ISSN 1819-1878

Asian Journal of Animal Sciences

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OPEN ACCESS Asian Journal of Animal Sciences

ISSN 1819-1878
DOI: 10.3923/ajas.2017.1.13

Review Article
Behavioral Responses to Livestock Adaptation to Heat Stress Challenges

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Abstract

Climate change leads to several environmental stresses that affects livestock production. In order to re-store the productive potential the animals need to adapt to the existing climatic conditions. An animal may respond to a particular stress either through behavioral, physiological or by a combination of both and reactions of an animal to a particular stress can vary based on the animal's earlier experience with the stressors, the duration and its intensity, the physiological status and environmental restraints. The aim of this study is therefore to understand the significance of behavioral responses in livestock adaptation. In the livestock sector, stress is considered as a reflex reaction that happens when animals are undergone through severe climatic and environmental changes and this can lead to several unfavorable consequences which can lead to even death of an animal. The discomfort which has been faced by the animals due to such stress conditions are resolved by them by generating various adaptation techniques. These adaptation techniques generated can compromise the productivity and performance of an animal. Farm animals try to cope up with different stresses by using behavioral stress responses. A better understanding of the behavior of livestock could enable improved handling and animal welfare. Assessing the behavioural response should help the farmers to take immediate step to identify and minimize the stressful conditions faced by their animals and should keep their animals in a comfort zone by employing better management strategies.

Key words: Adaptation, behavior, defecation, drinking frequency, shade, urination, wallowing, water intake

Received: August 17, 2016 **Accepted:** November 23, 2016 **Published:** December 15, 2016

Citation: Athira P. Ratnakaran, V. Sejian, V. Sanjo Jose, Shalini Vaswani, M. Bagath, G. Krishnan, V. Beena, P. Indira Devi, Girish Varma and R. Bhatta, 2017. Behavioral responses to livestock adaptation to heat stress challenges. Asian J. Anim. Sci., 11: 1-13.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Livestock is an important sector, especially in developing countries, which contributes largely to the national economy and also employment for the rural population[1,2]. In India, livestock sector plays a major role in the socio-economic development and it is the major source of livelihood for 20 million people especially women[1]. In the coming decades, there will be a rapid demand for livestock products across the developing countries due to rapid urbanization[3,4]. As climate affects agriculture and water sources badly, the animals have to cover long distances in search of feed and water, resulting in negative energy balance[5,6].

Environmental factors such as temperature, relative humidity and solar radiation has both direct and indirect effects on livestock production[7,8]. Further, the changing climate can affect the feed availability and the higher temperature can result in the decline in milk production and reproductive efficiency of the animals[9,10]. In addition, heat and nutritional stress are considered to influence both the productive and reproductive efficiency of livestock[11]. Also the impaired metabolic and immune responses of the animals finally results in a worsened health condition of the animal[12]. An animal may respond to a particular stress either through behavioral, physiological or by a combination of both and reactions of an animal to a particular stress can vary based on the animal's earlier experience with the stressors, the duration and its intensity, the physiological status and environmental restraints[13]. An animal's response to a particular stress can either be beneficial or harmful and stress mainly affects the physiological process such as immune system and reproduction[14].

If the earth's temperature continues to rise further as predicted the harmful effects of environmental stress on animals welfare and production could be a great issue in the future[15,16]. There is negative energy balance in livestock because during extreme climatic conditions animals have to walk long distances in order to search for feed and water[5,6]. Thermal stress can lead to physiological and behavioral responses in an animal which changes its duration and intensity with respect to the genetic make-up and environmental factors in coordination with behavioral, endocrinological, cardiorespiratory and immune system[17]. It is a better option to use an adapted animal with lower productivity than by infusing stress tolerance genes to non-adapted breeds[18].

