

CHAPTER IV



RESULTS

Environmental conditions during experiments

Environmental temperatures and humidities were shown in table 1. The mean maximum ambient temperature value under control period at 1500 hours was $32.67 \pm 1.57^{\circ}\text{C}$ (dry bulb) and $24.00 \pm 1.30^{\circ}\text{C}$ (wet bulb) and under heat stress in the room at 1500 hours was $42.33 \pm 1.37^{\circ}\text{C}$ (dry bulb) and $31.83 \pm 0.41^{\circ}\text{C}$ (wet bulb). The mean relative humidity values on the control day were varied from 44.17 ± 4.40 to $58.75 \pm 9.55\%$ and the values on the day of heat stress were varied from 41.83 ± 1.83 to $48.16 \pm 3.60\%$.

Changes in heart rate, respiratory rate, packed cell volume and rectal temperature during heat stress of swamp buffaloes

In the control period, heart rate, respiratory rate, packed cell volume and rectal temperature of the buffaloes were almost constant throughout the period as shown in figure 1 and table 2. When the buffaloes were exposed to heat, the respiratory rate increased from 26 ± 10 to 46 ± 23 breath/minute after one hour of heat exposure but was significant after two to six hours of exposure by increase to 79 ± 27 breath/minute at the end of experiment. The heart rate increased when the environmental temperature was high. There was a small increase after two hours of heat exposure, but significantly

Table 1 Mean values (\pm S.D.) of environmental conditions during the experiments of six swamp buffaloes.

parameter	condition	time (hour)					
		1	2	3	4	5	6
Dry Bulb Temperature ($^{\circ}$ C)	control	28.83	30.17	31.75	32.50	32.67	32.67
		± 1.57	± 1.37	± 1.13	± 1.18	± 1.57	± 1.94
	heat	39.42	40.50	41.08	41.58	42.33	42.00
		± 1.36	± 1.05	± 0.80	± 0.49	± 1.37	± 1.09
Relative Humidity (%)	control	58.75	52.00	46.50	44.17	44.58	47.25
		± 9.55	± 5.39	± 4.28	± 4.40	± 6.76	± 8.18
	heat	48.16	44.67	43.83	43.67	41.83	42.83
		± 3.60	± 4.93	± 5.53	± 4.63	± 1.83	± 4.12

Table 2 Effects of acute heat stress on heart rate respiratory rate, rectal temperature and packed cell volume of six swamp buffaloes.

parameter	condition	time (hour)						
		0	1	2	3	4	5	6
Heart Rate (beat/min)	control	40.00	40.00	40.33	40.67	48.83	41.00	41.33
		± 6.32	± 6.32	± 5.72	± 5.16	± 4.67	± 4.52	± 4.32
	heat	43.50	46.67	47.33**	51.33*	51.50 ^{†††}	50.80 ^{††}	50.83 ^{††}
		± 6.19	± 3.93	± 4.18	± 8.82	± 4.18	± 3.92	± 2.99
Respiration Rate (breath/min)	control	21.33	21.33	20.67	22.83	23.00	22.33	22.83
		± 3.50	± 3.50	± 2.66	± 7.28	± 6.57	± 6.50	± 6.08
	heat	26.33	46.00*	58.00 ^{†*}	73.17 ^{†*}	82.17 ^{††††}	86.00 ^{††††}	79.00 ^{††††}
		±10.31	±22.80	±31.82	±32.87	±36.49	±38.28	±27.44
Rectal Temperature (°C)	control	38.33	38.33	38.33	38.34	38.36	38.40	38.57
		± 0.24	± 0.24	± 0.24	± 0.24	± 0.22	± 0.29	± 0.34
	heat	38.68**	38.82 ^{†††}	39.00 ^{†††††}	39.28 ^{†††††}	39.44 ^{††††}	39.72 ^{††††}	39.80 ^{††††}
		± 0.22	± 0.15	± 0.15	± 0.19	± 0.34	± 0.44	± 0.47
Packed cell volume (%)	control	24.75	23.75	24.17	24.17	24.58	24.17	24.42
		± 3.91	± 3.28	± 3.69	± 3.33	± 4.26	± 3.27	± 3.32
	heat	25.92	25.33	25.58	25.92	25.25	24.42	24.50
		± 2.24	± 2.75	± 3.18	± 2.42	± 3.52	± 4.76	± 4.85

P-value with respect to t_0 at the same condition : † P < 0.05; †† P < 0.01.

