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# Physiological parameters of cattle and buffalo in different seasons under different housing modification systems – A review

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**ABSTRACT**

Shelter management is the manipulation of microclimate of the animals to suit best to their welfare reducing climatic stress without affecting much to cost of construction. House should be designed to meet the requirements health and comfort to the animals, convenience and comfort of the operator, efficiency of labour and materials handling and compliance with applicable health regulation. Problems related with the cost of housing,ventilations, scare resources, hygiene, manifestationof disease,behavioural concerns etc. Amelioration of these problems could be achieved by management intervention with respect to various components of housing and installation of cooling system to reduce heat. The major physiological changes involved in this acclimation and acclimatization while animals do acclimatize by gradually adapting to such stressors within their natural environment. During extreme weather condition open sides of shed can be covered temporarily with gunny bags, plastic sheet, bamboo mats, straw panels etc. Area-wise housing strategies for different kinds of the animals can be indentified and evaluated of new housing design to suit for different local condition based on locality available resources in this context could be explored. Also some modification in loose house can be very useful for example, in summer the thatch roofing succeeded in ameliorating heat stress but in winters, modification of floor with sand or rubber mat improved productive performance of dairy animals. Mist foggers, mist fogger with heavy duty dairy fans and ceiling fans are used to reduce thermal load during ambient temperature when body thermoregulation mechanism are not able to maintain normal physiological parameters.

**Key words:** Dairy animals, Housing modification, Management, Physiological parameters, Shelter management.

The animal housing should normally act as buffer from the extremes of climatic conditions to reduce peak stress on the animal housed. Housing system should create a microenvironment inside animal sheds, which may provide protection to the animals against stressful environment. In planning of housing shelter requirement for any region, the agro-climatic condition of the region and socio-economic condition of its people have to be kept in mind. At the same time it should be conducive to the expression of normal behaviour by the animals (Nagpaul and Kataktalware 2003). Effective housing management of dairy animals should be designed to meet the requirements for health, comfort, comfort of the operator, efficiency of labour, and materials handling.Productivity of animals can be improved by providing proper shelter. Small farmers and landless labours that keep one or two animals have limited income from them and therefore they do not provide shelter to their animals. They have tendency to tie the animals on roadside in sun and rain. Naturally available wooden materials, straw and tree leaves were utilize with bamboo tree or plastic sheet as a cheapest resources for sheds of animals (Gawali *et al.* 2005).Under shade, the buffaloes have a better cooling mechanism than the cows (Mullick and Kehar1951). The magnitude of changes in thermal load of buffaloes have been measured (Chaiyabutr 1993) however, information on changes in skin temperature by shower cooling and wallowing.

Badreldin and Ghany, (1954) reported that buffaloes have a lower level of respiration rate, body temperature and pulse rate than cattle and exhibit noticeable distress in summer. Cattle manifest physiological responses in the way of increased body temperature, heart and respiration rate, when they are kept in hot environment (Bianca, 1965). These responses have been used as a measure of dairy cow comfort and adaptability to an adverse environment or as sensitive physiological measure of environmental modification (Roman-Ponce *et al*., 1977).

During thermal stress, several physiological rearrangements occur in dairy animals as they attempt to facilitate heat dissipation and/or reduce metabolic heat production. The major physiological changes involved in this acclimation and acclimatization while animals do acclimatize by gradually adapting to such stressors within

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their natural environment (Willmer *et al*., 2000). Body temperature of dairy cattle shows great susceptibility to hot weather (Akari *et al*., 1984), therefore it is a sensitive indicator of thermal stress. Also, McDowell *et al*. (1976) suggested that the temperature humidity index (THI) could be used as an indicator of thermal climatic conditions.

