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Heat Stress and Its Mitigation Strategies: A Review

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Review Article

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Abstract

With raising global temperature, significance on heat stress is also increasingly important. As long as the animals are within the thermo neutral zone, they are comfortable without any seen effects. Heat stress, up to a certain level could be efficiently overcome by the inherent mechanisms within the animal's body. But once it is crossed and the thermo neutral zone is disturbed completely, then although they are homoeothermic still they cannot maintain homeostasis and that in turn results in an adverse effect on the production, reproduction and health of the animal. Heat stress, the most vital climatic stress, along with an effect on the productive potential of animal, is lethal to its survival in harsh conditions. High temperature, air movement, solar radiation, wind speed and relative humidity are important parameters of the climatic variables. Amongst the mentioned, high temperature, radiation and humidity are the most important factors, which drastically affect the overall performance of livestock with reduction in meat, milk and egg production. Global warming and deforestation are also important contributors for increase in the earth's temperature, thereby causing heat stress. Keeping this in view, there is a need to take up different mitigation measures to overcome the heat stress. Although different precautionary measures are adapted to alleviate heat stress, still the livestock cannot be completely relieved of it.

Keywords: Heat Stress; Thermo Neutral Zone; Troductive Potential; The Climatic Variables; Global Warming; Mitigation Measures

Abbreviations: ROS: Reactive Oxygen Species; SOD: Superoxide Dismutase; CAT: Catalase; GPX: Glutathione Peroxides

Introduction

Heat stress is a condition where by the temperature, solar radiation and wind speed of the environment; increase the effective temperature of the animal. There by total heat load exceeds the animal's capacity for heat dissipation [1]. It affects the livestock production, reproduction and health. These days environment induced heat stress is of major concern as it has adverse effect particularly on high-productive animals. In tropical, subtropical and arid regions, high ambient temperature is the major factor hindering animal production. Heat stress along with high humidity, causes reduced heat dissipation by evapotranspiration [2].

A hot environment impairs production (growth, meat and milk yield and quality, egg yield, weight, and quality) as well as reproductive performance, metabolic and health status [3]. It also compromises the immune response due to which animals become more susceptible to diseases [4] reported the decrease in body weight, feed conversion efficiency and growth in broilers, lambs and beef cattle. Reproductive performance indicated by estrous activity, changes in ovarian function, pregnancy

rate are compromised in females. Similarly in males there is decreased sperm motility, sperm mortality as well as abnormalities. Embryonic mortality is also seen to some extent which may be due to reduced competence of acolyte to be fertilized. To avoid the above mentioned production losses it is highly important that there should be continuous monitoring of the livestock to observe the signs of heats stress. An increase in respiratory rate, body temperature, dullness, anorexia, animal's preference to stand, move towards shade are all indicative of the animal's state of stress. Then accordingly necessary measures need to be implemented to overcome the heat stress.

Heat Tolerance

Heat tolerance can be defined as the ability of the animal to maintain the expression of their inherited functional potential when raised under hot conditions. Physiological basis for this includes a large skin area to live weight ratio, pigmented skin and eye lids, shielded eyes and a light coloured or white body cover. Pregnant and lactating ruminants are more susceptible to heat stress than non-pregnant and non-lactating ones [5]. Environmental heat-tolerant animals should also be able to walk long distances, to adjust to low water intake and to high intake of salts as well as poor-quality food [6]. Goats are the best tolerant to elevated ambient temperatures [7]. Similarly, indigenous animals reared in tropical and arid regions are more adapted to hot climate, than those living under temperate environments [8]. Animals selected for high production potential are less tolerant to heat load than animals with low production potential [9]. Selecting thermo tolerant breeds of livestock species and their selective breeding may be good strategy for combating heat stress. However, a combination of heat stress ameliorative measures including nutritional management, shelter management, and reproductive strategies is required for getting maximum benefits [3].

Heat Stress and the Antioxidant System

Oxidative stress results from a disturbance in the steady state concentrations of pro-oxidants and antioxidants, leading to overproduction of free radicals and reactive oxygen species (ROS), and a decrease in antioxidant defense. Heat stress is responsible for inducing oxidative stress during summer in livestock animals [10]. Heat exposure enhances ROS production and induces oxidative stress, which can lead to cytotoxicity [11]. Heat stress was also shown to increase antioxidant enzymes activities, namely superoxide dismutase (SOD), catalase (CAT) and glutathione peroxides (GPX). The increased antioxidant enzymes activities in response to the increased ROS levels aim to maintain the steady state concentrations of generated free radicals. In a study conducted by [12] on Marwari goats, it was concluded that all the endogenous anti oxidants such as glutathione, vitamins (E, C and A) and ß-carotene decreased during hot and cold ambiences and the decrease during hot season is more relative to that of cold. Further it was concluded in this study that the extreme ambiences or so called stress depleted each of the anti oxidants thereby creating oxidative stress. When the steady state concentration of ROS is disturbed, mitochondria are the rest cellular compartment to be damaged. Indeed, histological abnormalities and altered morphology of mitochondria were denoted in skeletal muscle in a heat-stressed rodent [13].

