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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 1012-1015

www.thepharmajournal.com
Received: 03-05-2022
Accepted: 10-06-2022

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THI versus acidification indicators in *Tharparkar* cows during varying environmental periods

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Abstract
The Temperature-Humidity-Index (THI) has been developed as a marker of the ambient heat load placed on cattle. Animals from arid tracts commonly have combined effects of environmental changes incorporating ambient temperature and relative humidity. The THI is considered to be an excellent indicator of variations in physiological acidification parameters *viz*. plasma and urine bicarbonates and plasma and urine anion gap. The values of THI among ambiences varied significantly ($p \leq 0.05$) and humid-hot displayed maximum value. An interpretation was drawn from the data observation of THI that humid-hot ambience produced severe impact on the animals as compared to dry-hot ambience. Maximum levels of plasma and urine bicarbonate was observed during humid-hot ambiences. During humid-hot, the per cent variation in the value of plasma bicarbonate and urine bicarbonate were found to be maximum (+15.85) and (+85.95), respectively. According to the observations of research, in group A plasma bicarbonate and urine bicarbonate values were found significantly ($p \leq 0.05$) higher in pregnant dry cows than non- pregnant milch and pregnant milch cows. In group B, those values were significantly ($p \leq 0.05$) higher in multipara cows than the respective mean value of primipara cows.
The value of per cent variation of plasma anion gap was observed maximum (-15.42) during humid hot while the urine anion gap to be maximum (+40.68) during dry hot ambience. According to the observations of research, in group A plasma anion gap values were found significantly ($p \leq 0.05$) lower in pregnant dry cows than non- pregnant milch and pregnant milch cows. In group B, those values were significantly ($p \leq 0.05$) lower in multipara cows than the respective mean value of primipara cows, while the urine anion gap showed the reverse trend than that of plasma anion gap. Investigation revealed that the combined effect of temperature and relative humidity in terms of THI affect the acidification indicators, which alters the physiological levels of electrolytes in body.

Keywords: Temperature-humidity-index, plasma and urine anion gap, *tharparkar* cows, plasma and urine bicarbonate

Introduction
Temperature and humidity can be combined in the form of a single entity through temperature-humidity index. Maximum HLI obtained in present study during extreme ambiences corroborated the earlier recordings from the Bikaner region, Rajasthan (Kataria and Kataria, 2016) [9]. In arid tracts, animal population encounter intensive environmental temperatures and they need greater degree of contentment. It can be proposed that environmental thermal standards to placate native breeds from arid tracts can be bolstered by analyzing environmental elements of a particular area for a long time.
The data collected in the present investigation will certainly assist in reinforcing the strategies and campaign regarding the management of special micro environments of the animals. In the computation of THI, black globe temperature (BGT) was employed in place of ambient temperature and this takes into account the radiation influences as well as ambient temperature. Although according to previous workers, Higher THI than 72 can be crucial for cow as far as decrease in milk production and feed intake is concerned, but in native breeds it may touch to 80-85 even in harsh environmental conditions. Seasonal variations alters the kidney functions and acid-base balance so influence the plasma anion status in goat (Arora *et.al*. 2021) [2].

Materials and Methods
To investigate the acidification indicators in *Tharparkar* cows from Rajasthan during moderate, dry-hot and humid-hot ambiences, blood samples were collected from 180 cows. Collection of blood samples was carried out without causing stress to animals from jugular vein. Cows in each ambience were broadly divided into group A and group B according to

physiological states. Animals of group A included non-pregnant milch; pregnant milch and pregnant dry cows. Animals of group B were classified according to parity and included primipara and multipara cows. This was irrespective of states like pregnancy and milch. All primipara were between 3.5 and 6 years whereas all multipara were between 6 and 8.5 years of age. The mean value obtained during moderate ambience was considered as control for comparison from the mean values obtained during dry-hot and humid-hot ambiences. Distinctive computer programmes were used to various statistical analysis. (http://miniwebtool.com) and (www.danielsoper.com). The alteration in the means were assessed by Duncan's new multiple range test (Duncan, 1995).