Titto *et al*. (1996) explained that sprinkling young female buffaloes for 15 min caused a quick decrease in physiological parameters expressed as high reduction in rectal temperature and respiratory rate, Ablas *et al.* (2007) concluded that water for immersion or shade are essential benefits to buffaloes production in warm climates. This type of behaviour is more efficient than keeping in low temperature housing, although an artificial wallow becomes fouled by excreta unless the water is continually flowing (Cockrell, 1974). Dairy buffaloes maintained on shaded pastures, decreases in heart pulse frequency, respiratory rate and rectal temperature, under tropical conditions.The effect of shelter management practices on various physiological reactions is reviewed here.

**Rectal temperature:** Studies reported that the rectal temperature and skin temperature fluctuate much more in buffaloes than cattle under increased ambient temperature (Koga *et al*., 2004; Aggarwal and Singh, 2008; Singh *et al*., 2010).) Rectal temperature is good indicator of core body temperature (Omeran *et al.*, 2011). Sharma (1983) reported in Brown Swiss, the temperature did not show appreciable effect on physiological reaction whereas humidity affected pulse as well as respiration rates. Rise or fall 1°C of rectal temperature is enough to reduce performance in most of the livestock species (McDowell *et al*., 1976). Johnson (1972) reported that the rectal temperature rises above 21-26°C in Italics cattle and 32°C in zebu cattle are affected (younger cattle more affected than old ones), death may occur when rectal temperature of Italics cattle reaches 41.7°C (Vajrabukka, 1978).Lemerle and Goddard (1986) repeated that the rectal temperature only increased when THI was greater than 80, the respiration rate would begin to increase when THI = 73 and would probably increase steeply at THI=80. These findings suggested that homeostasis mechanisms, including increased respiration, can prevent a rise in rectal temperature until the THI reaches 80.Igono *et al.* (1986) reported that, morning and afternoon rectal temperature were higher for cows in shade than in shade plus spray with fan, but for both groups the p.m. rectal temperature were higher than a.m. rectal temperature in cows. Flamenbaum *et al. (*1986) found that the decrease in rectal temperature after wetting the animal by sprinkler for 30 sec was maximum compared to 10 sec and 20 sec. Also he stated that decrease in rectal temperature was maximum when duration of cooling was 45 min than 15 min and 30 min. Shalit *et al*. (1991) reported that rectal temperatures of lactating cows was $0.9^0$C higher than in pre-partum cows, although environmental conditions were similar. Their explanation was that lactating dairy cows appeared to be more thermo-labile than non-lactating ones because of a reduced capacity of lactating cows to stabilize their plasma volume and concentration within a narrow range. Koubkova *et al.* (2002) reported that the significant increase in rectal temperature from 37.3°C to 39.3°C, respiration rate from 28-81 counts per minute and pulse rate from 64-81 counts per minutes when high yielding Friesian cow were exposed to high ambient temperature conditions. Gupta *et al*. (2004) conducted experiment on fifteen buffalo heifers (13-18 month of age) under 3 housing conditions which (T1) loose house, (T2) loose house plus mud plaster roof and (T3) village type closed barn. The average respiration rates both in the morning and afternoon was affected ($P<0.05$) by housing management. The morning temperature was higher ($P<0.05$) in T3 than T1 group animals. However, no difference between T1 and T2 as well as T2 and T3 group was observed. The higher rectal temperature in barn housed than loose-housed buffalo heifers was reported during winters. Gudev *et al*. (2007) founded that rectal temperature (RT) values were significantly higher at 3 p.m. during the exposure to direct solar radiation compared to the RT values measured in the barn in cows. It shows that the animals were not able to maintain rectal temperature within thermo neutral zone in spite of the increased respiration rate and air velocity at that time. Aggarwal and Singh (2008) reported that in the morning, both groups had similar rectal temperatures, but in the evening the wallowing group was significantly ($P<0.01$) cooler than the showering group. The morning rectal temperature in showering group and wallowing group were 38.5±0.1p C and 38.6±0.1p C and in the eveningrectal temperature in showering group and wallowing group were 38.4±0.1p C and 38.0±0.1p C respectively. Perissinotto *et al.* (2007) reported that the body temperature is determined by the balance between loss and gain of heat, and its value is obtained bymeasuring the rectal temperature, ranging from 38 to 39.3°C for dairy cattle. It is often used as an index of physiological adaptation to a hot environment, once its increase indicates that the mechanisms of heat release became insufficient to maintain homeothermy. El-Kaschab *et al.* (2009) reported that rectal temperature was significantly higher ($P<0.01$) on straw bedding than sand, newspaper and hard surface ($37.89^0$C vs. $37.83^0$C, $37.80^0$C and 37.83 $^0$C respectively), while an intermediate value was recorded for buffalo cows kept on sawdust (37.84 $^0$C). Aggrawal and Singh (2010) observe that the rectal temperature during hot-dry season and hot-humid in the morning were not significantly different in showering (101.4+0.1 vs. $101.3+0.1^0$F) and wallowing (101.3+0.1 vs. $101.2+0.1^0$F) groups of buffaloes. However, in the evening, the decline in rectal temperature was greater in the wallowing group ($100.5+0.1$ vs. $100.7+0.1^0$F) of buffaloes as compare to shower group ($101.2+0.1$ vs. $102.3+0.1^0$F) thereby indicating