P-value with respect to control condition at the same time interval : * P < 0.05; ** P < 0.01; *** P < 0.001.

The value with no symbol = not significant.

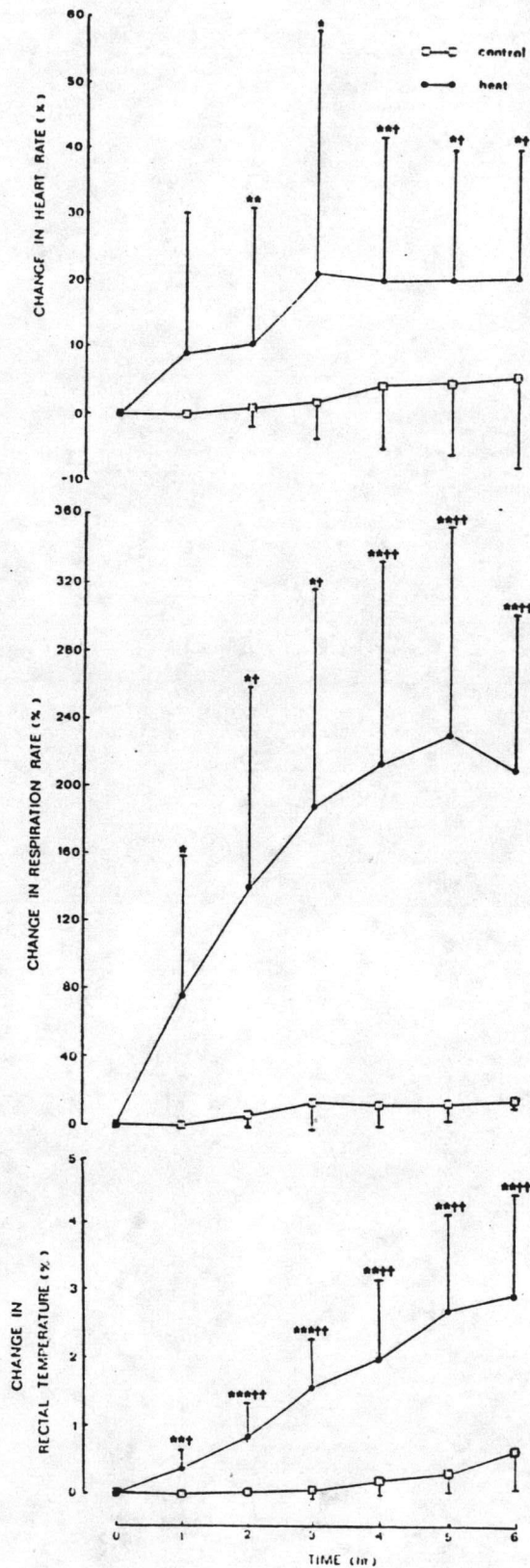


Figure 1 Effects of acute heat stress on the change (%) of heart rate, respiratory rate and rectal temperature of six swamp buffaloes. The values are mean \pm S.D.

P-value with respect to t_0 at the same condition, + P < 0.05, ++ P < 0.01.

P-value with respect to control condition at the same time interval, * P < 0.05; ** P < 0.01; *** P < 0.001.

increased from 43 to 52 beat/minute after four to six hours of exposure. Rectal temperature of the heat stressed buffaloes were higher than the control ones. It increased from 38.68 ± 0.22 to $39.8 \pm 0.47^{\circ}\text{C}$ after six hours of heat exposure. The significant increase in rectal temperature occurred during one to six hours after heat stress. Packed cell volume slightly decreased in heat stressed animal by approximately 5.48% after six hours of heat stress.

