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Effect of lamps as heat source to ameliorate cold stress in livestock: A review

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Abstract
Microclimate is very important for domestic animals as comfortable conditions are of paramount importance for good health and better growth in all livestock species. Better thermal ambience reduces the unnecessary stress on the animals caused due to adverse climatic conditions. Improving the thermal comfort in extreme winter by providing heating lamps in the microclimate zone results not only in improved production but also facilitates weight gain, proper health and welfare in animals. Ideal lamps should be easily available, cost effective, more heat efficient and durable. It should help the animal's microclimate by providing utmost thermal comfort by negotiating the adverse environment. This review article notifies the important research works done in this field for better understanding and selection of proper lamps for animal dwelling.

Keywords: Animal comfort, cold stress, heat, lamps, livestock

Introduction

Livestock plays a pivotal role in the overall social development through contributions to milk, meat, hides and draft power for agricultural operations. In fact, cattle and buffalo in our country contribute immensely toward the overall milk pool of the country with 187.75 MT of milk per annum (BAHS, 2019) [6]. Livestock sector not only provides essential protein and nutrition to the human diet but also plays an important role in utilization of non-edible agricultural by-products. The success of the livestock industry depends on good health of the livestock that helps to increase productivity. The knowledge of occurrence of animal disease and pattern of mortality in organized dairy herds serve as a useful indicator for assessing the status of herd health and management programs and their efficacy (Prasad *et al*., 2004) [50]. Young ones are considered the future of the herd, so keeping them healthy has a positive impact not on livestock farm productivity but also on the economy and production outputs. Newborns are protected from the cold using a variety of methods, including community housing or pens. In the winter, infrared heat lamps are often used to shield piglets and chicks from cold stress. Using the thermal and optical properties of infrared radiations, it is possible to reduce the overall heating demand of the young one's shed. The radiant energy can be transmitted directly from the source of radiation to the animals due to the directional property of thermal radiations. As a result, the traditional method of preheating large volumes of air is no longer necessary. Instant heat is another important property of infrared radiation, particularly when compared to the comparatively long time it takes for a traditional warm air system to bring the temperature of the air in the building to a comfortable level for the animal. The infrared and incandescent reflector lamps are designed to withstand the harsh environments, such as a farm, a bathroom, or a kitchen, as well as their immediate surroundings. Using such heat lamps is an excellent way to generate warmth. The animals are warmed directly and without draughts by the infrared lamps. However, microwave heating, and floor heating can all be used to keep the pigs warm in their living areas (Bodman *et al*., 1989) [13]. As opposed to other forms of heating such as the thermal floor and incandescent light bulb, creeps fitted with thermostatically operated infrared lamps provided a more suitable atmosphere for the piglets (Mores *et al*., 1998) [40]. In northern India, December and January are the most critical months for thunder waves and cold stress. To provide a better microclimate in these periods, it is paramount important to review the already documented data on use of various lamps as heating sources in various livestock species. Therefore, aim of present study was to cover wide range of studies done on effect of different lamps as heat source to ameliorate cold stress for animals in winter.

The literature related to the present study has been reviewed under the following sub-heads:

Season and Mortality

Studies show that calf mortality was higher in winter as compared to summer (Patil *et al.*, 1992, Singh and Singh, 1973, Katoch *et al.*, 1993) [4, 60, 30]. Tomar (1973) [64] studied the effect of season on mortality in Hariana and their crosses with exotic breeds. Mortality was highest in winter (55.5%) and lowest in autumn (8%). The highest mortality during winter might be due to the fact that newborn calves were easily affected by cold weather which was responsible for the incidence of pneumonia. Martin *et al*. (1975) [35] studied the calf mortality during winter (October through March) which was approximately 20% higher than other seasons. The months which had highest average calf mortality were December(31.5%), October (29.18%) and January (27.50%); however, the months of June, October and March showed a high increase in mortality rate relative to their respective three months moving average. The authors reported that the probable reason was that these months were "climatic change" periods when the temperature fluctuated widely. March was on the average a cool month with an increasing number of warm days, whereas October was the only month which, during the past 7 years had days with temperature in excess of 32 °C and nights below freezing. The lower critical temperature (the air temperature below which an animal must elevate its heat production) has shown to be +13 °C for a newborn calf and +8 °C for calves up to two months of age (Gonzalez- Jimenez and Blaxter, 1962; Holmes and McLean, 1975; Webster *et al*., 1978) [23, 28, 66]. Stull *et al*. (2008) [62] found an increase in death rates of calves for the high and low extremes of temperature in the Hanford, Merced, and Sacramento regions. The results showed that when the average daily temperature fell below 14 °C, mortality rates increased. Jain *et al.* (2008) [29] reported a mortality rate of 10% in cattle calves and 30% in buffalo calves in India and most of it was observed in winter.