Mitigation Strategies

Shelter management

Provide shade from direct sunlight (under the trees) temporary shade using portable shade cloth blocking 50% of radiation, or permanent structures. Whatever is the mode of shade provided, care should be taken that there is enough space for all the animals both adult and young ones to lie down and rest at the same time. Supplemental shade should also be provided for young calves. Research on beef cattle in this aspect showed improved weight gains and feed conversion efficiency [14]. Shading reduces the radiant heat load by 30% or more and reduces deaths due to heat stroke. Shading of the feed and water also offers production advantages for British and European breeds of cattle [15].

Managemental practices

A. Provide ample, cool, clean water in shade near loafing areas. Increase the number of watering stations as the animals cannot travel more when temperature, humidity and radiant solar heat are extremely high.

B. Increase airflow to the animals in shed by providing fans or coolers along with keeping the vents open. Opaque calf hutches should be preferred to translucent hutches for adequate air flow.

C. Usage of sprinklers for dairy cows in pasture-based systems reduces heat stress along with irritation to insects.

D. Avoid handling, transportation during hotter parts of the day. If necessary then prefer early hours of the day to avoid the handling and transportation stress. And also provide sufficient quantities of water feed and give rest to the animals every few hours.

E. Improve sanitation by use of repellents, traps so that animals may be relieved of biting flies and do not bunch together.

F. High quality forage (e.g. first cut dry hay) should be provided in feed bunks in shaded areas.

G. Maintain the livestock in good condition so that they can resist heat stress at least to some extent compared to ailing animals.

H. Managemental practices like shearing, castration, dipping etc should be done in early summer or in the early hours of the day itself when temperatures are less.

I. To lower body temperature cold water submersion, cold water enemas, ice applications, alcohol rubs can be done. In sheep application of cold water to body parts with little wool (head and lower legs) can help reduce heat stress to some extent.

Nutritional Management

In hot weather, reducing the heat increase of the body by dietary manipulation may protect the animals from heat stress to an extent. Dietary supplements such as vitamins, trace elements and minerals were exclusively used to ameliorate the adverse effect of heat stress [16]. Thermo protective role of vitamin E was reported in buffalo cows during the summer. In heat-stressed sheep, selenium injection decreased rectal temperature and body weight loss [17]. Supplementation of inorganic Cr to the diet of buffalo calves reared under high ambient temperature improved heat tolerance, immune status without affecting nutrient intake, and growth performance [18]. Betaine, a trim ethyl form of glycine has also been found to ameliorate heat stress in sheep [19]. Physiologically, mammals utilize betaine as a methyl donor able to participate in protein and lipid metabolism, or when not catabolized, betaine can be used as an organic cellular osmoprotectant [20,21] stated that the sheep supplemented with antioxidants also have lower respiration rates and rectal temperatures.

Sahin reported that glutathione supplementation to heat-stressed broiler chickens improves their performances and decreases the heat induced antioxidants status. Addition of betaine (0.3 g/kg) to feeds improves performance of poultry under heat stress [22]. Vitamin C is synthesized in the kidneys of chicken but then during heat stress the endogenous ascorbic acid is insufficient to meet the bird's requirement. Inclusion of Ascorbic acid in the feed ameliorates, heat stress induced problems like poor immunity, feed intake, weight gain, oxidative stress, body temperature, fertility and semen quality, carcass weight and mortality. Supplementation with L-ascorbic acid, both singly and in combination with l-tocopherol acetate, is helpful to heat-stressed layers [23]. Hosna Hajati et al. [24] made a study in Broilers suffering from chronic stress and concluded that supplementation of grape seed at the level of 300 mg/kg diet could improve live weight and suppress the detrimental effect of heat stress on blood metabolites such as the levels of glucose, cholesterol, and HSP70 gene expression.

Grey Areas

As mentioned above although there are different strategies to overcome the heat stress still there is a need to review the same in view of small holder dairy farmer in dry and rain fed areas. It is well known that the exotic breeds that are being used here due to their high production potential are less heat and disease resistant compared to the local breeds. There by the impact of heat stress is also more on these animals, and they require more amount of feed and water. Rearing these animals in dry, arid and water scares areas is definitely a costly affair. This shows that along with climatic conditions of an area, the vegetation and the breeds of livestock should also be taken into consideration while researching different strategies to overcome heat stress.

Strategic Approach to the Problem

It shows that the strategies adapted to one region/area may not work that efficiently to combat heat stress in the other as local conditions varies from one to other. So there is a need to design strategies against heat stress region specific for better production potential, taking into account the different parameters temperature, wind velocity, humidity, rainfall, vegetation, water availability and the level of heat resistance of the animals. There are many strategies to overcome heat stress as mentioned above but then it is further required to investigate which combination of strategies is able to overcome the heat stress better which is in turn reflected by the increased production potential of the animals. Therefore trials need to be conducted in different climatic areas applying combination of strategies to overcome the heat stress in a better way.

Conclusion

There are many strategies to protect the animals from heat stress but then they all are generalized. There is a need to undertake further study keeping in view the climatic variables of a region, breed of the animals along

with different combination of strategic measures which may result in better method of reducing heat stress.

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