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Effect of heat stress on production and reproduction performance of buffaloes-A review

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Abstract
Heat stress is a major problem causing economic losses to the dairy farmers. It causes hyperthermia and at its most severe form can lead to death. More commonly, heat stress reduces feed intake, milk yield, milk constituents, growth rate and reproductive function in livestock.It has a direct effect on breeding efficiency of female buffalo and reduces the intensity and duration of oestrus. Buffaloes fails to exhibit oestrus as a result of ovarian inactivity during summer. High environmental temperature causes hyper prolactinaemia, suppressing the secretion of gonadotrophins, which leads to an alteration in ovarian steroidogenesis. Heat stress also affects folliculogenesis, oocyte quality, Lactation length, calving interval, milk constituents and milk yield. Advances in management (i.e.,Cooling systems) have alleviated some of the negative impact of heat stress on buffaloes. In this review an attempt has been made to know the effect of heat stress and to discuss their impact on buffaloes.

Keywords: heat stress, buffaloes, milk yield, and reproduction performance.

Introduction
Buffalo (Bubalus bubalis) is produces milk, meat and utilized as source of power, fuel and leather production and known as the world's second most important mulch animal because it shares more than 95% of the milk produced in South Asia (Javaid *et al*., 2009) [24]. The Buffalo population in India is 108.7 million and contributes around 21.23% of the total livestock population in India. India is a tropical country with hot and humid summer and relatively less stressful winter season. During summer (May-June), the atmospheric temperature goes as high as 45° C during day time and 30°C during night and photoperiod extends up to 12-14 hours. Environmental temperature at which an animal's body is at equilibrium i.e., neither gain or lose heat is called Thermo Neutral Zone (TNZ). Heat stress is temperature related stress, which induces thermoregulatory changes. During the extreme hot humid or hot dry weather, this thermoregulatory capability of buffalo to dissipate heat by sweating and panting is compromised and heat stress occurs.

Buffaloes are more vulnerable to heat stress at high ambient temperature due to less number of sweat glands and black coat color leading to loss in their productive efficiency (Upadhyay *et al*., 2008) [49]. Exposure of buffaloes to the hot conditions causes a series of changes in the biological functions that include decrease in feed intake, efficiency and utilization, disturbances in metabolism of water, protein, energy and mineral balances, enzymatic reactions, hormonal secretions and blood metabolites. Such changes result in impairment of reproduction and productive performances (Das *et al.*, 2014) [14].

1. Effect of Heat Stress on Dry Matter Intake
Heat stress inhibits the lateral appetite center present in hypothalamus and thus reduced dietary intake and consequently lower milk production. And also increasing environmental temperature and rising rectal temperature above critical thresholds are related to decrease in the dry matter intake. (Albright and Alliston., 1972) [4].Buffaloes have been shown to voluntarily reduce intake by 9–13% in hot conditions and also factors reducing feed intake include panting, which reduces cud chewing, slows the breakdown of feed and reduces the amount of water and buffers from saliva reaching the rumen. (Savsani *et al*., 2015) [40].

Reduction in dry matter intake is the most important effect of heat stress in tropical and sub-tropical conditions (Marai and Habeeb 2010) [34]. Korde *et al*. (2006) [29] concluded that concentrate intake during cool hours change in buffalo calves; whereas, wheat straw intake decreased significantly by 29.65% and 30.09% during hot-dry and hot-humid exposures, respectively. Singh *et al*. (2008) [43] reported that decrease in feed intake in heat exposed group of Karan Fries calves compared to protected group of animals during hot dry and hot humid conditions.

Verma *et al.* (2000) [52] study shows that digestibility coefficient values for each of dry matter and crude protein were significantly lower in summer (43.0 and 50.50 ± 0.7, respectively) than in winter (68.31 and 66.83±0.05, respectively).

2. Effect of Heat Stress on Milk Production

Bouraoui *et al.* (2002) (11) found that daily THI was negatively correlated to milk yield. Increase of THI value from 68 to 78 decrease milk production by 21% and DMI by 9.6%. Milk yield decreased by 0.41 kg per cow per day for each point increase in the THI values above 69 (Aggarwal 2006) [5]. Upadhyay *et al*. (2009) [50] reported that the annual loss in milk production due to combined thermal stress and global warming on cattle and buffalo in 2020 are likely to about 3.4 million tones costing more than Rs.5000 crores in India.