1. Plasma and urine bicarbonate (P_{Bicarb} and U_{Bicarb})

Plasma bicarbonate was measured by using procedure of Van Slyke, a titration method (Varley, 1988) [15].

Bicarbonate in plasma (M dL-1) = ml of titrant for blank titration- ml of titrant for test titration

Titrant = 0.01 N sodium hydroxide solution

Urine bicarbonate was measured using protocol of Van Slyke, a titration method for plasma (Varley, 1988) [15]. Similar process was employed for the determination of bicarbonates in urine.

2. Plasma anion gap (P_{AG})

Determination of plasma anion gap was carried out as described by Bagga *et al*. (2005) [3] with little change in which potassium content was also used.

Plasma anion gap (mmol L-1) = (Plasma Na+ + Plasma K^+) – (Plasma Cl^- + Plasma HCO^-3)

3. Urine anion gap (U_{AG})

Determination of urine anion gap was carried out as described by Bagga *et al*. (2005) [3].

Urine anion gap (mmol L-1) = (Urine Na+ + Urine K+) – (Urine Cl-).

Results and Discussion

Indicators of acidification status

1. Plasma bicarbonate (P_{Bicarb}) and Urine bicarbonate (U_{Bicarb})

The Mean± SEM values of plasma bicarbonate and urine bicarbonate in *Tharparkar* cows of different physiological states i.e. group A (non-pregnant milch, pregnant milch and pregnant dry) and group B (primipara and multipara) during moderate, dry- hot and humid-hot ambiences are presented in table 1 and table 2, respectively. The moderate ambience mean value acquired during present study corroborated earlier findings (Phillips, 1970 in cattle; Oetzel *et al.*, 1991 in cows; Kataria and Kataria, 2005c in calves; Hagenmaier *et al.*, 2017 in cattle; and Singh, 2018 in goat) [11, 10, 8, 6, 13].

Effect of varying ambiences on the values of plasma bicarbonate and urine bicarbonate

The overall mean values of plasma bicarbonate and urine bicarbonate were significantly ($p \leq 0.05$) higher during dry-hot and humid-hot ambiences as compared to moderate ambience mean value. During humid-hot, the per cent variation in the value of plasma bicarbonate and urine bicarbonate were found to be maximum (+15.85) and (+85.95), respectively. Further, researchers have also associated oxidative stress with bicarbonate levels (Chauhan *et al.*, 2015) [5].

Pattern of changes in the values according to extreme ambiences corroborated the earlier findings (Joshi, 2018 [7] in cows in sheep and Singh, 2018 in goat) [13]. Increase in plasma bicarbonate divulged a rise in alkalinity in the body (Promila, 2018) [12].

Effect of physiological states on the values of plasma bicarbonate and urine bicarbonate

In the present investigation, statistical analysis revealed significant ($p \leq 0.05$) variations among all the three overall mean values according to ambiences. In each ambience, in group A, mean values of plasma bicarbonate and urine bicarbonate of pregnant dry cows were significantly ($p \leq 0.05$) higher than the respective mean values of non- pregnant milch and pregnant milch cows. As well as in each ambience, in group B, mean values of plasma bicarbonate and urine bicarbonate of multipara cows were significantly ($p \leq 0.05$) higher than the respective mean value of primipara cows. Effect of physiological state on the value of this parameter corroborated the earlier work (Joshi, 2018 in cows.) [7].

Table 1: Mean ± SEM values of plasma bicarbonate ($P_{Bicarb,}$ mmol L^{-1}) in the *Tharparkar* cows during varying ambiences

S. No.	Effects	Mean ± SEM values during varying ambiences		
		Moderate	Dry hot	Humid hot
1.	Overall values (60)	$25.21^{b} \pm 0.43$	$27.23^{b} \pm 0.44$	$29.20^{b} \pm 0.41$
2.	Categorization according to physiological states (A & B groups)			
I.	Group A cows (60), Physiological states: Pregnancy and milch status			
a.	Non-pregnant milch (20)	$21.20^{bd} \pm 0.22$	$23.24^{bd} \pm 0.20$	$25.26^{bd} \pm 0.23$
b.	Pregnant milch (20)	$25.23^{bd} \pm 0.23$	$27.22^{bd} \pm 0.22$	$29.24^{bd} \pm 0.21$
c.	Pregnant dry (20)	$29.25^{bd} \pm 0.26$	$31.24^{bd} \pm 0.23$	$33.21^{bd} \pm 0.22$
II.	Group B cows (60), Physiological states: Parity			
a.	Primipara (30)	$24.23^{be} \pm 0.61$	$26.22^{be} \pm 0.58$	$28.23^{be} \pm 0.60$
b.	Multipara (30)	$26.23^{be} \pm 0.59$	$28.24^{be} \pm 0.60$	$30.22^{be} \pm 0.61$

