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PLASMA BICARBONATE IN ACID-BASE BALANCE FOR SHEEP ADAPTATION TO HOT CONDITIONS

M.M. Shafie, A.L. Badreldin, Neama Ashmawy, and A.M. Hassanien

Department of Animal Production, Faculty of Agriculture, University of Cairo, Giza, Egypt

SUMMARY

The present investigation was carried out on subtropical sheep (Egyptian Ossimi), temperate sheep (Merino) and their Crosses (7,8 & 8 ewes respectively) to compare changes in their blood traits, plasma particulary bicarbonate, related to acid-base balance coincidentally with changes in their thermos-respiratory responses under natural climatic conditions of winter, autumn and summer seasons in Egypt. The animals were fasted 16 hours before recording the thermo-respiratory responses and collecting blood samples at the three diurnal times from each animal (8.00,12.00 & 16.00h).

During winter and autumn all ewes of the three breeds showed similar trend of diurnal changes in rectal temperature and respiration with rate changes in air temperature. However during summer all breeds showed a characteristic higher rectal temperature at morning than at noon. Respiration rate showed a trend in diurnal changes similar to that of rectal temperature, being augmented at evening.

The values of Hb concentration and Ht were lower in summer than in winter. This case was more obvious in Merino, the least heat tolerant breed.

During winter serum bicarbonate remained stable oliver the day in merino and the cross breed, the Ossimi, however, showed slight increase at noon followed by a decrease at 16.00h.

In autumn bicarbonate concentration of all breeds did not change all the day through. In summer bicarbonate of

Ossimi was maintained at 19 m mol/l all the day. The crossbreed had 18.5 m mol/l at morning and 17.5 at both noon and evening. The Merino ewes showed diurnal fluctuations in bicarbonate concentration increasing from 18.5 m mol/l at morning to 19.5 m mol/ at noon followed by a sharp drop to 16.5 m mol at evening.

Keywords: Sheep, acid-base balance, hot condition

INTRODUCTION

Adaptability assessment, of poor sweating species and breeds, to hot conditions has to take in consideration harmful disturbance of acid-base balance besides the change in body temperature - these animals rely on severe panting to increase water vaporization in struggle to keep their body temperature from increasing to deleterious level. This panting is apt to deplete Co_2 and affect the Acid-base buffer, HCO_3^-/H_2CO_3, system, the major buffer in maintenance of normal pH in the body. Little information is available about acid-base balance in sheep in relation with thermal regulation.

Blood plasma bicarbonate store has a great significance in assessment of main tenancy of acid-base balance, thus normal pH value. Abdelghany (1974) reported that plasma bicarbonate concentration. In Rahmani sheep (Egyptian) and Merino was 24 and 25 m mol Na HCO_3 /liter at 30 resp/.min and 20 and 21 at 56 resp./ min respectively. Harmansen and Osnes (1972) stated that vigorous exercise causes marked depression in blood pH and plasma bicarbonate due to on increase in blood lactate resulting in metabolic acidosis.

Morgan and Upton (1975) found that following exercise, blood haemoglobin (Hb), haematocrit (Ht) and lactate levels were lower than the normal values. Acid-base balance returned to near normal within 60 min, while Hb and Ht levels returned to normal faster, within 10 min. In adult sheep venous blood PCO_2 was 32.1 m m Hg and in the same time blood pH was 1.48. while the PO_2 was 88.0 mm Hg (Mitchell and Williams,1975). Singh et al (1991) concluded that rise in environmental temperature in both pregnant and non-pregnant buffaloes was accompanied by mixed respiratory and metabolic acidosis. These authors found significant decrease in PO_2, oxygen saturation (SAT), oxygencontents (O_2(T),pH and HCO_3 and increase in

PCO_2 and H_2CO_3. The changes produced in acid-base variables and blood gases due to variation in environmental conditions were of greater magnitude in pregnant buffaloes in comparison to non-pregnant ones suggesting that acid-base changes are physiological responses to pregnancy and environmental stress.

The present study was planned to compare the response of subtropical sheep (Egyptian Ossimi), with temperate sheep breed (Merino) and their crosses in their acid-base balance reactions as related with their thermo-respiratory responses under the mild natural cold and hat conditions of winter, autumn and summer seasons in Egypt.