Adaptation is the combined morphological, physiological, anatomical, biochemical characteristic feature of livestock, which is essential for its survival in the extreme environmental conditions[19]. To recreate the homeothermy and homeostasis, the animals perform adaptive and compensatory techniques. A significant decrease in productive potential and an increase in physiological responses is observed in those animals which are exposed to hot climates[12]. It was noted that in order to cope with the extreme environmental conditions an animal will undergo stress when it has to make extreme functional, behavioral, structural or immunological adjustments[20]. The relation between the climate variables and the neuroendocrine system of the animals tend to alter their behavior residing in an area[21]. Hot and humid conditions would cause heat stress among livestock inducing metabolic and behavioral changes resulting in lower productivity[3]. The behavioral attitudes of livestock towards climate change are complex and it is not well understood by the farmers. This hampers the development of various adaptive and mitigating policies which are targeting the rural farming community[22]. Hence this review is an attempt to collate and synthesize information pertaining to various direct and indirect effects of climate change on livestock production as well as the animals's response mechanisms that helps them to cope up to any adverse environmental condition. Special emphasis was given to cover in detail the information on the behavioral adaptability of livestock to heat stress challenges.

LIVESTOCK AND ITS CONTRIBUTION TO ECONOMY

Livestock sector has faced great changes from the early 1970s and it is the major source of draft power in rural areas which provides milk, meat, eggs, wool, hides, skin, manure and fuel. Livestock sector contributes generally around 8-10% to the GDP[23]. The livestock sector is highly dynamic sector and the demand for livestock products are rapidly rising in the developing countries[24]. Livestock sector has got both positive and negative effects on the economic growth[25]. Around 53% of agricultural GDP of industrialized countries is governed by livestock production and merchandizing[25].

About 30% of the global ice-free terrestrial surface area is occupied by livestock systems[26]. The total global asset of livestock sector would come to at least $1.4 trillion[24]. This sector employs around 1.3 billion people globally and 600 million poor smallholder farmers in the developing world are directly benefited[27]. There is an increasing demand for the livestock products recently due to increasing population, urbanization and rising incomes in the developing countries which leads to a quick growth in the GDP, where its share of agricultural GDP is already 33%[28]. Half of the global agricultural input and one third in developing countries is provided by the livestock sector[29].

The developing countries agricultural economy is mostly contributed by livestock production. It provides direct income to the farmers. Livestock is considered as a major contribution to food security. They are rich in high quality protein, minerals, vitamins and micro-nutrients. Animal proteins are more digestible and efficiently metabolized than plant proteins[30,31].

CLIMATE CHANGE AS AN IMPORTANT FACTOR INFLUENCING LIVESTOCK PRODUCTION

Livestock and livestock systems are the major factor which contributes to global warming through emission of Green House Gas (GHG). Climate change in return can also have an impact on the livestock keepers and also on the ecosystem goods and services on which they depend[32]. Even though the demand for livestock products, offers greater market and opportunities for small, marginal and medium farmers, livestock productions are under immense pressure due to the negative impact of environmental implications, predominantly GHG emissions[21]. Global GHG emissions will continue to rise and there are several adaptive technologies which are available to cope up with this changing climatic conditions, including drought tolerant fodder crops, different management practices, behavioral and policy changes [32]. It is noted that industrialized livestock based system is least affected by the effects of global warming when compared to mixed and grazing systems. The major reason behind this may be because of the direct effect of solar radiation and high temperature on animals and also due to increasing droughts and low rainfall availability affecting the pasture and crop growth in the later systems[33]. These systems are mostly prevalent over developing countries, where the per capita consumption and rising population demand depends more on animal products[4,34-36].

Climate change and heat stress will affect both directly and indirectly on animal productivity and welfare. The major indirect effects are reduced feed intake, water availability, immune system, reduced availability of pasture and more outbreaks of diseases[21]. Impact of climate change over different sectors such as livestock and agriculture is the current primary concern because the growing population is in need of more food especially of animal origin[33].

