Research article **Available online www.ijsrr.org** **ISSN: 2279–0543**

International Journal of Scientific Research and Reviews

Detrimental Effects of Heat Stress on Reproduction in Buffaloes

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ABSTRACT

India ranks first in milk production with 165.4 million tonnes in which major contribution is from buffaloes. They are efficient converters of poor quality roughages into milk and meat. In spite of its merits, buffaloes easily succumb to heat stress and results in production and reproduction impairment. A negative correlation exists between Temperature Humidity Index (THI) and fertility of buffaloes. The conception rate in buffalo was low if THI is > 75. A significant ($p \leq 0.05$) decline in the first service pregnancy rate was also observed. Estrus behaviour, oocyte quality, embryo quality was affected with elevated temperature. Heat stress decreases blood progesterone concentration that results in abnormal oocyte maturation, implantation failure and early embryonic death. Neuroendocrine mechanism that control gonadotropin secretion is more sensitive to heat stress. Mitigation measures to combat heat stress in buffaloes are by nutritional and environmental management along with timed artificial insemination protocol. As Indian buffaloes contribute significantly to milk and meat production it is highly essential to conserve this superior germplasm from adverse climatic conditions.

KEYWORDS : heat stress, buffalo, reproduction, fertility

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1. INTRODUCTION

Global temperature rise is an important concern for dairy farmers across the world as it causes impediment to production and reproduction in livestock. Currently, India ranks first in milk production with 165.4 million tonnes, in which, buffalo contributes significantly. The buffalo population in India is 108.7 million and contributes around 21.23% of the total livestock population in India[1]. Of all the domestic animals, the Asian water buffalo holds greatest promise and potential for production. Buffalo is a triple purpose animal as it serves with milk, meat and draught. Buffalo can efficiently utilize the roughages and crop by-products into high quality milk. India has largest buffalo population and buffalo germplasm diversity. In spite of its merits this animals succumbs easily to heat stress that results in production and reproduction failure [2].

2. HEAT STRESS IN ANIMALS

Environmental factors such as ambient temperature, solar radiation and humidity have direct and indirect effects on animals [3-5]. Heat stress occurs in animals when there is an imbalance between heat production within the body and its dissipation. Thermoregulation is the means by which an animal maintains its body temperature. It involves a balance between heat gain and heat loss. Under heat stress, a number of physiological and behavioural responses vary in intensity and duration in relation to the animal genetic make-up and environmental factors [6,7,8]. Climatic, environmental, nutritional, physical, social or physiological stressors are likely to reduce welfare and performance of animals [9,10]. The amount of stress experienced by the animals is correlated with temperature humidity index.

2.1 Temperature–Humidity Index (THI) In Dairy Animals

Temperature–humidity index (THI) is a measure of degree of discomfort experienced by an animal in warm weather. It is a calculated index that incorporates the effects of environmental temperature with relative humidity. This index was first introduced by Thom [11] to describe the effect of ambient temperature on humans and latter it was adapted to describe heat stress in dairy cattle [12]. The THI is divided into categories based on level of heat stress. Armstrong [13] used THI < 71 as a thermal comfort zone, 72 to 79 as mild heat stress, 80 to 90 as moderate heat stress, and > 90 as severe heat stress. Comparatively, De Rensis et al [12] defined THI < 68 to be outside the thermal danger zone for cows. Mild signs of heat stress are observed at THI of 68 to 74, and a THI ≥75 will cause drastic decrease in production. Vale [2] reported that THI >75 has a negative effect on reproductive performances of buffaloes in the tropical areas.

2.2 Effect of Heat Stress On Service Period

In murrah buffaloes a relation exist between average service period of a month and average THI values. Higher average service period of 180 days was observed in the month of May with the corresponding THI value of 80.27, whereas lowest average service period of 119 days was observed at average THI 67.80 in the month of March. The service period of buffaloes increased with increase in average THI above 75 [14]. The cooler months with lower THI values resulted in decrease in service period whereas hotter months with higher THI values above threshold level of 75 were associated with increase in service period in Murrah buffaloes [15].

2.3 Effect Of Heat Stress On Estrous

In cattle, heat stress decreases length, intensity of estrous period and conception rate. Heat stress affected the fertility of dairy cows in summer by poor expression of behavioural signs of oestrus due to reduced estradiol secretion from the dominant follicle. As a result the calving interval becomes longer and decrease in lifetime production of dairy animal [16]. In buffaloes, seasonal reproduction is a common phenomenon. Silent estrus is a limiting factor during hot months that leads to poor reproductive efficiency in buffaloes. The concentration of oestradiol-17 beta decreases in summer which reduces the intensity of estrus manifestation and results in silent heat in buffaloes. Buffaloes are sexually active during decrease in day length and temperature. Buffalos exhibit estrus when the ambient temperature is low, with THI value of less than 70. Highest breeding frequency was reported during winter and lowest during summer season[17]. Total protein concentration during different stage of follicle development did not differ during breeding season in buffaloes [18].