Zheng *et al*. (2009) [55] observed that heat stress significantly reduces the production of milk, the percentage of milk fat and percentage of proteins but it has no effect on the content of lactose in milk.

Temperature Humidity Index (THI) increases from 59.82 in the winter season to78.53 in the summer season, heat stress reduced total (305 days) and daily milk yield by 39.00, 31.40 and 29.84%, respectively. Heat stress also leads to decrease in lactation period by 35 days and the fat, protein, lactose, SNF, total solids and ash by 7.92, 4.06, 3.97, 4.03, 5.21 and 5.63%, respectively when compared with that of winter season in HF cows (Gaafar *et al*.2011) [[18]. Aggarwal and Singh (2006) [5] studied the effect of water cooling on physiological responses, milk yield and composition of Murrah buffaloes during hot-humid season and concluded that control group buffaloes show lower milk fat, protein and SNF content due to heat stress.

2.1 Milk yield and constituents

Lactation length and dry period are affected significantly by season of birth in Egyptian buffaloes (Marai *et al*. 2009) [34] the shortest lactation length was reported in summer and the longest in spring (Mohamed, 2000) [36]. Lower milk yield was recorded during summer than spring and winter in buffalo and decline in milk yield as a direct result of high environmental temperature. (Marai *et al*., 2009) [34]. At 30 °C, the high producing animals showed a mean reduction of 2.0 kg / day compared to a reduction of only 0.65 kg / day for the low producing animals (Vanjonack and Johnson, 1975) [53]. It was reported that in lactating Holstein cows transferred from an air temperature of 18 to 30° C, milk fat, solids-not-fat, and milk protein percentages decreased with 39.7, 18.9 and 16.9%, respectively, (McDowell *et al*., 1976) [35].

3. Effect of Heat Stress on Reproduction Performance

Buffaloes are seasonal breeders. They are polyoestral animals and are able to breed the whole year (Ståhl-Högberg and Lind, 2003) (47). Buffaloes have poor reproduction efficiency attributed mainly to poor expression of estrus symptoms especially during hot summer months and due to long calving interval. THI play an important role in the reproductive functions of buffaloes and suggested that THI >75 has a negative effect on reproductive performances of buffaloes in the tropical areas (Vale, 2007) [51]. Bachalaus *et al*. (1979) [7] reported that high ambient temperature shortens the duration of estrus and symptoms of estrus expression. Plasma Progesterone level and its cyclic variations influence the estrus expression that occur mainly due to cyclic changes in corpus luteum. Rao and Pandey (1982) revealed that the circulating levels of progesterone, estradiol and luteinizing hormone in buffaloes were low in hot months and responsible for poor expression of estrus and low conception in buffaloes. Bhat *et al.* (1983) [10] observed that buffalo cows continue to come in heat regularly in all months, the highest incidence being after a period of wet season feeding. Sastry (1983) reported that buffaloes that calved during the cool season have better reproductive performance than calving during the hot season. The marked seasonality of buffalo breeding handicaps the commercial milk production, which alternate between surplus and shortage. Buffaloes may have silent estrus even in no stressful periods of the year. Shah (1990) [41] reported that the prolonged calving intervals in Nilli-Ravi buffalo and concluded that domestic buffaloes have a tendency to showing a suspension of sexual activity during summer in almost all parts of the world.

Buffaloes exhibited the signs of estrus in the early morning (3.00 to 9.00 h) and in the evening (15.00 to 21.00 h) with a peak in early morning (about 37 %), while the lower percentage was at noon (about 12 % of estrous cases started during the period from 9.00 to 15.00 h.(16) Buffaloes under heat stressed having increased blood flow in the proximity of the superficial vessels in detriment of the deep vessels whereas such change in the deep circulatory flow affect the circulation and nutritive supply at the uterus and ovaries level causing an impairment in its normal physiology [20]. El-Wishy (2006) [17] concluded that successful breeding must take place within 85 – 115 days after parturition to maintain a calving interval of 13 – 14 months in buffaloes. Garcia(2007) [19] reported that the impact of the heat stress on the female buffaloes can be observed on the sexual behavior with less estrous cycle identification, low conception rate, high embryonic dead rates and reduction in the reproductive efficiency.

