Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(1): 1092-1094

Received: 02-11-2018
Accepted: 05-12-2018

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Effect of heat stress on physiological indices

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Abstract
Heat stress occurs due to imbalance in heat gain and loss mechanism which causes disturbances in various physiological parameters. There are various physiological indices for judging the heat stress but out of them Rectal Temperature (RT), Respiration Rate (RR) and Pulse Rate (PR) shows early alteration. During summer stress, animal shows an elevation in. RT, RR, PR, levels for combating the stress. The elevation in RT & RR is in accordance to environment temperature while PR do not shows definite trend with environment. RT & RR in combination with PR can be used as a summer stress indicator in animals.

Keywords: Heat stress, rectal temperature (RT), respiration rate (RR) and pulse rate (PR)

1. Introduction
Heat stress results from an imbalance between the heat gain and heat loss mechanism. Heat gain occurs by environmental factors (sunlight, thermal radiation, air temperature) animal properties (e.g., rate of metabolism). Heat loss occurs by a sensible and insensible mechanism. When the temperature difference is more then heat loss occur by sensible mechanism. But when outside temperature is more then insensible heat loss mechanism is the only way for thermoregulation. Physiological parameters like respiration rate, heart rate and rectal temperature changes immediately with the environmental temperature. These responses can be used as a indicator of thermal stress and to judge animal comfort [2].

2. Rectal Temperature (RT)
Rectal temperature of the animal changes if the heat load of animal is more so it can be used as an indicator to judge the effect of environmental condition on animal [12]. It is seen that a rise of 1˚C can severely reduce the animal performance. This change in RT indicates the change in core body temperature. The normal range of RT is very narrow in domestic animal and it should not vary more than 2.5˚C [17].

Verma and Husain (1986) showed a significant rise in the rectal temperature in buffaloes during the warmer part of the year when the environmental temperature exceeded the critical limit [30]. This high rectal temperature noticed in the heat stressed animals indicate the disruption in the homoeothermy of the animals which was not being countered by the physical and physiological means of heat loss [13].

Joshi and Tripathy (1991) reported when buffaloes were exposed to direct sun rays in the months of June and July, it causes 2.6 °C increase in their rectal temperature [13]. High relative humidity reduces the efficacy of evaporative cooling and the high relative humidity in conjunction with high environmental temperature worsens the capacity of the cow to maintain normal body temperature.

Prasanpanich *et al.* (2002) showed significantly higher respiration rate (87.9 Vs 62.9 breaths /min: $P< 0.01$) rectal temperature (40.4° C Vs 39° C: $p<0.01$) after housing HF crossbred cows outdoor (29.5° C and 76% RH) [22]. Mayengbam (2008) in crossbred cattle also showed rise in RT during climatic chamber exposure (40 and 45° C and 50% RH) studies and during heat stress [19]. Dandage (2009) showed a positive correlation between physiological responses and RT, humidity in Karan Fries, Murrah buffaloes and crossbred cattle [7]. Pandey *et al.*, 2017 found the RT of both breeds significantly higher ($p<0.01$) at 40 °C, 42 °C, compared to control conditions, and the increase in these parameters was more in KF than Tharparkar [21]. Purwar *et al.*, 2017 also found significant increase in RT during hot humid month [23, 24]. Kim *et al.*, 2018 also found increased RT ($p<0.05$) in high THI compared to those at low THI [15].

3. Respiration Rate (RR)

Respiration rate and rectal temperature is more sensitive indicator of summer stress than the pulse rate [16]. The increased respiration rate due to heat stress occurs by the stimulation of peripheral receptor by heat which trigger thermal center in hypothalamus [26]. Cardio respiratory center is also stimulated which sends impulse to intercostal muscle and diaphragm. High RR indicates that the animal is trying to restore normal heat balance. So increase in respiratory frequency can be used an index of discomfort in large animals. McLean (1963) showed that increase in respiration rate under summer stress allowed the animal to dissipate the surplus body heat by vaporizing more moisture in the exhale air, and this mechanism is responsible for 30 % of the total heat dissipation in animal [18].