Effect of heat stress on body fluid of swamp buffaloes

The results of plasma volume and blood volume under control and heat stress periods were presented in table 3. The mean plasma volume significantly increased from 16.78 ± 2.49 to 17.96 ± 2.81 litres ($P < 0.05$) in the heat stressed buffaloes. The mean blood volume of heat stressed buffaloes inclined nonsignificantly. There was a nonsignificant elevation in the mean total body water of buffaloes while the water turnover rose significantly along with increased temperature under heat stress (table 4). The total body water did not significantly increase during exposure to heat. Under heat stress, the animals turnover 144.03 ± 61.46 litres/day of water which was approximately 2-fold more than the rate of under control period. The biological half-life of tritiated water under control period was about one-half of heat stress period. The heat stressed group had the biological half-life of tritiated water about 54.17 ± 20.28 hours which was shorter than the control group. The results of ruminal fluid volume, expressed in litres/100 kg of body weight, and its outflow rate under control and heat stress period were presented in table 5. Ruminal fluid volume was nonsignificantly

Table 3 Effects of acute heat stress on plasma volume and blood volume of six swamp buffaloes.

Parameter	control	heat
Plasma Volume (L)	16.78 ± 2.48	17.97 ± 2.18*
Plasma Volume (L/100 kg)	4.75 ± 0.53	5.00 ± 0.51*
Blood Volume (L)	22.61 ± 3.06	24.04 ± 3.08 ^{NS}
Blood Volume (L/100 kg)	6.41 ± 0.56	6.69 ± 0.66 ^{NS}

P-value with respect to control, * P < 0.05, NS = not significant

Table 4 Effects of acute heat stress on total body water, water turnover rate and half life of tritiated water of six swamp buffaloes.

parameter	control	heat
Body Weight (kg)	343.42 ± 19.41	359.0 ± 23.34
Total Body Water (L)	321.32 ± 88.69	360.53 ± 128.55 ^{NS}
Total Body Water (L/100 kg)	93.11 ± 23.38	100.92 ± 36.79 ^{NS}
Half Life (hr)	98.33 ± 32.73	54.17 ± 20.28*
Water Turnover Rate (L/d)	62.55 ± 19.34	144.03 ± 61.46*
Water Turnover Rate (L/100 kg/d)	18.31 ± 5.86	40.23 ± 17.14*
Water Turnover Rate (ml/kg ^{0.82} /d)	523.26 ± 165.92	1,159.21 ± 493.28*

P-value with respect to control, * P < 0.05, NS = not significant



Table 5 Effects of acute heat stress on ruminal fluid volume and its outflow rate of six swamp buffaloes.

parameter	control	heat
Ruminal Fluid Volume (L)	40.11 ± 16.81	48.47 ± 15.51 ^{NS}
Ruminal Fluid Volume (L/100 kg)	11.59 ± 4.46	13.59 ± 4.28 ^{NS}
Outflow Rate (L/hr)	3.57 ± 4.25	8.99 ± 7.25 ^{NS}

P-value with respect to control, * P < 0.05, NS = not significant.

higher under heat stress than control period by the values of 13.59 ± 4.28 and 11.59 ± 4.46 litres/100 kg respectively. The outflow rate of ruminal fluid did not significantly increase from the rate of 3.57 ± 4.25 to 8.99 ± 7.25 litres per hour in heat stressed buffaloes.

Effect of heat stress on plasma electrolyte concentration, fractional electrolyte excretion, ruminal fluid electrolyte concentration and plasma aldosterone levels of swamp buffaloes

Mean plasma concentration of sodium, potassium and chloride ions remain constant throughout the period of both control and heat stress (figure 2, table 6). In control period, fractional excretion of sodium did not significantly change while the fractional excretion of potassium and chloride trended to decrease. Fractional excretion of sodium, potassium and chloride trended to decrease by the effect of heat stress (figure 3, table 7).

Endogenous plasma creatinine levels in figure 3 and table 6 showed a tendency to increase due to the effect of heat stress.

The concentrations of potassium and chloride in ruminal fluid of buffaloes in both control and heat stress periods were almost constant throughout the period of experiment while sodium concentration in acute heat stress period significantly increased on the fifth and sixth hour (figure 4, table 8).

Plasma aldosterone levels of buffaloes under control period in figure 5 and table 9 showed no significant change but under heat stress they showed a tendency to increase.