Madan and Prakash (2007) [33] stated that reproductive efficiency of buffaloes has been observed to greatly influence by temperature. Estrus expression and intensity of heat in buffaloes is weak during summer as compared to winter with a diurnal pattern.

Buffaloes are sexually activated by decreased day length and temperature. The highest breeding frequency in buffaloes is found during the winter and the lowest in the summer season (56). Maximum percentage of Buffaloes exhibited postpartum estrous during the month of September followed by October and minimum during April and May due to high maximum air temperature [2]. Murrah buffaloes having the highest average conception rate i.e., 78% in the month of October while the lowest was 59% in the month of August. The threshold THI for conception rate was identified as 75 for the reason that with increase in average THI above threshold 75, the decline in overall conception rate was observed [13].

The incidence of anestrus in buffaloes varies between 20-80 %, depending on season. Most female buffaloes which exposed to extreme hot conditions during the summer season cease ovarian activity. During this time the milk production and reproductive efficiency are negatively affected, probably due to the combined effects of nutrition, environment and management as reported by Sastry, 1983.

Heat stress results in a significant reduction in conception rate during the hot and humid-hot months when the monthly average THI is higher than 75 in buffaloes. Badr (1993) [8] reported that incidence of the silent heat was higher in buffaloes calving during the hot season (35.7 %) than in those calving in the mild season (27.3 %).

3.1 Silent estrus

Silent estrus is a important limiting factor especially during hot months which leads to poor reproductive efficiency in buffaloes (44). It is clinically characterized by failure of overt symptoms of estrus, though the animal is normal. Under these conditions, follicular development and ovulation occurs normally in animals without the manifestation of overt signs of estrus.. Progesterone secreted from regressing CL of previous cycle potentiates the action of estrogen and seems to favors the manifestation of estrus in next cycle Thus, lack of progesterone priming results in sub–estrus. Such conditions have been frequently reported in dairy buffaloes especially in summer months [44]. The concentration of estrogen determines intensity of behavioral signs of estrus which is low in high yielding dairy cow (31). And Lower concentration of estrogen may be either due to higher metabolism and clearance with a high metabolic load or sub–optimal follicular growth (Awasthi *et al.,* 2007) [6].

Showers or foggers with fans or wallowing tanks should be made available to buffalo during the hottest part of the day. Thermal ameliorative measures such as sprinkling and cooling are known to increase comfort levels and feed intake in buffalo (Thomas *et al.,* 2005).

3.2 Oocyte

Wolfenson *et al*. (2000) (54) observed that the higher ambient temperature during the summer has been associated with reduced fertility in dairy cattle through its deleterious impact on oocyte maturation and early embryo development.

Heat stress delays follicle selection and reduces the degree of dominance of the dominant follicle and decreases blood progesterone concentration, which is a major cause for abnormal oocyte maturation, implantation failure and finally early embryonic death in dairy cattle. (Khodaei-Motlagh *et al*. 2011)(28). Heat **stress** reduces the synthesis of pre ovulatory surge, luteinizing hormone and estradiol leads to poor follicle maturation and this leads to ovarian inactivity in cattle (Hansen *et al*. 2007) [21]. Madan and Prakash (2007) [33] observed reproductive efficiency of buffaloes greatly influenced by temperature. Estrus expression and intensity of heat in buffaloes is weak during summer as compared to winter.