The major priorities for the human kind in the coming 21st century would be mainly for food and water security and the rising population would be in more demand for food production especially of animal origin. A loss of 25% of animal production is anticipated in the developing countries due to global warming[37]. The rising temperature and extreme events such as drought can affect the forage availability and also the crop production. Apart from this heat stress can also impair production functions like milk yield, egg yield and quality, reproductive performance, behavioral response, immune response, increase incidence of disease, metabolic and health status all are affected. It is thus necessary to cope up with these adverse impacts of climate change through the development of proper management strategies and through the genetic selection of the heat tolerant livestock species[33].

DIFFERENT STRATEGIES OF ADAPTIVE MECHANISMS

There are different types of adaptive mechanisms through which animal adapt to the changing climatic conditions, including genetic or biological adaptation, phenotypic or physiological adaptation, acclimatization, acclimation and habituation[38]. Stress is any changes in the environment which can be a change in the climate or management which is hard enough to provoke a behavioral or physiological response from the animal[20]. The major problems of stress are inducing changes in the secretion of pituitary hormones, which leads to changes in the metabolism, reproductive failure, immune competence and changes in the behavior[39]. Climate change can affect the livestock production system in many ways. The animals may be exposed to many stress conditions such as under feeding, lack of water availability or restricted use of water due to changes in climatic conditions. In addition, they may be also subjected to other environmental and nutritional stresses and in order to cope up with these adverse conditions farm animals develop some adaptive mechanisms to survive in these harsh conditions[40]. Adaptation is not only the tolerance level of the livestock of environmental stresses but also their ability to survive under harsh living conditions and their ability to grow and reproduce under poor nutrition and disease conditions[41]. Animal's health, their ability to grow, reproduce all these factors are affected due to the impact of duration and intensity of the stress[13].

When animals encounter an environmental challenge they are likely to respond to them through a variety of interacting mechanisms including physiological, biochemical, immunological, anatomical and behavioural[13]. There are several factors which can affect the response of the animal towards stress, such as the duration and intensity of stress, the previous experience of animals towards the stressors, the physiological status and the immediate environmental constraints[42].

Acclimatization occurs in two phases that is acute and chronic and it would take weeks rather than days for the completion of these two phases. The process of acclimatization changes the secretion rate of hormones and also alters the amount of receptors in the target tissues. Acclimation is a homeorhetic process under the control of the endocrine system[40]. Homeostasis in livestock are retained by the neuroendocrine responses of them to stress. These responses vary based on the stressor and these are precise and classified accordingly. The chronic stressors causes endocrine responses which lead to morbidity and mortality, these conditions can be managed and survived by the adaptive functions through acute responses[11,43].

SIGNIFICANCE OF BEHAVIORAL RESPONSES TO LIVESTOCK ADAPTATION

Livestock's behavior is directly in relation to that of its status of well-being. The effect of heat stress and other environmental changes often leads to a reduction in the animal's performance and productivity. Change in the behavioral pattern can implicate a dreadful environment. Figure 1 represents the various behavioral responses of livestock adaptation. The major behavioral responses to livestock adaptation are feeding, defecating and urinating frequency, water intake, lying time, standing time, shade seeking behavior and increased frequency of drinking. There are also several factors influencing these behavioral responses which have been depicted in Fig. 2.

Feeding: When the cattle are exposed to hot environmental conditions, reduced feed intake was observed[44,45]. In lactating cows, feed intake started to decline at temperatures 25-26°C, in temperate climatic conditions with rapid decrease recorded at 30°C and it reduced by 40% at 40°C[46]. Since the heat increment of feeding act as a source for heat production in ruminants, reduction in feed intake can help to decrease heat production during warm climate[47] and due to this negative energy balance body weight and the body condition score will go down[48]. It was seen that cows showed an increased probability of starting to feed with the advancement of time since the last feeding[49-51]. Studies show that under heat stress conditions dairy cows show a reduced rumination[52,53], but if the feed contains high starch content, longer rumination was observed in order to reduce the ruminal pH[54].