Table 6 Effects of acute heat stress on plasma concentration of electrolytes and creatinine of six swamp buffaloes.

parameter	condition	time (hours)							
		0	1	2	3	4	5	6	
Plasma Sodium (mEq/L)	control	130.83	131.67	132.17	129.67	131.17	130.67	131.67	
		± 5.19	± 7.17	± 7.41	± 3.20	± 2.56	± 4.46	± 5.92	
	heat	125.50*	127.17	126.67	126.00*	125.67*	126.50	127.20	
		± 1.64	± 2.32	± 1.75	± 2.97	± 2.58	± 3.08	± 3.56	
Plasma Potassium (mEq/L)	control	4.53	4.52	4.38	4.32	4.40	4.25	4.25	
		± 0.56	± 0.67	± 0.63	± 0.36	± 0.62	± 0.62	± 0.59	
	heat	3.97*	4.05*	3.97*	4.07	4.03	3.97	3.98	
		± 0.42	± 0.39	± 0.35	± 0.27	± 0.27	± 0.19	± 0.38	
Plasma Chloride (mEq/L)	control	96.00	96.00	94.33	94.67	95.67	96.50	96.50	
		± 4.56	± 3.97	± 4.18	± 3.08	± 2.50	± 2.81	± 5.58	
	heat	95.67	95.00	96.33	96.50	93.83	96.33	96.20	
		± 3.33	± 3.22	± 2.88	± 4.28	± 1.72	± 4.76	± 3.27	
Plasma Creatinine (µg/ml)	control	22.24	18.08	17.92	19.54 [†]	17.27	20.30	19.69	
		± 3.93	± 3.81	± 6.09	± 3.58	± 8.38	± 5.31	± 4.19	
	heat	26.41	26.82 ^{†*}	25.12	27.34	27.31	29.29 [†]	29.52	
		± 5.54	± 5.79	± 5.42	± 5.10	± 4.89	± 5.56	± 6.40	

P-value with respect to t_0 at the same condition : † P < 0.05.

P-value with respect to control condition at the same time interval : * P < 0.05.

The value with no symbol = not significant.