Carolynn (1992) [15] detailed the Thermal Neutral Zone (TNZ) in calves and range was between 50 °F to 85 °F in still air. This optimal thermal environment promotes maximum performance and provides the least stress for calves. Within this Thermo Neutral Zone, the calf can maintain body temperature or homeothermy by constriction or dilation of blood vessels, changing postures of behavior, or by sweating and panting. As temperature falls below 50 °F, known as Lower Critical Temperature (LCT) the calf must direct food energy from production or growth to produce additional metabolic heat and maintain body temperature. This ultimately leads to a reduced feed efficiency. Cold stress also decreases the rate of absorption of colostrum in newborn calves. Azzam *et al*. (1993) [5] reported that climatic conditions affect neonatal survival and at low environmental temperatures mortality increases. During low ambient temperatures, at birth a calf loses great amounts of body heat due to the evaporation of amniotic fluids and exposure. Roenfeldt (1998) [56] reported that ambient temperatures preferred by dairy cows are between 5 ℃ and 25 ℃, the so-called "Thermoneutral" zone. They also suggested that energy requirements increased during winter or when animals are under cold stress to maintain body temperature by shivering or other thermogenic processes (Christopherson, 1985[18], Nonnecke *et al*., 2009) [43]. It was reported that an animal lying on a cool wet surface will have greater conductive heat transfer depending on the thermal conductance of the substrate as well as the temperature gradient and magnitude of the area of contact relative to the total surface area (Prasad *et al.,* 2013) [49].

Borderas *et al*. (2009) [14] installed the infrared heat lamps in calf pens in a naturally ventilated barn during winter and studied the temperature preferences of newborn dairy calves. The calves spent more time under the heat lamps than in other pen areas. The heat lamps were sought after by the older calves more often, indicating a better ability to thermoregulate by actively choosing warm places with increasing age.

Microclimate and its significance

It was found that the infrared lamp and the floor-heating panel presented a temperature of 32 °C and 28 °C respectively, when used as a source of heat (Mount, 1963, Perdomo *et al*., 1987) [46]. Another experiment conducted on regaining euthermia and reported that by placing calves in a warm water bath (38 °C) euthermia was faster and more efficient than by placing them in a warm box (20 to 25°C) with blankets or infrared heat lamps (Robinson and Young, 1988) [55]. Hover, infrared heating, and floor heating can be used to provide the proper thermal environment in the calves' sleeping area (Bodman *et al*., 1989) [13]. Infrared lamps can be used to provide a warm microclimate to calves (Roland *et al*., 2016) [57]. Bhat *et al*. (2015) [9] studied to determine the effect of Infrared lamps to ameliorate morbidity and mortality in Vrindavani calves and found that the infrared lamps are efficient in providing favourable microclimate and can be effectively used in calf shed to protect newborn calves from adverse conditions of winter.

Effect of lamps on body weight parameters

It was reported that during the first 3 days postpartum, supplemental heat is very advantageous, whereas the control group animals used more energy for homeothermy and possibly the average weight gain was significantly ($P < 0.01$) reduced (Adam *et al*., 1980, Beshada *et al*., 2006) [1, 7]. This might be due to heat lamps (175 W, infrared lamps) with heat sensors which maintain the temperature of animals thereby improving average daily gain. Reynolds *et al*. (1990) [53] and Chakrabarti (1991) [16] studied the effect of winter management systems on growth performance of female Murrah buffalo calves. Results revealed that buffalo calves raised in conventional barn during winter had better utilization of nutrients and growth and were in more comfortable condition as compared to the calves maintained under other management systems. Loy *et al*. (2000) [33] reported that the higher daily weight gain in calves provided with blankets than the calves with no such provisions during winter season. Similarly, higher ADG in buffalo calves was reported by (Collier *et al*., 2006) [19]. Nonnecke *et al.* (2009) [43] compared the performance of pre ruminant calves in a warm (average temperature 15 ℃, average relative humidity 59%) and a cold (average temperature 5 °C, average relative humidity 68%) environment. The calves and their surroundings in the cold environment were wetted to augment humidity and cold perception. Calves raised in the cold environment exhibited similar weight gains compared with the calves raised in the warm environment, but consumed more concentrates. Lopes *et al*. (2010) [32] reported that the final body weight of calves was higher at 10 week of age (70 days) exposed to 8hr of supplementary light (14.433kg) as compared with calves exposed to 4hr supplementary light

