Heat tolerance of crossbred female calves as indicated by Iberia heat tolerance coefficient, Benezara coefficient of adaptability and dairy search index

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ABSTRACT

A study was conducted to assess the heat tolerance of crossbred female (n=7) calves of six to twelve months of age for thirty days each in summer, monsoon and winter. Temperature humidity index (THI) was calculated at forenoon and afternoon in all the seasons and heat tolerance was carried out using Iberia heat tolerance coefficient, Benezara coefficient of adaptability and Dairy search index. The highest THI was recorded in summer afternoon while lowest was recorded in winter forenoon. There was a significant increase in THI from forenoon to afternoon in all the seasons. IHTC was within the reference value in winter forenoon while rest of the time it was below the normal. IHTC decreased significantly from forenoon to afternoon in all the seasons. BCA was above the reference value in forenoon and afternoon in all the seasons. BCA increased significantly from forenoon to afternoon in all the seasons. DSI was significantly lower in winter compared to summer. It was concluded that crossbred female calves have low heat tolerance during afternoon in all the seasons.

Key Words: Heat tolerance, season, adaptability, crossbred calves

INTRODUCTION

India is an agricultural country with livestock sector as main source of livelihood for major population of rural India. Many factors negatively impairs livestock health and production, out of all the stressors the effects caused by heat stress are much more detrimental (Rivington *et al*., 2009).

Heat stress results from a negative balance between the net amount of energy flowing from the animal to its surrounding environment and the amount of heat energy produced by the animal (Bernabucci*et al*., 2010). Heat stress results in inability of the animals to lose heat to the surroundings. Under heat stress numerous physiological responses were operated (Blackshaw and Blackshaw, 1994; Sejian*et al*., 2008; Tej*et al*., 2017) to maintain the homeostasis compromising production behind (West, 1999). Changes in physiological responses such as rectal temperature (RT), respiratory rate (RR), heart rate (HR) and pulse rate (PR) are reliable indicators for recording heat tolerance/ adaptability in cattle (Kumar *et al*., 2016). Tropical cattle

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(*Bosindicus*) are thermo-tolerant with minimum physiological changes, while temperate cattle (*Bostaurus*) are susceptible to heat stress with significant alterations in physiological variables (Hansen, 2004). However, crossbreeding has been adopted for blending the adaptability of Zebu cattle with high milking potentials of exotic breeds (Sailo*et al*., 2017) to optimize production. In real, there is a need to assess heat tolerance/ adaptability in crossbred cattle inhabiting hot and humid tropical regions of India. Knowledge on adaptability of animals to existing ambience may contribute to the adoption of procedures that improve the welfare and efficiency of production. On this background the objectives, of the present study was conducted to assess heat tolerance of crossbred female calves to pre-monsoon, monsoon and post-monsoon seasons.