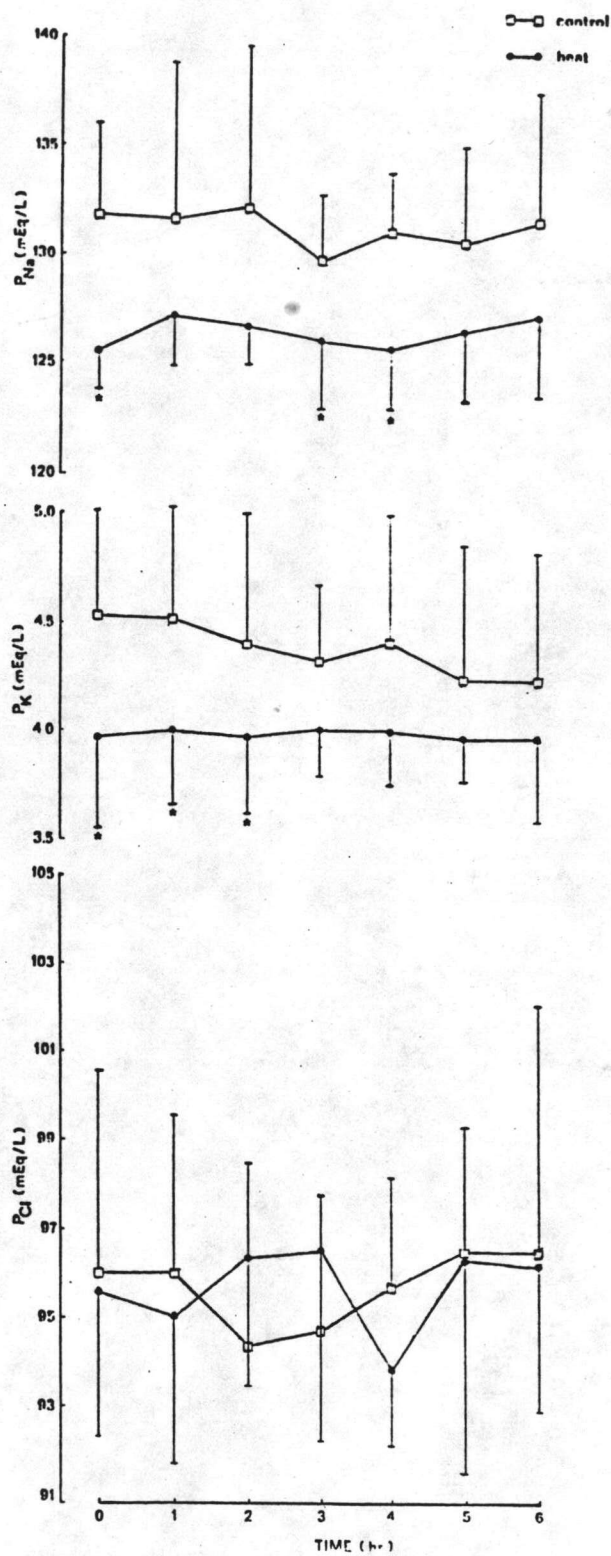


Figure 2 Effects of acute heat stress on plasma concentration of electrolytes (Na,K,Cl) of six swamp buffaloes. The values are mean \pm S.D.

P-value with respect to control condition at the same time interval, * P < 0.05.

Table 7 Effects of acute heat stress on fractional excretion of electrolytes and urinary/plasma ratio of creatinine of six swamp buffaloes.

Parameter	condition	time (hour)						
		0	1	2	3	4	5	6
Fractional Excretion of Sodium (%)	control	0.517	0.063	0.237	0.810	0.593	0.432	0.098
		± 0.560	± 0.990	0.095	± 1.594	± 0.896	± 0.765	± 0.060
	heat	1.023	0.845	0.387	0.349	0.521	0.441	0.284
		± 1.010	± 0.718	0.348	± 0.393	± 0.679	± 0.490	± 0.340
Fractional Excretion of potassium (%)	control	187.19	170.82 [†]	133.23	153.81	126.75	119.98	107.16 [†]
		± 79.08	± 64.83	29.66	± 77.03	± 61.84	± 38.12	± 40.48
	heat	256.30	268.67	219.94	177.44	182.90	167.88 [†]	153.97
		± 116.46	± 129.00	± 111.74	± 62.35	± 91.14	± 92.54	± 98.51
Fractional Excretion of chloride (%)	control	5.39	5.28	3.26	4.91	4.36	4.04	3.02 [†]
		± 2.37	± 3.34	± 1.14	± 2.74	± 2.40	± 1.96	± 2.13
	heat	10.53*	7.95 [†]	6.24 [†]	4.66 ^{††}	4.07 ^{††}	4.92 [†]	5.58 ^{††}
		± 2.54	± 3.14	± 2.35	± 1.53	± 1.56	± 2.65	± 4.03
Urinary/Plasma Ratio of creatinine	control	37.63	42.13 [†]	54.19	46.25	44.87	51.51	67.08 [†]
		± 18.46	± 23.03	± 2.85	± 20.47	± 17.97	± 15.99	± 18.43
	heat	25.09	29.38 [†]	36.11 [†]	41.58 ^{††}	48.89 ^{††}	43.37 [†]	49.48 ^{††}
		± 10.54	± 12.41	± 18.72	± 14.81	± 19.47	± 22.07	± 20.46

P-value with respect to t_0 at the same condition : † p < 0.05; †† p < 0.01.

P-value with respect to control condition at the same time interval : * p < 0.05.

The values with no symbol = not significant.