3.3 Service period

Service period of Murrah buffaloes was prolonged (180 days) in the month May with the corresponding THI value of 80.27. On the contrary, the lowest average service period (119 days) was observed at average THI 67.80 in the month of March. -(Das *et al*. 2016) [15]. Service period of buffaloes was found increased with increase in average THI above 75 and he also stated that the cooler months with lower THI values caused decrease in service period while the months with higher THI values above threshold level 75 were associated with increase in service period in Murrah buffaloes (Dash, 2013) [13]. A substantial decline in pregnancy rate was observed from 34.1% to 15.7% with increase in mean THI from 69 in May to 74 in July in a subtropical climate. (El-Wishy, 2013) [17].The significant ($p<0.05$) reduction in a pregnancy rate of crossbred dairy cattle due to heat stress was also evident in India. When the dairy cattle was in Thermo Neutral Zone (TNZ), the pregnancy rate of was estimated as 32.6%, but it was significantly decreased to 20.5% when the animals came into heat stress (Khan *et al.,* 2013) [27].In summer, risks for ovulatory failure, impaired oocyte quality or embryonic development, reduced progesterone production and increased embryo mortality may be the possible reasons for dramatic decline in fertility in animals (Wolfenson *et al.,* 2000) [54].

3.4 Estrous Cycle

The average length of estrous cycle has been reported to be 21 days in the riverine type. Several factors such as climate, temperature, photoperiod and nutrition have shown to affect the length of estrous cycle and degree of heat expression. Average length of the estrous cycle is 20–22 days for river buffaloes; however, great variations have been observed under rural conditions (Madan, 1988) [32]. The average duration of estrous appears to be slightly longer in river buffalo 23.8 ± 6.2 h than in swamp buffalo 19.9 ± 4.4 h (Shimizu, 1987) [42]. Janakiraman, (1978) [23] reported that the duration of estrous was estimated to be 14, 18 and 8–10 h in the monsoon, winter and summer seasons respectively, in river buffaloes.

Heat stress can depress the reproductive performance of dairy cows including by decreasing intensity of estrous, reducing the pre ovulatory LH surge and decreasing secretion of luteal progesterone (Howell *et al*. 1994) [22]. Buffaloes are able to show more estrus activity in the morning (06:00–07:30 hour) than in the afternoon (14:00– 15:30 hour) or during the night (22:00–23:30 hour). (Srivastava and Sahni, 2003) [46].

4. Housing management

Microclimate alteration devices like ceiling fans, sprinklers, ceiling fans combining with sprinklers, cooling ponds are good management tools, which modify the microenvironment to enhance heat dissipation mechanism to relieve heat stress. Scientifically, constructed Sheds provide comfortable environment to animals. Provide Shade is one of the cheapest ways to modify an animal's environment during hot weather. (Kimothi and Ghosh, 2005) [26].

Sandeep reddy *et al.* (2016a) [38] studied on micro climate change and concluded that fans sprinklers foggers are effective in reduce heat stress and increase in reproductive and productive performance. Jegoda *et al.* (2015) [25] reported that Mehsana buffaloes provided with foggers shows increased weekly mean feed intake (kg/animal/day) on dry matter basis of experimental group is 12.66 kg/buffalo/day than control group of buffaloes (11.95 kg/buffalo/day) was significant ($P<0.01$). Singh *et al*. (2014) [45] conducted experiment on Murrah buffalo heifers and experiment group kept under fan cum mist system, control group under normal ambient conditions and reported that Dry Matter Intake (DMI) of experimental group heifers increased by 0.5 kg amounting to 6.3 kg /day where control group heifers were 5.8 kg/day. Singh *et al*. (2008) [43] reported that decrease in feed intake in heat exposed group of Karan Fries calves compared to protected group of animals during hot dry and hot humid conditions.

Aggarwal and Singh (2006) [5] conducted research on Murrah buffaloes and observed that feed intake increased by 13.24% in wallowing group as compared to showers group.

Conclusion

Heat stress is a great concern among livestock owners in tropical countries. It negatively impact the production and reprodutive performances of buffaloes. In hot-humid climates, although buffalo attempts to acclimatize through physiological changes including cutting down on feed intake and heat production, but this does not come without sacrificing part of its productivity finally resulting decrease in performance. There are a number of management and housing alterations that can be made to decrease the impact of heat stress. Shelter management with microclimate alteration devices like foggers, fans sprinklers can be available at a relatively low cost and helpful for reducing the heat stress. They are helpful in reducing heat stress, increased DMI resulting in increase in milk yield and reproduction performance.

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