Defecation and urination: Urination and defecation are a common natural physiological process of the livestock. The frequency of urination and defecation vary with the factors affecting the livestock like water intake, feed intake, type of feed, environmental temperature, disease condition, immunity of the animal and stresses etc. Among the stresses, heat stress plays a vital role in affecting urination and defecation in livestock.

Effect of heat stress on goats exposed to high temperature showed that the defecation and urination frequency showed a significant decrease in the heat treated groups, where T2 group animals were exposed to high temperature for 2 h, while the T3 group was exposed to high temperature for 4 h than the control. However, duration per urination in goats per each group did not vary significantly within the three groups[55]. Similar results were seen in the study conducted in black Bengal goats, where the heat

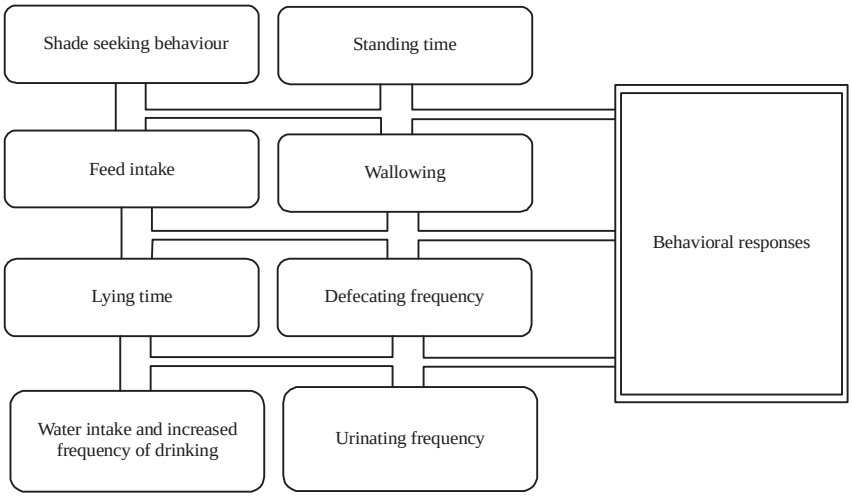

Fig. 1: Various behavioral responses of livestock adaptation

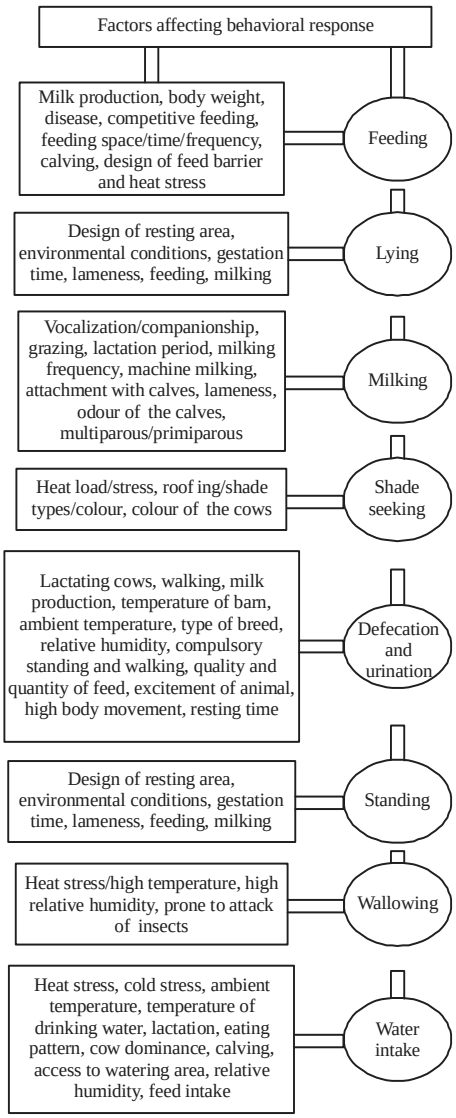

Fig. 2: Factors affecting behavioral responses

exposed group showed only significant changes in the frequency of urination and defecation[56]. Loss of heat from livestock to the environment happens through evaporations of sweat, saliva and respiratory secretions. In combined stresses group, there is increased respiratory and cutaneous evaporative cooling mechanisms leading to severe dehydration thereby leading to reducing their urinary and defecation frequency. However, the interaction between groups and experimental days did not influence significantly both the defecating and urination frequency in the bucks[57]. Similarly, heat stressed non-pregnant dry Holstein cows under heat stress showed a significant decrease in urine output along with the rise in urinary sodium excretion and a significant reduction in serum sodium[58].

Lying and standing behavior: Generally, the cows spend nearly half of their life lying down to rest and a reduction in this time may lead to physiological changes associated with stress, which may eventually have a negative impact on health[59]. The changes in behavior associated with high heat stress increases the standing time. The animals maximize the evaporative heat loss from the body surface and assist in convection by standing more time to get away by the conductive and radiative heat from the hot ground surface[60]. Further, the time spent on standing has increased by 10% (13.8-15.3 h day^{-1}) when the heat load increased by 15% (THI = 60-70) to enhance the heat loss by increasing the surface area of skin exposed to air or wind flow[61]. The higher standing time during heat stress is an adaptive behavioral mechanism in animals to avoid the additional heat load from the ground and to favour easy heat dissipation form the body. Further, standing diminishes heat gain by direct contact with the ground and tends to decrease heat