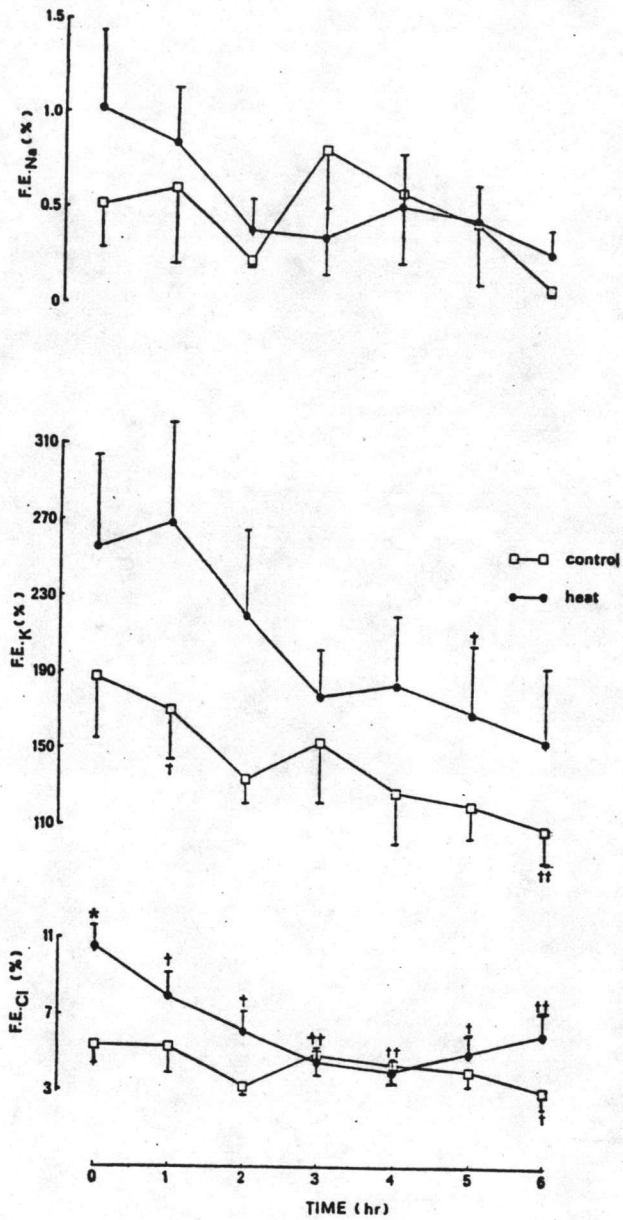


Figure 3 Effects of acute heat stress on fractional excretion of electrolytes (Na,K,Cl) of six swamp buffaloes. The values are mean \pm S.E.

P-value with respect to t_0 at the same condition, \dagger $P < 0.05$,

$\dagger\dagger$ $P < 0.01$.

P-value with respect to control condition at the same time interval, * $P < 0.05$.

Table 8 Effects of acute heat stress on ruminal fluid concentration of electrolytes of six swamp buffaloes.

parameter	condition	time (hour)						
		0	1	2	3	4	5	6
R_{Na} (mEq/L)	control	107.83 ±13.57	98.33 ±25.45	99.00 ±23.08	104.00 ±18.95	112.67 ±14.81	106.83 ±17.27	111.17 ±18.28
	heat	123.33* ±10.33	117.67 ±15.86	128.67 ±10.73	129.5* ±11.22	124.83 ±14.44	132.50* ^{††} ± 9.03	132.00* ^{††} ± 9.12
R_K (mEq/L)	control	26.67 ± 5.05	23.83 ± 7.68	23.67 ± 6.12	24.50 ± 5.99	27.17 ± 4.88	26.83 ± 6.34	25.33 ± 6.25
	heat	21.50 ± 8.96	19.17 [†] ± 7.52	19.33 ± 8.21	18.67 ± 7.23	18.33 [†] ± 7.87	18.50 ^{††} ± 7.39	19.33 ± 8.41
R_{Cl} (mEq/L)	control	15.32 ± 6.08	14.35 ± 8.22	14.67 ± 6.69	15.23 ± 6.69	15.43 ± 5.03	15.08 ± 7.12	15.22 ± 6.67
	heat	14.23 ± 2.76	13.65 ± 2.91	14.95 ± 1.99	14.90 ± 2.77	14.47 ± 2.71	15.12 ± 2.40	15.27 ± 2.55

P-value with respect to t_0 at the same condition : † P < 0.05; †† P < 0.01.

P-value with respect to control condition at the same time interval : * P < 0.05.