MATERIALS AND METHODS

Seven crossbred female calves of six to twelve months of age were randomly selected from University Livestock Farm and Fodder Research and Development Scheme, Mannuthy, Thrissur, Kerala. The animals were kept in calf shed with appropriate facilities for feeding and watering. The animals were fed as per ICAR feeding standards (Ranjhan, 1998). The study was conducted for 30 days each in May (summer), July (monsoon) and November (winter) seasons. Same animals were used in all the three seasons. Meteorological parameters such as ambient temperature (AT, ºC) and ambient relative humidity (RH, %) were recorded at forenoon and afternoon on all days of experiment using HOBO data logger (HOBO U 12 Temp/ RH/ Light/ Ext). Temperature humidity index (THI) was calculated using the equation, THI = (0.8 X Tdb) + [(RH/100) X T db – 14.4] + 46.4 (Tdb= temperature of dry bulb, RH= relative humidity) (Mader *et al*., 2006) from daily recordings AT and RH. Physiological variables such as RT, RR and PR were measured at forenoon and afternoon in all the three seasons. RT was measured by inserting a clinical thermometer in to rectum for one minute. RR was recorded by counting the flank movements for one minute.PR was recorded by manual palpation of middle coccygeal artery pulse for one minute. Heat stress tolerance of crossbred calves was carried out using Iberia heat tolerance coefficient (IHTC= 100-10 (BT ºF–101)) (BT=body temperature, F= Fahrenheit) (Rhoad, 1942), Benezara coefficient of adaptability (BCA=BT ºC/38.33+ RR/23) (RR= respiratory rate per minute) (Benezara, 1954) and Dairy search index (DSI) = 0.5(X1/X) + (0.2 (Y1/Y) + 0.3 (Z1/Z), where X1, Y1 and Z1 are the observed RT (°C), RR and PR (per min) respectively while X, Y, and Z are normal RT, RR and PR (per min) (Thomas *et al*., 1973). The data was analyzed by comparing the means of IHTC and BCA between forenoon and afternoon in each season using unpaired t- test. Whereas for DSI, one way Analysis of variance (ANOVA) was performed for between season comparison by taking winter forenoon values (normal values) as X, Y, Z and their respective afternoon values during summer, monsoon and winter X1, Y1, Z1. The data obtained on various parameters were statistically analyzed as per the standard techniques (Snedecor and Cochran, 1994) using computerized software programme SPSS Ver. 20.

RESULTS AND DISCUSSION

Adaptability is the capacity of body's physiological system to withstand unfavourable environmental conditions without significant impairment of its normal operations (Azam*et al*., 2012). Adaptability levels vary with breed and species. Cattle from Zebu breed are thermotolerant, the consequences of exposure to heat stress for milk and meat production are less pronounced compared to temperate cattle which are susceptible to heat stress with numerous changes in neuroendocrine and physiological varaibles compromising production behind (Hansen, 2004). Thus, assessment of thermal tolerance is of paramount importance for adoption of strategies to optimize production. With this background, the current study was aimed to evaluate heat tolerance of crossbred calves by non-invasive techniques. The mean±SE of THI at forenoon and afternoon during summer, monsoon and winter seasons were presented in Table 1. The lowest ($p<0.01$) THI was recorded in winter forenoon with an overall mean value of 76.71±0.31, while highest ($p<0.01$) mean THI was recorded in summer afternoon (85.87±0.26). THI significantly ($p<0.01$) increased from forenoon to afternoon in all the three seasons. THI is a single value which accounts for the combined effect of AT and RH and is one of the most commonly used measure of heat stress in livestock (Marai and Haeeb, 2010).

A THI of above 74 was considered to cause heat stress in dairy cattle (Armstrong, 1994). In the present study a THI of above 74 was noticed during forenoon and afternoon in all the three seasons, which is indicative of heat stress in all the animals. A significant increase in THI from forenoon to afternoon in all the three seasons indicates that the quantum of heat stress was high in afternoon compared forenoon in all the three seasons. Our findings was in accordance with the reports of Tej*et al*. (2017) and Aziz *et al*. (2016) who recorded critically high THI prevailing in summer, monsoon and winter seasons and significantly higher THI in the afternoon compared to forenoon in all the seasons in Thrissur, Kerala. Similarly studies on effect of high THI of above 74 significantly altered on physiological (Vaidya*et al*., 2010; Abdelatif and Alamenn, 2012), haematological (Lateef*et al*., 2014), biochemical parameters (Tej*et al*., 2017) which are indicators of heat stress in cattle. Though, THI does not take in to account of solar radiation and wind speed, it is one of the best method to assess heat stress in cattle (Marai and Haeeb, 2010).

Table.1 Mean±SE of THI at forenoon and afternoon during summer, monsoon and winter seasons.

Season	Time	THI
Summer	00.80-00.90h	80.58^{a}±0.31
	00.13-00.14h	85.87^{b}±0.26
Monsoon	00.80-00.90h	77.15^{a} ±0.23
	00.13-00.14h	81.70^{b}±0.29
Winter	00.80-00.90h	76.71^{a}±0.31
	00.13-00.14h	82.12^{b}±0.26

Means with different superscript (a, b) in a column within a season differ significantly ($p<0.01$).