Bhatnagar and Choudhary (1960) found that the relative humidity and air temperature in combination causes variation in RT and RR of animals, whereas the relative humidity alone causes variation in pulse rate [4]. Hafez (1968) shows the normal respiration rate is approximately 10–30 breaths/minute and as the environmental temperature increased the RR also increased [11]. Taneja (1960) recorded increased respiration rate of 71.5 breaths/minute during summer in comparison to 38.8 breaths/minute in winter in dairy cows [29]. Bond (1972) showed a very high positive correlation between the respiration rate and ambient temperature and it increased upto 0.833 when the humidity was constant in buffaloes [5]. Salem (1980) also showed an increase in the RR of buffaloes and crossbreds cattle during summer compared to other seasons [28]. When the RH was kept constant, Chikamune and Shimizu (1983) in swamp buffalo and Holstein cows also found a highly significant correlation between RR and seasonal air temperature, but in constant air temperature there was no such significant correlation observed between RR and RH [6]. Joshi and Tripathy (1991) also showed a rise in RR from 14 to 70/minute in Murrah buffalo calves in the month of June after introducing to direct sunlight for 6 hours [13]. Mishra *et al.* (1995) also showed 0.839 0.918, 0.883 and the correlation coefficient of between RR and ambient temperature in purebred Jersey, crossbred heifers and crossbred cows respectively [20]. Aggarwal and Upadhyay (1997) also demonstrated significantly higher RR in crossbreds (90 per min) than in Sahiwal cattle (25 per min) after four hrs of exposure and also the rise in RT was more in crossbred than in Sahiwal [1]. Hahn (1899) demonstrated a strong positive correlation between respiration rate and surrounding temperature once it goes beyond 21 ˚C (the rise in respiration rate @ 4.3 bpm per ˚C above a baseline of 60 bpm) [10]. Dandage (2009) demonstrated increased RR of Karan Fries, Sahiwal and Murrah buffaloes after four hours exposure in climatic chamber at 50% RH and 40 °C temperature and also in the extreme seasons (winter and summer) [7]. Pandey *et al*., 2017 found the RR of both breeds significantly higher (p<0.01) at 40 °C, 42 °C, compared to control conditions, and the increase in these parameters was more in KF than Tharparkar [21]. Purwar *et al*., 2017 also found significant increase in RR during hot humid month [23, 24].

4. Pulse Rate (PR)

Pulse rate did not show a definite trend with altering environmental conditions. Regan and Richardson, (1938) recorded a decrease in PR whereas Gaalas (1945) and Blaxter and Prince (1945) showed an increase in PR with rise in environmental temperature [3, 8, 27]. In swamp buffaloes negative correlation was showed between air temperature and pulse rate. Radadia *et al*. (1980) also found a positive correlation (r=0.234- 0.768) between surrounding temperature and respiration and pulse rates in buffaloes [25]. Mishra *et al*. (1995) showed 0.71 correlation coefficient between environmental temperature and PR and between RH and PR - 0.56 in crossbred heifers [20]. The apparently contradictory finding that heart rate response to heat exposure either by a rise or by a fall may be largely explained by the fact that heart rate is positively correlated with metabolic rate [3].

Joshi *et al*. (1982) showed that PR increased after the introduction of buffalo to hot environment [14]. This increasing pattern of pulse rate continued even if the ambient temperature declined showing that the physiological reaction of animals come back to its normal levels only after a certain period when the animals came to comfort zone. Gangwar *et al*. (1988) showed that surrounding temperature has a significant relation with the change in the pulse rate [9]. The result of their studies demonstrated that the average values of pulse rate were greater during summer and lower during winter season. Aggarwal and Upadhyay (1997) demonstrated significant (P<0.01) rise in PR when treadmill exercise were given to the crossbred male calves during hot-dry season of the year [1]. Pandey *et al*., 2017 found the PR of both breeds significantly higher (p<0.01) at 40 °C & 42 °C, compared to control conditions, and the increase in these parameters was more in KF than Tharparkar [21]. Purwar *et al*., 2017 also found a significant increase in PR during hot humid month [23, 24].

5. Conclusion

Summer stress in animal causes a lot of metabolic disturbances which ultimately results in loss of production. The early responses of heat stress reflects in elevated RT, RR & PR of animal. The farmer should adopt such type of summer managemental practices which kept these parameters in normal limit for the better production performance.

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