(9.666kg). The highest body weight at 10th week of age observed in the former animals demonstrates the efficiency of supplemental artificial light in stimulating concentrate consumption by calves during the milk-feeding stage; increased concentration consumption can result in early weaning, which is characterized by daily consumption of concentrate. Bhat *et al*. (2015) [11] found significantly (*P*< 0.01) higher body weight gain in Vrindavani calves provided with Infrared lamps as compared to calves with no such provision during the winter. The results revealed that the calves protected under Infrared lamps had significantly higher (*P*< 0.01) body weight gain of 31.24 ±.75 Kg as compared to 25.12 ± .76 Kg as presented in following Table 1:

Table 1: Study indicating the effect of lamps on calves body weight

Parameter	No heat source (G_1)	Infrared lamps (G_2)
Total body weight gain (Kg)	$25.12^A \pm 0.76$	$31.24^B \pm 0.75$
Average daily gain (g)	$398.70^A \pm 12.15$	$495.80^B \pm 11.9$

They concluded that the infrared lamps are efficient in providing favorable microclimate and hence can effectively be used in calf sheds to protect new born calves from adverse conditions of winter and to improve their body growth performance.

Effect of lamps on Body measurements

Playshtenko and Leonova (1977) [48] performed experiments to assess the effect of various artificial lighting regimens on physiological condition, growth and meat productivity of feedlot calves. Those reared under short artificial light duration (6 L: 18 D) demonstrated significantly higher daily weight gain. According to the authors, this could be due to the comfort and fewer sexual behaviour manifestations. Grewal *et al*. (1982) [24] revealed that the body measurement shows an increasing trend with the advancement of age and increases in body weight but the change also depends on the comfort and wellbeing of animals, which is directly affected by the microclimate inside the shed. However, the animals in the thermal comfort zone keep their physiological parameters in a normal range so their body energy can be used in increasing body measurements whereas cold-stressed animals divert their body energy to maintain homeothermy. Donald *et al*. (2005) [21] conducted that the calves in colder areas divert energy from growth to maintain body temperature. Weight is the primary measurement for production value in heifer calves due to the negative correlation of body weight and onset of puberty. Osborne, (2007) [44] studied the average increase in heart girth of the calves subjected to the greatest amount of supplementary lighting was 0.09m (*P*< 0.05) compared to that animals that had access to 12 hr of light. Heart girth was highly (r=0.79, *P*< 0.001) correlated with average daily weight gain, which in turn was related to dry matter intake. Rafiuddin *et al*. (2009) [52] studied the effect of group size on body measurements of buffalo calves in winter and revealed that average change (cm) in body length was 1.90, 2.51 and 2.85 cm, in body height 1.61, 1.88, and 2.08, also in heart girth was 2.46, 2.90 and 3.17 in different three groups having single, four and eight calves in each.