MATERIALS AND METHODS

This work was carried out in research laboratory of Animal physiology, Animal production department, Faculty of Agriculture, Cairo University. The study was carried out on 8 Merino ewes, 7 Ossimi ewes of their crossbred. The sheep were fed concentrate ration (1 kg/head daily) plus hay and maize stalks in Summer, Berseem (Trifolium alexandrenum) in winter. The thermo- respiratory reaction was studied during three seasons, winter (cold), and summer (hot), and intermediate temperature in autumn.

The Animals were fasted 16 hours before recording the thermo-respiratory responses and collecting blood samples for each Animal at the three diurnal times (08.00 & 12.00,16.00,h) at which the rectal temperature and respiration rate were tested. These diurnal tests were carried out at weekly intervals, for 4 times in each season.

For determining serum bicarbonate, blood samples were obtained from Jugular puncture through a tube immersed under neutral paraffin oil to avoid contact with air, thus preventing loss in CO_2 from blood. Serum bicarbonate was determined by the titration method of Van Slyke (1922) as reported by Oser (1965). Small heparinized blood sample was drown into another tube at each time for determination of haematocrit and haemoglobin.

Statistical calculations were done according to Snedecor and Cochron (1967).

RESULTS AND DISCUSSION

Seasonal and diurnal air temperature and relative humidity, coinciding with testing animals responses, are shown in Table (1).

Table 1. Average temperature and relative humidity, during winter, autumn and summer seasons at day times of testing the reaction of the ewes

Item		Daytime		
		Winter	Autumn	Summer
Airtemp.°C	08.00	10.7	18.8	27.4
	12.00	17.6	25.8	33.0
	16.00	19.4	25.3	36.6
Relative humidity%	08.00	88.7	86.5	82.0
	12.00	73.0	72.0	62.7
	16.00	65.6	68.9	53.8

I. Thermo-respiratory response

During winter and autumn all ewes of the three breeds showed similar trend of diurnal change in rectal temperature (Table 2). The diurnal variations in thermo-respiratory responses were greater during summer. In the three seasons rectal temperature of the three breeds showed slight change between morning and noon day times while it showed great increase at evening (16.00). Respiration rate did not show considerable diurnal change during winter (10.6- 19.4 °C) and autumn (18.6-26.0 °C). At any day time Merino had the fastest rate followed by the cross and Rahmani, however the breed differences were slight (Table 2). During summer respiration rate showed a trend of diurnal change similar to that of rectal temperature, being augmented at evening (Table 2).

Table 2. Diurnal changes in thermo-respiratory responses of sheep breeds to climatic conditions during winter(W), autmn(A) and summer(S) (mean± S.E)*

Breed	Season	Body temp. °F			Resp. rate/ min		
		Day time			Day time		
		8.00	12.00	16.00	8.00	12.00	16.00
Ossimi	W	101.9±0.14	102.0±0.14	102.6±0.12	22.6±0.51	23.0±0.77	22.6±0.67
Merino		101.7±0.09	101.9±0.09	102.4±0.09	25.0±0.67	25.0±0.87	26.4±0.86
Crossbreed		101.9±0.09	102.0±0.06	102.5±0.07	23.0±0.58	23.9±0.65	23.8±0.60
Ossimi	A	101.9±0.21	102.0±0.17	103.0±0.17	24.0±0.99	24.0±0.77	23.0±0.61
Merino		102.0±0.09	102.0±0.08	103.0±0.09	33.0±2.45	32.0±2.99	34.0±3.29
Crossbreed		102.0±0.08	102.0±0.07	103.0±0.07	26.0±0.90	27.0±1.02	28.0±1.50
Ossimi	S	102.0±0.12	101.6±0.08	102.7±0.16	30.8±1.40	31.4±0.04	58.0±5.72
Merino		102.6±0.08	102.3±0.09	102.8±0.13	51.8±2.72	49.1±2.99	72.0±5.18
Crossbreed		102.1±0.08	101.9±0.08	102.7±0.12	38.6±1.87	39.1±1.84	70.1±6.66

* Each value is obtained from 28 observations 7 animals X4 weeks.