stress. The conductive heat loss is minimal in the standing animals due to the presence of a layer of air against the skin where most of the body heat load is transferred to the air[62]. In addition, the standing animals transmit its heat load to the ground only by the feet with a small area of contact. Moreover, the distance between the blood vessels and surface area is much greater in the feet of the animals than its skin[63]. However, the provision of sprinklers and fans to mitigate heat stress facilitates the buffalo heifers to reduce the heat load and increased the time of lying down[64]. Shilja *et al.*[57] recorded highest ($p<0.01$) lying time in the group of restricted feeding with heat stress in comparison to heat stress goats because standing requires more energy than lying down. This shows the importance of optimum level of nutrition for adaptation in goat as sufficient energy levels are needed to support the behavioral responses which will help an animal to adapt to heat stress condition[65]. The sheep exhibit more time for rumination by standing where the ruminants have been characterized by the use of night time to perform lying rumination to mitigate the effects of heat stress[66, 67]. Even a mild heat stress can appeal to increase in the standing time, which may advance incidence of lameness when cattle stand longer than 45% of the day. Provolo and Riva[68] reported that there is a negative correlation in between time spent on lying, the incidence of lameness and THI. Further, the reduced resting time may also be dropped the milk production by each hour of increase in resting time has reduced 1.7 kg of milk yield[69].

Shade seeking behavior: It is proved that excess heat load would compromise animal welfare and in extreme cases may culminate in death[70]. The shaded structures are commonly

used on dairy farms to alleviate heat stresses condition in cows[61,71]. It was reported in cow that the use of shade was opted when the temperature reached 20°C and increased usage when the temperature climbed 25°C[72]. During warm summer conditions, cows which used shade showed lower core body temperature and lower respiration rates when compared to those without any shade[73,74].

Cows gave more preference towards standing in the shade rather than lying during hot weather conditions[75]. It was found that the cows preferred shade created by iron roof even when given access to every shade type (like shade cloth, choko vines and single trees) because it blocked 70% of solar radiation provided that less solar radiation was allowed to fall on it by means of shading from other treatments[76]. The paint colour of the shade structures can vary the amount of radiation emitted from those structures[77]. Another study shows the preference of cows towards shade created by trees due to the efficiency in blocking the solar radiation and evaporation from leaves which causes the air to cool rather than artificial shade structures[78].