more relief from heat stress in wallowing buffaloes. Chikamune (1986) also reported that wallowing was more efficient in lowering body temperature and respiration rate of buffaloes than water shower or shading.

Marai and Habeeb (2010) explained that sprinkling on female buffaloes for 15 minutes because quick decrease in physiological parameters expressed as high reduction in rectal temperature and respiratory rate.When exposed to high ambient temperatures dairy cows were found to show increased body surface temperature (Martello *et al.,* 2009), respiratory frequency and rectal temperature (Avendano-Reyes *et al.,* 2011). Khongdee *et al*. (2013) reported that the rectal temperature of the buffaloes maintained under the NR shed (Normal shed) (RTNR; 40.00±0.10°C) was significantly (P<0.01) higher than the rectal temperature of the buffaloes maintained under the MR shed (Modified shed) (RTMR; 39.14±0.07°C). Joshi and Kamboj (2014) reported that in winter, rectal temperature in control and treatment group of animals was 38.29±0.04$^0$C (100.92$^0$F) and 38.00±0.05$^0$C (100.40$^0$F) respectively. Kumar *et al.* (2017) also reported that the rectal temperature of Murrah Buffaloes , during autumn and winter season the mean were significantly (P<0.05) lower in buffaloes housed under modified shed as compared to existing shed.But in the hot-dry summer rectal temperature in the control group was founded to be 38.67±0.09$^0$C (101.60$^0$F) and for treatment group it was 38.48±0.07$^0$C (101.27$^0$F). The rectal temperature of control group of animals was significantly higher (P<0.05) from treatment group of animals. It was that in the winters rectal temperature was lower in both groups compared to the corresponding values of hot dry season. This may be due to the fact that the rectal temperature is in positive correlation with the ambient temperature of the shed, as the environmental temperature rises rectal temperature also raises. Rectal temperature is also very sensitive parameter and as rise of 1ºC or less in rectal temperature is enough to reduce the performance in the livestock species (Mc Dowell *et al.;* 1976), which makes body temperature a sensitive indicator of physiological response to stress in a cow because it is nearly constant under normal conditions.During hot-humid season, the overall means of rectal temperature of cows housed under modified shed and existing shed were 101.00±0.15ºF (38.33ºC) and 101.36± 0.19ºF (38.53ºC), respectively and in autumn season, were 100.49±0.08ºF (38.05ºC) and 100.74±0.10ºF (38.19ºC), respectively by Sinha and Kamboj (2015). The mean rectal temperature was significantly lower in cows housed under modified shed as compared to existing shed during autumn season.

Seerapu et *al.* (2015) observed significantly (p<0.001) lower mean rectal temperature (°F) of the Murrah buffaloes in (foggers) group II, (fans) group III and (foggers + fans) group IV (101.6±0.02, 102.1±0.06 and 101.5±0.02°Crespectively) as compared to (control) group I (102.5±0.06°C) under different shelter management practices.This might be due to decrease in heat stress due to cooling effect caused by provision of foggers, fans, foggers and fans for the Groups II, III, and IV, respectively.Yadav *et al.* (2016) observed that rectal temperature was significantly (P<0.05) lower in misting (38.41$^0$C) and wallowing group (38.57$^0$ C) as compared to control group (38.81$^0$ C) in lactating Murrah buffaloes.