All breeds showed a characteristic higher rectal temperature in summer morning than at noon although the ambient temperature increased around 10 °C. This case was not present in colder seasons particulary in winter. Could this higher rectal temperature be due to active metabolic rate with the drop in air temperature during summer night to compensate for the depression of metabolism during the summer midday and afternoon hot condition. The switching from the quiescent behavioral and biological activity during night to active behaviour at morning evokes the circadian elevation rhythm in hormones' secretion, enzyme synthesis, metabolic activity and other functions causing the release of more metabolic heat, thus elevation of rectal temperature. Humans' body temperature was the lowest at sleeping (night) and showed a steep increase at start of activity (awakening) at morning till midday (Aschoff, 1980). This author suggested that cortisol, for instance, has six hours rhythm like body temperature. Where humans' plasma cortisol increased from 0.0 mg/100 ml (non detectable) in the evening, to 10-15 mg/100 at morning.

At Summer evening (16.00 h) the respiration rate was more than at (12.00 h) by 85% in Ossimi, 79% in the

Cross but only by 47% in Merino. This means that the local breed has better chance of increasing its respiration without disastrous side effects particularly on pH and water turnover since it had initial low rate till midday (Table 3) than the others. The contrary case is that of Merino which had the highest initial rate (So/min) thus it has check the following increase, anyhow, it reached 24% more than that of Ossimi (72 vs 58/min). Shafie and Abdelghani, (1978) found that the respiratory surface of the alveoli in the lung was around 55 m^2 in the Merino versus 43 m^2 in the Rahmani, a subtropical Egyptian breed like Ossimi. Accordingly respiration rate and/or depth has to be checked to reduce heat production during hot condition as that of summer in this and at the some time to avoid more output of CO_2, thus reducing H_2CO_3 acid in the blood leading to alkalosis.

Table 3. Comparative thermo regulation and blood parameters responses of sheep breeds under the coldest and the hottest climatic temperature

	Ossimi			Merino			Crossbreed		
Item Airtemp. °C	10.7	36.6	%*change	10.7	36.6	%*change	10.7	36.6	%*change
Resp.	23.0	58.0	+152	25.0	72.0	+188	23.0	70.0	+204
Bic.	18.0	19.0	+ 5	18.0	16.5	- 8	18.0	17.5	- 3
Hb.	9.6	8.6	- 10	9.3	8.4	- 10	9.8	9.1	- 7
Ht.	23.6	19.4	- 18	23.4	18.3	- 22	26.0	23.3	- 10
Rectal temp. °F	127.4	128.3		127.3	128.3		127.4	128.3	

* % change induced by hot condition.

II. Haematocrit and haemoglobin

The values of Hanatoiril and haemoglobin were lower in summer than in winter In all breeds, at any day time (Table 4) denoting seasonal adaptation of lowering O_2 intake and metabolic heat production during hot conditions. On the other hand the reduction of haematocrit in summer, by greater value than that of haemoglobin, suggests that the majority of reduction in Haemoglobin is due to reduction of RBC_s in the peripheral circulation rather than haemadilution by increase in

plasma volume. Khalifa et al (1987) studied the response of sheep breeds (as that present of the study) to heat stress of direct solar radiation for 2 hours (13.00-15.00 h) in Egyptian summer midday. They found that plasma volume was decreased by 22.9,19.9 and 15.9% in Merino, Crosses and Ossimi respectively.

This case was more obvious in Merino, the least heat tolerant breed, as shown in Table (3).

Table 4. Diurnal changes in haematocrit and haemoglobin of sheep breeds during winter (W), autumn (A), and summer (S) (mean ± S.E)*