It was observed that darker coloured cows opted for a shade less than lighter coloured animals[61]. In order to increase the airflow around the body and to maximize the surface area exposed to the environment, the cows stand, adjusted its standing posture[79]. The cattle shifted their time budgets for increased use of shade during the day and increased grazing time during night[71]. Compared to shaded ruminants, in grazing ruminants the stressful effects of hot climate are determined by the reduction of ruminal contractions, increased rectal temperature and decreased milk yield[80].

Shade can be considered as a mitigation approach by reducing production losses due to high Temperature Humidity Indices (THI) or ambient temperatures[81,82]. When shade was limited or unavailable, time spent around the water trough by the cows increased[83,84]. When the water trough was placed in the corridor, usage of shade was more in order to compensate the lower water intake[85]. At high relative humidity levels (>55%) the usage of shade was lowered[75]. Silanikove[59] reported that buffaloes seek for shade in the absence of wallows and shade seeking is a common behavior among livestock to adapt to hot humid conditions.

Wallowing: Wallowing behavior is a learnt behavior, especially in buffaloes and pigs. The wallowing behavior of animals can enhance their level of production of buffalo heifers as well as improve their welfare[86]. Wallowing would enhance the grazing time of buffaloes because it reduces the heat stress. Buffaloes are adapted to the tropical and sub-tropical climatic conditions because of their thermoregulatory mechanisms such as wallowing that would protect them from solar radiation and provide cooling effect[87]. It was reported that the greater amount of wallowing occurs during the sunrise and sunset time and especially during high solar radiation[86]. Standfast and Dyce[88] studied that apart from protecting from solar radiation wallowing help to reduce the attack from insects.

Generally wallowing is done for two purposes, one for cooling purposes and the other for protection from insect. Wallowing is done both during day and night time. During the day time it is done in the hottest period and at night time it is done to protect it from insects. The study of Chikamune and Shimizu[89] found that the effect of lowering the body temperature of buffaloes is better through wallowing than that of spraying. During high environmental temperature conditions, buffaloes dissipate the excess heat from their body through wallowing[90]. There was no correlation obtained between wallowing and breeding activity but it was found that wallowing is related to the time of shedding[91]. Wallowing has been described in free-ranging animals and this behavior was generally classified as ambivalent, functioning both as a comfort or a threat gesture[92]. Further, wallowing was considered a sex independent, self -grooming behavior in livestock[91].

The buffaloes are having a dark skin and relatively very less sweat glands in its body due to this, it is difficult for them to maintain their body temperature during hot and humid conditions so they depend on wallowing to maintain their body temperature. The wallowing activity is mostly seen in older dominant animals than younger ones because wallowing activity is often restricted to the younger animals by the priorities of high ranking opponents where they will displace dominate and displace them from wallowing[92]. Wallowing is generally a behavior learnt from its birth when the animal has not wallowed from its birth it will not do it on its own and thus if there is no water or mud hole available it will behave more or less like cattle and they will seek shade and do grazing at cool hours and less during the hot hours. When the buffaloes enter water they will either urinate or defecate. This is a way by which to mark their wallow. Wallowing is considered as a saving of wasteful heat production under heat load apart from a physical well-being of buffaloes[89].