**Skin temperature:** Skin temperature of the animals increased when the intensity of solar radiation increased (Das *et al*., 1997). It is highly correlated with rectal temperature, unlike physiological reactions, blood parameters were found relatively unaffected by the conditions of shelter. Zähner *et al.* (2004) found that the skin temperature during night time (29·0±2·9ºC) was significantly (P<0.01) lower than during day time (29·8±3·2ºC). During the day as well as during the night the skin temperature decreased significantly (P < 0·001) with a decreasing THI. The significant interaction between THI and farm (night: P < 0·001; day: P < 0·05) indicates that this difference in skin temperature was affected by the different climatic conditions on the farms. Alam *et al.* (2011) observed that no difference in skin temperature and rectal temperature but respiration rate were increased with increase ambient temperature. These physiological adjustment are essential to maintain normal body temperature and to prevent hyperthermia (Al-Haidary, 2000). Ragab *et al.* (1953) reported that sprinkling adult females for 2 h showed an average fall of 0.9 °C in body temperature. Aggarwal and Singh (2008) observed that in the morning, both groups had similar skin temperature but in the evening the wallowing group was significantly (P<0.01) cooler than the showering group. The morning skin temperature at trunk region was 35.7°C and declined by 1.8°C in the evening in showering group (33.8±0.1). But, skin temperature declined by 2.3 times more in wallowing (31.4±0.1) than in shower group buffaloes. Further, decline in skin temperature at head region was 1.9 times higher in wallowing group. In showering group, udder skin temperature was 35.4°C in the morning and decreased by 1.3°C in comparison to 2.9°C (P<0.01) during evening in wallowing group. Furthermore, skin temperature of subcutaneous abdominal vein decreased by 1.4°C in showering group and 2.3°C in wallowing group during evening. Average morning skin temperature in neck region was 37.1 and 36.7°C in showering group and wallowing group buffaloes and significantly (P<0.05) declined to 35.3 and 33.8°C in evening. Skin temperature measured at all the sites were significantly lower (P<0.01) in wallowing buffaloes than the shower group. Further, skin temperature of neck, head, udder and udder vein varied (P<0.01) in showering and wallowing buffaloes during periods of study. El-Kaschab *et al.* (2009) reported that body temperature of buffaloes was significantly affected (P<0.01) by different

lying surfaces. The highest body temperatures were recorded with buffalo cows kept on sawdust and straw followed by hard surface and sand (34.42, 34.37, 34.19 and 33.76 $^0$C respectively). The lowest body temperature was recorded with buffalo cows kept on newspaper bed (33.41 $^0$C). Ambulkar *et al.* (2011) reported that Murrah buffaloes maintained under the high pressure fogger showed significantly ($P < 0.01$) lower body temperature (37.52°C) than the buffaloes maintained without any cooling system (37.83°C). The HPFF had reduced the body temperature significantly by 0.31°C; this suggested that the high pressure fogger system was helpful in thermoregulation. Kumar *et al.* (2017) reported that the skin temperature during autumn season was significantly ($P<0.05$) lower in buffaloes housed under modified shed as compared to existing shed, but no significantly during winter season. Joshi and Kamboj (2014) observed that in the winter mean skin temperature in control group (30.70±0.26°C) was significantly higher ($P<0.05$) than treatment group of animals (30.03±0.23°C) but in the dry-hot summer rectal temperature in control group (34.83±0.52°C) and treatment group of animals (34.58±0.47°C) was differ significantly. The overall means of skin temperature during hot-humid season of cows housed under modified shed and existing shed were 94.84±0.86ºF (34.91ºC) and 95.15±0.98ºF (35.08ºC), respectively and in autumn season, were 89.44±0.36ºF (31.91ºC) and 90.52±0.42ºF (32.51ºC) differs significantly by Sinha and Kamboj (2015). The means of skin temperature was significantly lower in cows housed under modified shed as compared to existing shed during autumn season.