Abayawansa [19] reported that maximum percentage of buffaloes exhibited postpartum estrous during the month of September followed by October and minimum during April and May due to maximum air temperature. Roy and Prakash [20] observed a lower plasma progesterone and higher prolactin concentration during oestrus cycle in Murrah buffalo heifers and reported that prolactin and progesterone profiles during summer and winter months are directly related with the reproductive performance.

2.4 Effect Of Heat Stress On Conception Rate

Heat stress has a direct influence on the conception rate in buffaloes. Dash[15] reported that highest average conception rate was observed as 78% in the month of October while the lowest was 59% in the month of August. The threshold THI for conception rate was reported as 75 because with increase in average THI above threshold 75, the decline in overall conception rate was observed in

Murrah buffaloes. 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.

2.5 Effect Of Heat Stress On Pregnancy Rate

Heat stress during pregnancy impairs growth of the foetus due to decreased blood supply to the uterus and early embryonic death in cows [21]. A strong correlation exists between THI and pregnancy rate in Murrah buffaloes. The average pregnancy rate of Murrah buffaloes declined from 0.41 to 0.25 with the increase of THI ≥75. A comparision was done between monthly average pregnancy rate of Murrah buffaloes with monthly average THI values. It was found that lowest average pregnancy rate was observed as 0.25 in the month of July with corresponding THI 80.88 and the highest average pregnancy rate was obtained as 0.58 in the month of November at average THI value 66.09. The threshold THI for pregnancy rate in buffaloes was 75 and more than 75 will cause heat stress and poor fertility [15].

2.6 Effect Of Heat Stress On Oocyte And Embryo Quality

The higher ambient temperature is associated with reduced fertility in buffaloes due to its adverse effects on oocyte maturation and early embryonic development. Several possible reasons exist by which heat stress prevent the growth of oocytes. One of the reason is a decrease in preovulatory surge of luteinizing hormone and estradiol. Follicular growth is compromised due to inadequate secretion of gonadotropins by the hypophysis. It leads to poor follicle maturation and ovarian inactivity [22]. Heat stress also delays follicle selection, recruitment and degree of dominance. Heat stress decreases blood progesterone concentration, which is a major cause for abnormal oocyte maturation, implantation failure and early embryonic death. High ambient temperatures during oocyte maturation and ovulation or during the first 3–7 day of pregnancy reduced the embryonic viability and development. Although elevated temperature affect the pre-attachment stage of embryos, the degree of the effect decreases as the embryo develops. Heat stress causes embryonic death by interfering with protein synthesis, oxidative cell damage, reduction in successful pregnancy recognition and expression of stress-related genes associated with apoptosis [15].

3. MITIGATION STRATEGIES

Natural strategies adopted by dairy cows to withstand heat stress are by increasing its respiration rate, panting, sweating, reduced milk yield and reproductive performance [23,24]. Behavioural coping strategies include increased water intake, decreased feed intake, feeding during cooler part of the day, increased standing time and decreased physical activity and movement [25]. Managemental strategies to combat heat stress are by physical modifications of environment, nutritional management, genetic development of breeds that are less sensitive to heat stress and by assisted reproductive technologies [26]. The physical modifications of environment by providing shade, paddock with trees, cooling systems and wallowing pond are useful during heat stress to maintain production, reproduction and health [27,28]. The cooling systems and wallowing will alleviate heat load from buffaloes by evaporation[29]. Nutritional management includes providing balanced ration, supplemention of 7–25% extra maintenance ration, increasing nutrient density by feeding high quality forage, concentrates, fat supplements, additives, stabilizes, vitamins, trace elements, minerals and buffers. In addition, summer infertility may also be treated with assisted reproductive technologies such as timed artificial insemination and embryo transfer. Timed artificial insemination (AI) program improves summer fertility when combined with GnRH therapy to induce recruitment of the ovulatory follicle. Embryo transfer (ET) improves pregnancy rates during summer as embryos are transferred after the heat sensitive period [30].

4. CONCLUSION

In future, the effect of thermal stress will be more detrimental in livestock with increased atmospheric temperature. Although information on exact impact of the global climate change on livestocks are scarce there is no denial that it causes physiological, metabolic, production and reproduction disturbances. Thermal stress at farm level can be ameliorated by altering microclimate in the farm and by adopting nutritional management strategies. Future research must examine the possibility of developing breeds that are better adoptable to hot environments along with measures to reduce the environmental temperature.

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