One of the typical behaviors of pigs is wallowing in the mud which is generally done for temperature regulation. The sweat glands are less for pigs so it is difficult for them to control their body temperature by perspiration so they wallow in muds. Mud will remain in their skin for a long time, so that the moisture retention would be more than cooling them

with water. When the pigs enter wallowing they generally dig and root in the mud before immersing their body completely into it and this is done to cover their entire body surface with mud[93]. McGlone[94] also reported that pigs won't completely immerse their body in mud and it depends according to the temperature of the environment. McGlone[94] also reported that when the temperature is slightly warm, they stand in cool water and when the temperature rises, they lie with their udders in mud and cold water but when the temperature is still high they roll down in the mud and allow to evaporate. During hot days only their head can be visible and their entire body will be immersed in the mud. Pigs also wallow during the cold conditions in which the mud acts as an insulation to help retain their body heat. In addition to that the mud layer protects the pig's skin from harmful ultraviolet (UV) rays because mud blocks the UV rays entering and also mud layer will protect the pigs from various insects like lice and ticks. Sambraus[95] reported that during summer conditions pigs wallow on an average twice a day and around 3 h in the morning and 0.5 h in the afternoon. Huynh *et al.*[96] stated that under confined conditions the pigs may wallow more frequently for shorter time periods like 1-15 times in a day for 1-9 min.

Both domestic and feral pigs are known to mark their wallow by using wallowing holes to make their presence and also to determine their territorial foothold. In addition to pig's elephant, deer, rhinos also undergo wallowing. About 50-70% of the body of the pigs will be covered with mud during the hot days[94]. Dellmeier and Friend[97] reported that, two types of wallowing in pigs, such as active and passive type; passive wallowing is one in which the pigs will stand or lie in the mud and active wallowing is the one in which they root below the surface and shake their heads in water and roll down in the water.

During overheating conditions pigs may show increased panting, reduced activity, reduced feed intake, elevated body temperature, modified lying behavior, delayed return to oestrus[98] increased drinking[99] and wallowing, skin wetting[100]. When there is no access to mud pool the pigs lay in any wet surface or in their own faeces and urine[101]. Wallowing increases not only during high temperature but also at high relative humidity levels[100]. Pig's adaptation to humid environment is being indicated by wetting through wallowing[102].

Pigs lose their body heat through conduction, convection and through evaporation of water through wallowing. By direct contact with cool surfaces like moist soil heat loss through conduction can be enhanced[103]. Cooling by mud is better than water because mud allows the evaporation process to continue for a long period[104]. Pigs are more effective at losing heat during warm periods through wallowing than they would do with sweating when compared with the evaporation rate of cattle[94].

Water intake and water drinking frequency: Devendra[101] reported that the water consumption by livestock would increase by 20-30% during severe weather conditions. Ali and Goonewardene[102] reported that the water consumption of animal per unit is 48.9 L day^{-1}, which is increased by 0.81 L per animal unit for every degree celsius rise of temperature. Coimbra *et al.*[105] found that the time of water consumption increases with the hotter and drying conditions. In growing ruminants, the intake of water increases with the increasing ambient temperature[106]. The daily average temperature was established to be responsible for an observed variation in water consumption by 25.7% in cows[107]. Water is an important nutrient during heat stress and the properties of water are an important factor for the transfer of heat from the body to environment[108]. The body heat is preserved by the high heat capacity of water and it acts as insulation during cold stress.

Within 1 h after milking the cows consume nearly 30-50% of their daily water intake. The temperature of the drinking water has only very little effect on its drinking behavior. Cows generally prefer moderate temperature water to drink, which is neither too cold nor too hot[109].

Markwick[110] reported that during hot weather conditions sheep use more water for evaporative cooling because shearing increases the heat load so consumption of water will increase by 78% during hot conditions. The consumption of water will be 40% higher during summer than that in winter. The temperature of water is also a crucial factor, generally cold water can be given during hot conditions and water temperature below the body temperature would be better than warm water. The salinity of water also may increase during hot conditions due to evaporation[109]. The bull's demands for more water during heat stress condition. Need to drink water was emphasized when the THI went above[54] 78. The increased consumption of water is used to dissipate heat and for cooling the reticulo-rumen[52]. Water intake by cattle can be affected by many factors including water quality and ambient temperature[111]. The water requirements of the livestock can vary based on the species and the water consumption rate can also vary based on several factors like age, rate of gain, pregnancy, lactation, activity, type of diet, feed intake and environmental temperature[112]. Some of the factors which affect the drinking behavior of animals are cows eating pattern and the access of

watering area, water temperature, water given in a trough or bowl and cow dominance if water bowls are shared. Water intake of cows is maximum when feed intake is maximum. For adequate water intake, the water temperature should be kept open free of ice during the cold months some studies show that cows drink chilled water with no effect on milk yield and feed intake.