Table 2.Mean±SE values of IHCT, BCA and DSI of crossbred female calves at forenoon and afternoon during summer, monsoon and winter seasons

Season	Time	IHTC	BCA	DSI
Summer	00.80-00.90 h	95.73^{a}±0.19	4.23^{a}±0.05	1.35±0.03^{a}
	00.13-00.14 h	79.19^{b}±1.82	5.91^{b}±0.10	
Monsoon	00.80-00.90 h	98.77^{a}±1.76	4.02^{a}±0.01	1.32±0.01^{ab}
	00.13-00.14 h	78.08^{b}±1.00	5.71^{b}±0.04	
Winter	00.80-00.90 h	100.41^{a}±0.48	3.93^{a}±0.02	1.28±0.01^{b}
	00.13-00.14 h	79.41^{b}±0.41	5.64^{b}±0.03	
Reference value		100	2	1

Means with different superscript (a, b) in a column differ significantly ($p<0.05$).

The Mean±SE values of IHCT and BCA of crossbred female calves at forenoon and afternoon during summer, monsoon and winter seasons were presented in Table 2. IHTC and BCA were used to assess heat tolerance in cattle. IHTC and BCA are linear equations which take in to account of RT and RR and the resultant value obtained indicates the heat tolerance capacity or adaptability of animals to heat stress. The reference range for IHTC was found to be >100 (Rhoad, 1942) and BCA was found to be <2 (Benezara, 1954). Animals with highest IHTC and lowest BCA are considered to be highly thermotolerant. In the current study, highest IHTC (100.41±0.48) was observed during winter forenoon while lowest IHTC (78.08±1.00) was observed during monsoon afternoon. Further, IHTC decreased significantly ($p<0.05$) from forenoon to afternoon in all the seasons. BCA was found to be above the reference value at forenoon and afternoon during all the three seasons. Furthermore, BCA increased significantly ($p<0.05$) from forenoon to afternoon in all the seasons. IHTC and BCA values close to reference value was observed during winter forenoon indicating highest adaptability of calves to winter forenoon which could be due to low THI recorded at that period. However, the IHTC and BCA values were above the reference range during forenoon and afternoon in all the seasons which could be due high THI recorded in all the seasons. The present findings were in accordance with the reports of Mandal and Tyagi (2008), Das (2012), Sailo*et al*., (2017) and Kumari *et al*., (2018) where they observed a lower IHTC and BCA during winter season in cattle. A significant change in IHTC and BCA from forenoon to afternoon in all the three seasons could be due to rise in THI from forenoon to afternoon.

DSI is another commonly used heat tolerance index to assess adaptability in ruminants. An increase in DSI value from '1' indicates decrease in thermal adaptability (Kumari*et al*., 2018). ANOVA indicated significant ($p<0.05$) difference in DSI between summer and winter season with lower ($p<0.05$) value recorded in winter while higher ($p<0.05$) value recorded in summer indicating high adaptability in winter and thermal susceptibility to heat stress in summer. Similar findings were reported with high thermal adaptability in

winter and low DSI in summer in Sahiwal, Gir, Jersey cross, Holstein Friesian cross and Murrah buffalo (Kumari*et al*., 2018).

From the present study it was concluded that the animals are less thermotolerant during afternoon in all the three seasons. This could be due to failure of the calves to acclimatize with stressful diurnal variation in THI from forenoon to afternoon. High THI must have imposed significant heat stress on animals resulting in altered RT, RR and BT which could result in reduced production. Thus necessary management strategies must be employed to reduce the risk of heat stress to optimize production.

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Compliance with ethical standards

The animal studies have been approved by the appropriate ethics committee, Order No. KVASU/DAR/ACAD A(1)/11795/2014, dated 30.05.2014. Code No CB/25/38/MVM2013/PY and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Disclosure statement

The authors declare that there is no any conflict of interest for this manuscript

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