Breed	Season	Haematocrit %			Hb gm/100 ml		
		Day time			Day time		
		8.00	12.00	16.00	8.00	12.00	16.00
Ossimi	W	23.6±0.24	23.2±0.56	22.6±0.51	9.6±0.17	9.0±0.19	9.0±0.20
Merino		23.4±0.39	23.4±0.35	22.5±0.42	9.3±0.11	9.1±0.12	9.1±0.12
Crossbreed		26.0±0.02	26.0±0.60	24.0±0.49	10.0±0.17	9.8±0.16	9.9±0.21
Ossimi	A	23.6±0.60	24.0±0.51	23.0±0.50	9.0±0.22	9.0±0.22	9.0±0.18
Merino		23.0±0.34	23.0±0.38	20.0±0.38	9.0±0.15	9.0±0.18	9.0±0.19
Crossbreed		27.0±0.47	26.0±0.49	26.0±0.45	10.0±0.17	10.0±0.19	10.0±0.14
Ossimi	S	19.9±0.48	20.0±0.48	19.4±0.53	8.6±0.16	8.6±0.16	8.6±0.22
Merino		16.7±0.49	19.0±0.41	18.3±0.47	8.3±0.16	8.3±0.17	8.4±0.20
Crossbreed		21.9±0.47	21.8±0.40	23.3±0.47	8.9±0.14	9.0±0.08	9.1±0.13

* Each value is obtained from 28 observations 7 animals X4 weeks.

III. Bicarbonate store

During winter serum bicarbonate remained stable all over the day in Merino and the crossbreed, the Ossimi, however, showed slight increase at noon followed by a decrease at (16.00 h) (Table 5) in autumn serum bicarbonate of all breeds did notching all the day through. The Merino ewes, shoed the highest bicarbonate concentration in blood at (16.00 h) compared with the other two groups the cross had the lowest value.

In summer serum, bicarbonate of Ossimi of was maintained at 19 m ml/liter all the day, Being the highest of the three breeds. The Crossbreeds had 18.5 m ml/liter at morning and 17.5 at both noon and evening. The Merino ewes showed diurnal fluctuation in

bicarbonate concentration increasing from 18.5 m mol/liter morning to 19.5 m mol at noon followed by a sharp drop to 16.5 m mol at evening (Table 5).

Table 5. Diurnal changes in bicarbonate concenrtation in blood serum of sheep breeds during winter (W), autumn (A) and summer (S) (mean ± S.E)*

Breed		Time		
		Bicarbonate (m mol/L)		
		8.00	12.00	16.00
Ossimi	W	18.0±0.20	19.0±1.10	17.0±0.30
Merino		18.0±0.40	18.0±0.40	18.0±0.50
Crossbreed		18.0±0.30	18.0±0.40	18.0±0.30
Ossimi	A	20.0±0.30	20.0±0.30	19.0±0.30
Merino		20.0±0.30	20.0±0.20	20.0±0.20
Crossbreed		19.0±0.20	19.0±0.30	19.0±0.01
Ossimi	S	19.0±0.40	19.0±0.30	19.0±0.40
Merino		18.5±0.50	19.5±0.60	16.5±0.70
Crossbreed		18.5±0.50	17.5±0.90	17.5±0.40

* Each value is obtained from 28 observations (7 animals X4 weeks).

It is clear from Table (6) that the diurnal change bicarbonate store was negligible in Merino and cross during winter and autumn, thais is under coldad mild air temperature, the Ossimi showed clear change. It is interesting to notice from the table that Ossimi was the only breed which showed coincident and similar trends change in of changes in respiration rate and bicarbonate in these two seasons.

From Table (6) it can be noted that the most obvious change in bicarbonate -in the present study was that in summer particulary from noon to evening. The two discrete breeds, Ossimi and Merino, showed clear specific response in this concern. Although the subtropical breed (Ossimi) exercised greater increase in respiration rate (87.0%) it did not suffer any change in bicarbonate store. Under the some environmental summer conditions the merino ewes, although restricting the increase in respiration rate to only 47.0%, it suffered a clear drop in bicarbonate 15%. Table (3) shows that the hyperventilation in merino and crosses under hot

condition (72 & 70/min) lead to drop in bicarbonate, to a greater extent in merino. The crossbreed showed mild drop in bicarbonate at noon, compensated at evening although it had great increase in respiration rate at evening (79%) which gives a clue that crossbred ewes had intermediate response between their parents responses.