Figures in the parenthesis = Number of *Tharparkar cows* 'b' = Significant ($p \leq 0.05$) differences among mean values for a row. 'd' = Significant ($p \leq 0.05$) differences among mean values for an ambience 'e' = Significant ($p \leq 0.05$) differences between mean values for an ambience

Table 2: Mean ± SEM values of urine bicarbonate ($U_{Bicarb,}$ mmol L^{-1}) in the *Tharparkar* cows during varying ambiences

S. No.	Effects	Mean ± SEM values during varying ambiences		
		Moderate	Dry hot	Humid hot
1.	Overall values (60)	$29.68^{b} \pm 0.22$	$48.19^{b} \pm 0.33$	$55.19^{b} \pm 0.44$
2.	Categorization according to physiological states (A & B groups)			
I.	Group A cows (60), Physiological states: Pregnancy and milch status			

a.	Non-pregnant milch (20)	$27.67^{bd} \pm 0.11$	$45.22^{bd} \pm 0.46$	$51.20^{bd} \pm 0.22$
b.	Pregnant milch (20)	$29.68^{bd} \pm 0.10$	$48.69^{bd} \pm 0.15$	$55.20^{bd} \pm 0.23$
c.	Pregnant dry (20)	$31.69^{bd} \pm 0.11$	$50.67^{bd} \pm 0.11$	$59.18^{bd} \pm 0.23$
II.	Group B cows (60), Physiological states: Parity			
a.	Primipara (30)	$29.19^{be} \pm 0.30$	$47.18^{be} \pm 0.54$	$54.52^{be} \pm 0.52$
b.	Multipara (30)	$30.17^{be} \pm 0.35$	$49.20^{be} \pm 0.29$	$56.20^{be} \pm 0.60$

2. Plasma anion gap (P_{AG}) and Urine anion gap (U_{AG})

The Mean± SEM values of plasma anion gap and urine anion gap in *Tharparkar* cows of different physiological states i.e. group A and group B during moderate, dry- hot and humid-hot ambiences are presented in table 3and table 4, respectively. The moderate ambience mean value attempted to authenticate the previous work (Bednarski *et al.*, 2015 in calves; Joshi, 2018 [4, 7] in cows; Promila, 2018 [12] in sheep and Singh, 2018 in goat) [13]. Very modest deliberation have been given to plasma anion gap and urine anion gap in veterinary science, in spite of the fact that computation of plasma anion gap is very simple and the parameter is of vast significance in assessing acid-base balance. Exploration related to anion gap in urine of animals (Vagnoni and Oetzel, 1998) [14] have been observed to be affected by ration having anionic salts. The anion gap is the distinction between the determined positively charged ions and the measured negatively charged ions in plasma or urine. The degree of this gap can be very easily computed.

Effect of varying ambiences on the values of plasma anion gap and urine anion gap

The overall mean values of plasma anion gap were significantly ($p \leq 0.05$) lower during dry-hot and humid-hot ambiences as compared to moderate ambience mean value while, the urine anion gap were significantly ($p \leq 0.05$) higher during dry-hot and humid-hot ambiences. A highly significant ($p \leq 0.01$) effect of extreme ambiences i.e. dry-hot and humid-hot was observed by analysis of variance. During humid-hot ambience plasma anion gap was observed at minimum level while urine anion gap was maximum. The per cent variation in the value of plasma anion gap was found to be maximum (-15.42) during humid-hot, while the urine anion gap was observed maximum (+40.68) during dry-hot environmental period.