**Respiration rate:** An increase in respiration rate is one of the first visible reactions when ruminants are exposed to ambient temperature above the thermo neutral zone. The responses to ambient temperature of dairy heifers and dairy cows were similar, such that there was a rapid increase in respiration rate in the first hour exposure to high ambient temperature and would maintain, thereafter while rectal temperature would be increased gradually to a certain level (Allen *et al.,*1974). Normal respiration rate is approximately 10-30 breaths/min (Hafez, 1968) and the respiration rate increases when environmental temperature increases (McDowell, 1972; Singh and Bhattacharya, 1991). Johnston *et al*. (1959) reported increases from 20 breaths/min under cool conditions to 100 breaths or more per minute at 32$^0$C and above.It rises above 50–60 breaths /min when ambient temperatures higher than 25$^{0C}$ in high-producing dairy cows in a subtropical environment (Berman *et al*., 1985).The critical respiration rate before the onset of panting for cattle is around 80 breaths/min (Robertshaw, 1985, Kabunga, 1992). Exposure of lactating buffaloes to direct solar radiation (THI-77.83) caused significant elevation of respiration rate (RR) and rectal temperature showing that heat load was greater than the body capacity to dissipate the heat (Gudev *et al*., 2007; Agarwal and Singh, 2006). Klein and Weiniger (1986) conducted an experiment on German Black Pied cows (n=58) which were housed at 28$^0$C and 50% RH or at 18$^0$C and 70-80% RH (controls) during their first lactation. Respiration rates and body temperature were higher in heat stressed than in controls cows. The correlation of daily milk yields with respiration rate, pulse rate, body temperature and sweating rate were 0.09, 0.35, 0.04 and 0.06 respectively. Ferreira *et al* (2006) reported that the normal measurements of respiration rate (RR) in adult cattle vary from 24 to 36 breaths per minute (breaths/min) but may have a greater range, between 12 and 36 breaths/min. Under heat stress, the respiration rate rises first than rectal temperature. Mist cooling of Holstein cows in hot summer reduced body temperature by 0.9 to 1$^0$C and respiration rates by 22 to 25 counts per min (Ali *et al*. 1988). Similarly, Taylor *et al*. (1988) found that evaporative cooling reduces respiration rate and body temperature compared to shed (75 Vs 87.4/ min, 38.9 Vs 39.1$^0$C). In Holstein Friesian cow rectal temperature and respiration rates of cows under heat stress was higher than cows maintained under air-conditioning (Wise *et.al*. 1988). Aggarwal and Singh (2008) reported that the morning respiration rate non-significantly varied in both group however, in the evening the respiration rate was more ($P<0.01$) in showering group in comparison to wallowing group. The morning respiration rate in showering group and wallowing group were 24.1±0.4 counts/min. and 23.3±0.2 counts/min. and in the evening respiration rate in showering group and wallowing group were 21.2±0.2 counts/min. and 16.3±0.2 counts/min. respectively. Ambulkar *et al.* (2011) reported that the average respiration rate in the Murrah buffaloes maintained under the high pressure fogger was 21.61 counts/minute, which was significantly ($P < 0.01$) lower than that of the buffaloes maintained without any cooling devices (23.01 counts/minute). Kumar *et al.* (2017) reported that the respiration rate during autumn ($P<0.01$) and winter season were significantly ($P<0.05$) lower in buffaloes housed under modified shed as compared to existing shed. Joshi and Kamboj (2014) reported that in winter respiration rate in control and treatment group of animals was 24.66±0.60 counts/minute and 22.74±0.74 counts/minute respectively. But in the hot-dry summer respiration rate in the control group was founded to be 53.81±3.52 counts/minute and for treatment groups it was 40.39±0.47 counts/minute. The respiration rate during hot-humid season for cows housed under modified shed and existing shed were 36.88±1.89 and 43.75±1.85 counts per minute, respectively and in autumn season, were 23.15±0.86 and 25.82±1.07 counts per minute, respectively by Sinha and Kamboj (2015). Seerapu*et al.* (2015) observed significantly ($p<0.001$) lower mean respiration rate (°F) of the Murrah buffaloes in (foggers) group II, (fans) group III and (foggers + fans) group IV (22.15±0.26, 28.32±0.58 and 22.50±0.23 counts/minute respectively) as compared to