Depending on the grazing pattern and nature of nutrients goats require zero to several liters of water per day. The water intake of loose-housed cows are positively correlated with dry matter intake and number of meals per day[113]. The water intake is reduced when high moisture content fresh forages or silage is supplied. The water intake will be comparatively less in areas which have high humidity because of lower losses of evaporation. Brahman cattle adapt much better than the temperate breeds to dry conditions and they better withstand the short term restriction of water[111].

Advance developments in recording animal behavior: Animal behavioral studies were primarily based on the observations made visually in the written records. The advancement of the technologies has made this job easier with the help of recording instruments like photographs, video recording and other sophisticated instruments like Global Positioning System (GPS), GPRS etc. Range meter was the first mechanical devices to measure the animal travel. However, automated recording of animal monitoring has replaced the older ones. The distance traveled by the animals should also be correlated with the type of terrain on which the animal grazes. Sheep movement was monitored using the pedometer attached to the legs of the sheep which was later implemented to the cattle's too. Pedometers attached to a sheep's legs were used to monitor activity many years before they were used to successfully monitor travel of cattle on brush infested rangeland[114]. Radio collar used in the wild animal was used in the livestock living in free range to monitor their movement, which was later replaced by the use of GPS-based tracking devices. To monitor the movement, feeding and other behaviors GPS combined with video recording best fits in. Other tracking devices like use of access control systems[115], lasers[116], video systems[117], video systems combined with GPS[118] and cell phones[119] has also been attempted in livestock.

CONCLUSION

Adaptation is the tolerance level of an animal as well its ability to survive and reproduce under harsh living conditions. In the changing climate scenario, the environmental challenges are hard enough to provoke behavioral responses in animals. The status of well being is directly linked to the livestock behavior and hence change in behavioral pattern will help to determine dreadful environmental conditions. A better understanding of the behavior of livestock could enable improved handling and animal welfare in the changing climatic condition. At the time of excess heat load the animal in general will try to re-establish their heat balance with surrounding by altering their normal behavioral attributes. As behavioral response is the first step taken by animal to combat the heat load, studying the animal behavior is a useful tool not only to overcome the heat stress but also to understand how to best use and design strategies to manipulate the micro-environment.

FUTURE PERSPECTIVE

Detailed studies on correlating behavioral responses to other stress responses and inputs from behavior specialists are very crucial for further developments in the field of animal welfare. To improve the living conditions and implement engineered adaptive mechanisms, a strong data base on the behavior of each species is required. The behavioral study is essential to develop synthesizing life-like systems, understand the brain functions which generate these responses, predicting the individual character from the genome and to understand the interactions of biosphere, climate and earth. Based upon the modeled data on climate for the future, engineered adaptive measures could be implemented, so as to avoid the harsh environmental conditions for the livestock species. In the changing climate scenario, the study of behaviour of animals has got its relevance. The impact of stress and the responses of the animals is difficult to precisely determine, opportunities for further research is delineated and we need a better understanding of the reaction of the animals under stress. It is quite evident that this issue receives much more research attention because it mainly focuses on improving the animal welfare, its yield and productivity. Such efforts in establishing the behavioural adaptability in livestock may yield important biological m arkers through which we can identify the superior adaptive animals. Such markers can be incorporated in breeding programs to evolve a thermo-tolerant breed using marker assisted selection.

ACKNOWLEDGMENTS

The authors thank Indian Council of Agricultural Research and Director, NIANP for providing necessary permission for this manuscript.

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