Effect of physiological states of on the values of plasma anion gap and urine anion gap

In the present investigation, statistical analysis revealed significant ($p \leq 0.05$) variations among all the three overall mean values according to ambiences. In each ambience, in group A, mean value of plasma anion gap of pregnant dry cows was significantly ($p \leq 0.05$) lower than the respective mean values of non- pregnant milch and pregnant milch cows. In each ambience, in group B, mean value of multipara cows was significantly ($p \leq 0.05$) lower than the respective mean value of primipara cows. While the urine anion gap trend was observed reverse.

Table 3: Mean ± SEM values of plasma anion gap (P_{AG}, mmol L^{-1}) in the *Tharparkar* cows during varying ambiences

S. No.	Effects	Mean ± SEM values during varying ambiences		
		Moderate	Dry hot	Humid hot
1.	Overall values (60)	$20.94^{b} \pm 0.36$	$19.23^{b} \pm 0.24$	$17.71^{b} \pm 0.20$
2.	Categorization according to physiological states (A & B groups)			
I.	Group A cows (60), Physiological states: Pregnancy and milch status			
a.	Non-pregnant milch (20)	$34.17^{bd} \pm 0.22$	$21.05^{bd} \pm 0.31$	$19.51^{bd} \pm 0.32$
b.	Pregnant milch (20)	$21.04^{bd} \pm 0.17$	$19.17^{bd} \pm 0.14$	$17.08^{bd} \pm 0.11$
c.	Pregnant dry (20)	$17.56^{bd} \pm 0.07$	$17.47^{bd} \pm 0.27$	$16.39^{bd} \pm 0.08$
II.	Group B cows (60), Physiological states: Parity			
a.	Primipara (30)	$21.50^{be} \pm 0.55$	$20.18^{be} \pm 0.31$	$18.18^{be} \pm 0.37$
b.	Multipara (30)	$20.34^{be} \pm 0.4$	$18.28^{be} \pm 0.27$	$17.12^{be} \pm 0.12$

Table 4: Mean ± SEM values of urine anion gap (U_{AG}, mmol L^{-1}) in the *Tharparkar* cows during varying ambiences

S. No.	Effects	Mean ± SEM values during varying ambiences		
		Moderate	Dry hot	Humid hot
1.	Overall values (60)	$29.89^{b} \pm 0.05$	$42.08^{b} \pm 0.15$	$41.75^{b} \pm 0.12$
2.	Categorization according to physiological states (A & B groups)			
I.	Group A cows (60), Physiological states: Pregnancy and milch status			
a.	Non-pregnant milch (20)	$29.09^{bd} \pm 0.01$	$41.05^{bd} \pm 0.10$	$40.60^{bd} \pm 0.11$
b.	Pregnant milch (20)	$30.04^{bd} \pm 0.01$	$42.57^{bd} \pm 0.15$	$42.05^{bd} \pm 0.10$
c.	Pregnant dry (20)	$30.09^{bd} \pm 0.11$	$42.60^{bd} \pm 0.32$	$42.53^{bd} \pm 0.12$
II.	Group B cows (60), Physiological states: Parity			
a.	Primipara (30)	$29.71^{be} \pm 0.05$	$42.08^{be} \pm 0.17$	$41.42^{be} \pm 0.15$
b.	Multipara (30)	$30.05^{be} \pm 0.10$	$42.40^{be} \pm 0.23$	$41.76^{be} \pm 0.1$

Conclusion

In present investigation it was observed that animals exhibited physiological variations during different ambiences, among those the humid-hot condition was more critical. In same way the physiological states of animals also influence the ion balance of animals. On the basis of results it could be concluded that the plasma bicarbonate, urine bicarbonate and plasma anion gap were affected more during the humid hot condition than other environmental conditions. It could also be concluded that pregnant dry and multipara animals showed highest values of plasma bicarbonate, urine bicarbonate and plasma anion gap comparatively. While urine anion gap showed the reverse trend. So during harsh environmental conditions especially during humid-hot EP. It is required to

maintain the ionic balance in body.

Acknowledgement
All research work were conducted in Department of Veterinary Physiology, College of Veterinary and Animal Science Rajuvas, Bikaner, Rajasthan**.**

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