Effect of lamps on Physiological parameters and skin temperature

Riek and Lee (1948) [54] observed that an increase in RR is one of the first visible reactions when ruminants are exposed to an ambient temperature above the thermo-neutral zone and the respiration rate increases when environmental temperature increases (McDowell, 1958) [37]. The normal respiration rate is approximately 10-30 breaths/min (Hafez, 1968) [26] The significance of an increase in RR under heat stress is that it enables the animals to dissipate excess body heat by vaporizing more moisture in the expired air, which accounts for about 30% of total heat dissipation (McLean, 1963) [38]. It increases on exposure to high ambient temperature at 32- 38° C (Bianca, 1976) [12]. Similarly, the normal pulse rate of buffalo is 40-60 per minute, a rate which reflects primarily the homeostasis of circulation along with the general metabolic level (Habeeb *et al*., 1992). Petrov *et al*. (1979) [47] concluded that there is no significant difference in body temperature, respiration, and heart rate in calves during the winter season when kept in enclosures. The efficient thermoregulation capacity of calves stabilizes the physiological reaction in relation to energy. Webster (1984) [67] reported that normal body temperature of calves between 101.3 to 102.2 °F and any temperature over 103 °F is the indication of disease. However, respiration rate increased in calves during winter in general and particularly in evening. All the observation on respiration rate falls within the normal ranges in both the groups indicating no effect of infrared lamps on the respiration rate of animals. Thickett *et al*. (1988) [63] reported that normal body temperature of the calves to be 101.5-102.8 °F. Radcliffe and White (1972) [51] found that the body temperature of the scouring calf was significantly higher than other calves. Ashour (1993) [4] reported an increase in skin temperature of calves, when exposed to high ambient temperature. Sethi and King (1994) [58] reported that the ability of an animal to withstand the rigors of climatic stress under warm conditions had been assessed physiologically by the means of changes in body temperature, respiration rate and pulse rate. The ability of the neonates to maintain normal core body temperature is a function of its ability to produce enough heat to balance the loss of heat by evaporative and non evaporative heat losses. Prolonged periods of exposure below the cold lethal limit will obviously result in death (Himms-Hagen, l990) [27]. Mota (1997) [41] observed that the environmental temperature is closely associated with body temperature, for which reason rectal temperature is often used as the evaluation parameter of physiological adaptation to the environment. Any rise in rectal temperature shows that the mechanisms for maintaining homeostasis can no longer release sufficient heat from the organism. Ghaughan *et al*. (1999) [22] reported an increase in pulse rate of animals kept in open shade compared to close sheds during summer. Calves can acclimatize to cold temperatures by increasing respiration rate. Das *et al*. (1999) [20] have also reported circadian changes in the pulse rate of Murrah buffalo calves exposed to direct solar radiation during the summer season. Soly and Singh (2001) [61] reported higher RR during the afternoon hours than morning hours in crossbred calves in the summer season. Lynn (2001) [34] reported that the Lower Critical Temperature (LCT) is the temperature at which a calf must produce more heat to maintain its body temperature. For a fed calf the LCT is approximately 8-10 ℃. For a newborn calf the LCT is between 13 to 20 °C. Young calves have limited reserves of energy and these reserves are quickly depleted when temperature dips below the LCT. For example in a 40 kg (88 lb) newborn calf, energy reserves would be depleted in 18 h. Calves housed in open barns with chilling drafts have actually shivered to death losing as much as 10% of their body weight overnight. When calves that have died in this manner are examined they show signs of malnutrition because of their total lack of fat reserve called "starvation syndrome". Kumar and Singh (2002) [31] investigated the physiological parameters in crossbred female calves of HF (1/8 F x 7/8 H) breed from birth to 28 days of age reported that rectal temperature decreased from 102.5 to 103.5 °F from birth to 101.2±0.06 °F at 28 days of age. Respiration rate decreased from 46.5±0.62 per min at birth to 33.13±0.6 per min at 28 days of age. Pulse rate decreased from 108.67±1.83 per min at birth to 83.83±0.61 per min at 28 days of age. Al-Haidary (2004) [2] conducted that the changes in the RR are an adaptive response of the animal to maintain homoeothermic balance. In domestic animals, RR increases due to the activation of thermo-receptors in the skin when they are exposed to higher ambient temperature. Such activation of the receptors, in turn, sends neural signals to the hypothalamus that increases respiratory activity to accelerate heat loss from the body by respiratory evaporation. Maurya *et al*. (2007) [36] reported that the physiological responses were consistently higher in the lambs exposed to cold stress. The reason for this could be that the homoeothermic animals initially react to cold stress by enhancing the thermoregulatory mechanism, such as increase in RR and PR, to avoid undesirable increase in RT. Singh and Upadhyay (2009) [59] who observed higher respiration rate with an increase in ambient temperature and relative humidity. Vaidya *et al*. (2010) [65] reported that the higher RR and PR in growing and adult buffaloes during afternoon compared to forenoon due to exposure. Chandra Bhan *et al*. (2013) [17] reported the positive correlation between RT, humidity and other physiological responses in Murrah buffaloes and Karan-Fries cattle. Amaral *et al*. (2014) [3] reported that the physiologically dark periods activate melatonin secretion, this hormone is synthetic and secreted by pineal gland, whose neural control depends on light-dark cycle. Thus, melatonin influences the reduction of the digestive system motility and thyroid hormones. This physiological response reduces animal feed intake and metabolism (Mellado *et al*., 2014) [39]. Bhat *et al*. (2016) [8] conducted a study to learn about the effect of infrared lamps to ameliorate morbidity and mortality in Murrah calves. They concluded that the Infrared lamps were efficient in providing favorable microclimate in-terms of better physiology and hence can be effectively used in calf sheds to protect newborn calves from adverse conditions of winter.

Conclusion

Livestock being the backbone of rural India, they have to be saved from extreme winter. The future of any herd exclusively depends upon the successful levitation of the young ones. Healthy newborns are not only essential for the sustenance of any farm but also for preserving and maintaining good quality germplasm. Neonatal mortality is a serious problem, particularly during the initial months of their life and causes a severe economic loss to the farming community. To protect them from such adverse climatic conditions, better housing management is the primary requirement. Due to their low thermoregulatory capacity, their mortality rate goes high in winter due to cold stress. Under housing management, micro ambient temperature using heat sources is the key factor for animal health and welfare in winter as it reduces the cold stress on the animals caused due to adverse climatic conditions. Therefore, the study had been taken up to review the effect of different lamps as heat sources to ameliorate cold stress for young livestock in winter. The various studies listed above show that lamps play an important role in the healthy rearing of neonates. Various literature focused on the efficient use of infrared bulbs over incandescent bulbs in terms of better growth rate, improved physiological conditions and reduced stress profile with more cost effectiveness.

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