al* (1973) observed that Murrah Buffalo heifers completely sheltered and water sprinkled during summer and given a concentrate supplement gained at the rate of 487 g/day as against 296 g/day in controls. Thiagarajan and Thomas (1991 a) observed that rearing crossbred calves in the open resulted in no retardation of growth eventhough the physiological responses like respiratory rate, pulse rate, skin temperature and rectal temperature were significantly higher I the exposed groups.

These observations indicate that some relief may be afforded to animals by partially controlling incoming radiation. These shade structures reduce radiant heat load by 30-35%. Some studies have shown no benefit of shades compared with no shade on milk yield and reproductive performance (Nelson *et al*, 1961, Thiagarajan and Thomas, 1991b) and growth (Thiagarajan and Thomas 1991a).

Under extensive systems of livestock management sophisticated artificial shades may not be justified economically. Relatively simple shade structures from locally available materials may be constructed. The feeding and watering arrangements should be under the shade. No hindrance to natural ventilation should be allowed. Constructing the sheds on poles or pillars leaving the sides open is ideal. Promoting convection and evaporative cooling is a key consideration.

Breeding for stressful environments has especially to consider the existence of genotype x environment interactions. Thereby in stressful environments exploitation of maternal heterosis seems important, especially for maternal reproductive abilities (Mausolf *et al*, 1983).

Differential individual reactions to thermal stress through generating physical heat loss by physiological reactions and change in behaviour and through reduction in basal energy production results in a distinct 'Productive adaptability". This term refers to the ability of the animals to maintain their normal bodily functions in unfavourable conditions and means the absolute individual productive and reproductive performance in a given environment.

Efficient measures of productive adaptability should include combined indices of re production and production like weaned biomass per dam and birth internal (Horst, 1984).

Experiments in mice involving 23 generations indicated that productive adaptability vary among performance selected groups, whereby under unfavourable environments the heavier lines are clearly at a disadvantage compared to lines with lower body weight potential (Major *et al*, 1983).

Because of the antagonism between adaptive and production performance in stressful environments, selection for major physiological mechanisms against rising body temperatures such as reduction in metabolic rate and appetite would be of no advantage in most production systems where increased productivity is desired.

In some intensive systems in Israel and the U.S. additional evaporative cooling was given by sprinkling cows with cool water for short periods and then force ventilating with atleast 0.5 m/sec air flow (Wiersma et al, 1984). Total air-conditioning or partial air-conditioning during daytime increased milk production by 10% (Thatcher *et al*, 1974). However, it is not economical under most situations.

Keeping the air breathed by animals below 18°C reduced heat stress (Canton *et al*, 1982). Keeping the head cooled by an ice-pack also reduced heat stress in working bullocks (Thomas and Pearson, 1986). But such measures are not very practicable.

Genetic improvement for better production in unfavourable tropical climate is another way of circumventing the problem. For that depending on productive adaptability rather than single component traits such as heat tolerance seems more appropriate.

As might be expected from its effect on heat dynamics and basal metabolism, body size proves to be a critical determinant of productive adaptability of animals in hot and stressful environments. Therefore, selection should strive for optimum body sizes appropriate to the specific locations (Horst, 1984).

Approach to improve productivity in thermally stressful environments through selection for productive adaptability has potential. However, in many tropical conditions, more rapid advancement towards increased productivity could possibly be made through utilising existing higher yielding animals, protecting them from environmental stress through better housing, management and adequate nutrition.

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feed stuff for mycotoxins like aflatoxin and ochratoxin should be made mandatory since we know now that these can result not only in mortality, and morbidity but also loss of production and immuno-suppression.

Cost effective preventive mechanisms should be put in place supported by information transmission for implementation of a successful health care system in livestock health care programmes should be proactive in conception and execution.