(control) group I (37.81±0.37 counts/minute) under different shelter management practices. Yadav*et al.* (2016) observed that respiration rate was significantly (P<0.05) lower in misting (31.67 counts/min.) and wallowing group (32.39 counts/min.) as compared to control group (36.61 counts/min.) in lactating Murrah buffaloes.

**Pulse rate:** Pulse rate of heat stressed cows are inconsistent (Herz and Steinhauf, 1978). The normal pulse rate of cows is 60-70 breaths/min (Hafez, 1968), a rate which reflects primarily the homeostasis of circulation along with the general metabolic level (Bianca, 1965; Habeeb *et al.,* 1992). It increases on exposure to high ambient temperature at 32-38° C (Mullick and Kehar, 1959; Bianca, 1965), and associated changes in capillary flow cause an increase in blood flow from core to surface and thus allow more heat to be lost by sensible (conduction, convection and radiation) and insensible (evaporative) ways. Singh and Bhattacharyya (1990) concluded that the pulse rate of livestock was very variable at different test temperatures and among different genetic groups. Newer data indicate that heat stress can cause either dilution, concentration, or have no effect on blood plasma volume and the effect of heat stress on blood volume affects steroid hormone concentrations in blood (Johnson *et al*., 1991; Elvinger *et al*., 1992).

Aggarwal and Singh (2008) observed that pulse rate is a stress indicator which can be altered with thermal stress. The morning pulse rate non-significantly varied in both group however, in the evening respiration rate was more (P<0.01) in showering group in comparison to wallowing group. The morning pulse rate in showering group and wallowing group were 56.3±0.3 counts/min. and 56.0±0.2 counts/min. but in the evening pulse rate in showering group and wallowing group were 53.8±0.2 counts/min. and 46.0±0.3 counts/min. respectively. Kumar *et al.* (2017) reported that the pulse rate during autumn and winter season were significantly (P<0.01)lower in buffaloes housed under modified shed as compared to existing shed. Joshi and Kamboj (2014) observed that in winter pulse rate in treatment 76.86±0.90 counts/minute group of animals was significantly higher (P<0.05) than control 72.99±0.19 counts/minute. In hot-humid season, the overall mean values of pulse rate the cows housed under modified shed and existing shed were 75.09±1.28 and 80.21±1.43 counts per min and in autumn season, were 72.62±0.85 and 77.05±1.38 counts per minutes, respectively by Sinha and Kamboj (2015). The mean values of pulse rate ware significantly lower in cows housed under modified shed as compared to existing shed in both season. Seerapu *et al.* (2015) observed significantly (p<0.001) lower mean pulse rate (°F) of the Murrah buffaloes in (foggers) group II, (fans) group III and (foggers + fans) group IV (51.39±0.32, 57.12±0.40 and 52.00±0.26 counts/minute respectively) as compared to (control) group I (67.86±0.41counts/minute) under different shelter management practices. Yadav *et al.* (2016) observed that pulse rate was significantly (P<0.05) lower in misting (49.06 counts/min.) and wallowing group (50.61 counts/min.) as compared to control group (58.56 counts/min.) in lactating Murrah buffaloes.

## CONCLUSION

Stress is a major economic issue in the dairy industry. Its effects reach beyond milk production into reproduction, health, and welfare through physiological and behavioural changes. Housing modifications of dairy animals are linked to overall physiological parameters and production performance. Cooling mechanism is useful to maintain normal physiological parameters during thermal load conditions.

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