Table 6. Percentage diurnal and seasonal change in blood serum bicarbonate (Bic) and respiration rate (Resp.) of sheep breeds

		Winter		Autumn		Summer	
Breeds.	Item.	N-M	E-N	N-M	E-N	N-M	E-N
Ossimi	Bic.	+5.6	-10.5	0	-5.0	0	0
	Resp.	+1.8	- 1.7	0	-4.2	+3.3	+87.0
Merino	Bic.	0	0	0	0	+5.4	-15.4
	Resp.	0	+5.5	-3.0	+6.3	-3.9	+46.9
Crossbreed	Bic.	0	0	0	0	-5.4	0
	Resp.	0	0	+3.8	+3.7	+2.6	+79.0

N-M = values at noon (12.00 h) minus values at morning (8.00 h).
E-N = values at evening (16.00) minus values at noon (12.00 h).
Bic., Plasma bicrbonate concenteration m mol/l
Resp., Respiration rate/minute.

Environmental thermoneutral zone (confort zone)

The almost diurnal stability of thermo-respiratory reactions and blood constituents (haenatoerite, haemoglobin and bicarbonate) during winter (10.6°C-19.4°C) suggests that the climatic conditions during this experimental period could be considered of the thermoneutral (confort) zone for sheep. The breed difference in response to environmental temperature denotes that the thermoneutral (contort) zone of Ossimi and their crosses extends further than merino towards hot conditions (up to 25°C in the present study in autumn season). According to the conditions of the study the upper limit of the thermonentral zone for the temperate breed, merino, could 20°C, that is around 5°C less than for the sub-tropical breed, Ossimi. The cross bred sheep appear to aquire adaptation capability equal to the sub-tropical parent.

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بيكربونات البلازما فى التوزان (حمض - قاعدة) واقلمه الاغنام تحت الظروف الحارة

محمد محمود الشافعى - عبد اللطيف بدر الدين - نعمة عشماوى - احمد محمد حسنين

قسم الإنتاج الحيوانى، كلية الزراعة، جامعة القاهرة، الجيزة، مصر.

نفذ هذا البحث على اغنام اوسيمى (تمثل اغنام المنطقة شبه الحارة) والمرينو (يمثل اغنام المنطقة المعتدلة) وكذلك اغنام ناتجة من الخلط بين النوعين السابقين ٠

حيث استخدم ٧ ،٨ ، ٨ نعجات من كلا منهم على التوالى ٠ وذلك لمقارنة التغيرات فى خصائص الدم والبلازما وبالذات البيكربونات وعلاقتها بالتوازن (حمض - قاعدة) ومدى علاقتها بالاستجابة الحرارية التنفسية تحت الظروف المناخية للشتاء والخريف والصيف فى مصر ٠

الحيوانات تم تصويمها لمدة ١٦ ساعة قبل تسجيل الاستجابة الحرارية التنفسية وجميع عينات الدم ٠ حيث تم جمع عينات الدم ثلاث مرات يوميا من كل حيوان فى الساعة ٨ صباحا ، ١٢ ظهرا ، ١٦ بعد الظهر٠

اثناء موسم الشتاء والخريف كل النعاج للثلاث انواع اوضحت اتجاه مشابه للتغيرات اليومية فى درجة حرارة المستقيم ومعدل التنفس٠ مع ذلك فأثناء موسم الصيف كل الانواع اوضحت زيادة فى درجة حرارة المستقيم فى الصباح عن المساء٠ معدل التنفس اوضح تغير خلال ساعات اليوم وبالذات بين الظهيرة والمساء حيث ارتفع تركيز الهيموجلوبين والمكونات الخلوية كانت منخفضة فى الصيف عن الشتاء وبالاخص فى نوع المرينو ٠

اثناء الشتاء بيكربونات السيرم بقيت ثابتة طوال اليوم فى المرينو والخليط ولكن الاوسيمى اوضح زيادة طفيفة فى ساعة الظهيرة ثم انخفضت فى المساء٠ فى الخريف فأن بيكربونات الدم لكل الانواع لم تتغير٠

فى الصيف الاوسميى سجل ١٩ ملىمول/لتر طوال اليوم من بيكربونات الدم بينما الخليط سجل ١٨,٥ ملىمول/لتر فى الصباح و ١٧,٥ فى الظهيرة والمساء نعاج المرينو اوضحت تغير يومى فى تركيز البيكربونات حيث ذادت من ١٨,٥ ملىمول/لتر فى الصباح الى ١٩,٥ فى الظهيرة ثم حدث انخفاض حاد حيث سجلت ١٦,٥ ملىمول/لتر فى المساء٠