The value with no symbol = not significant

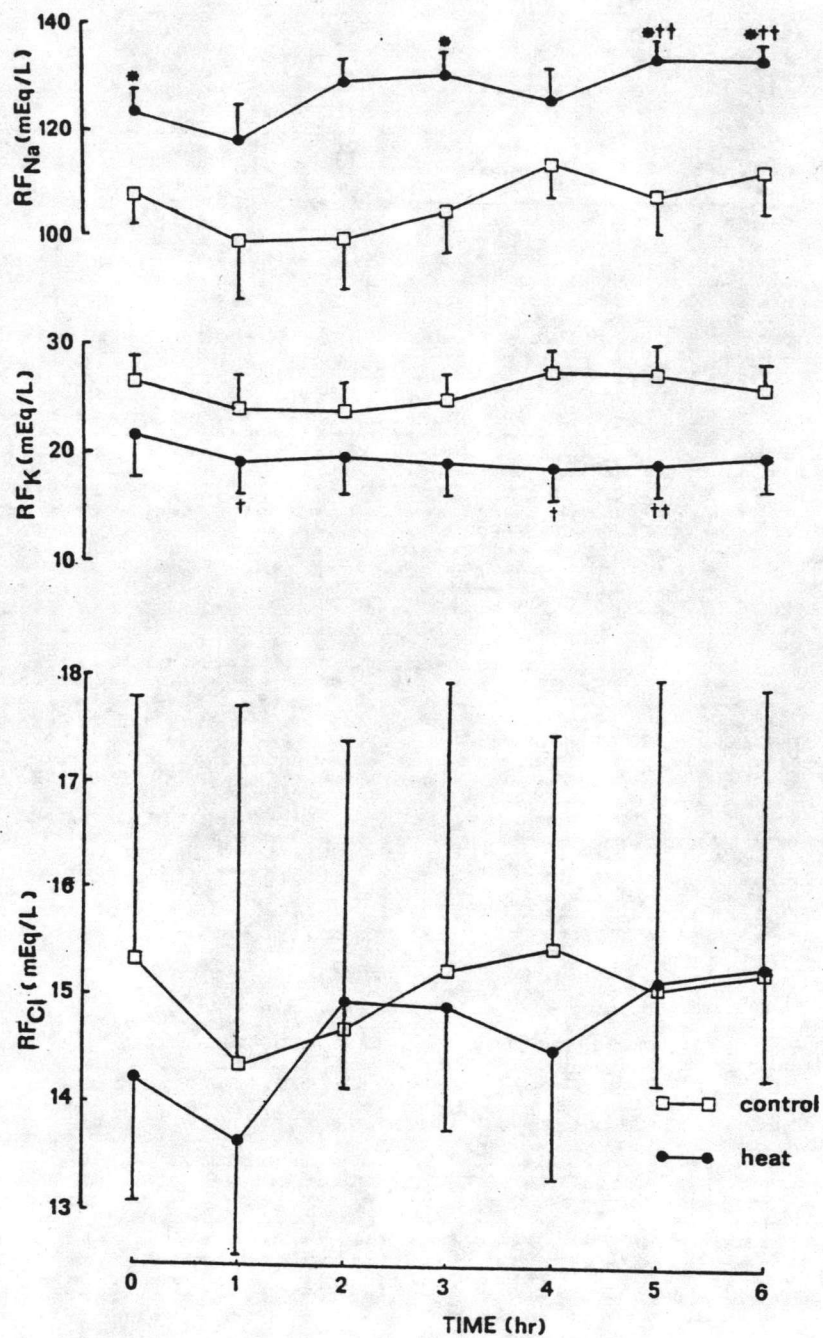


Figure 4 Effects of acute heat stress on ruminal fluid concentration of electrolytes (Na,K,Cl) of six swamp buffaloes. The values are mean \pm S.E.

P-value with respect to t_0 at the same condition,

+ P < 0.05, †† P < 0.01.

P-value with respect to control condition at the same time

interval, * P < 0.05.

Table 9 Effects of acute heat stress on plasma aldosterone levels of six swamp buffaloes.

time (hr)	Plasma Aldosterone (pg/ml)	
	control	heat
0	—	13.63 ± 13.79
1	42.30 ± 84.73	—
2	73.60 ± 113.88	19.77 ± 34.48
3	41.98 ± 70.19	26.50 ± 52.68
4	69.97 ± 112.63	25.48 ± 40.05
5	48.32 ± 98.77	32.83 ± 63.52
6	80.83 ± 124.87	32.50 ± 60.69
7	55.00 ± 103.54	—

All values are not significant.

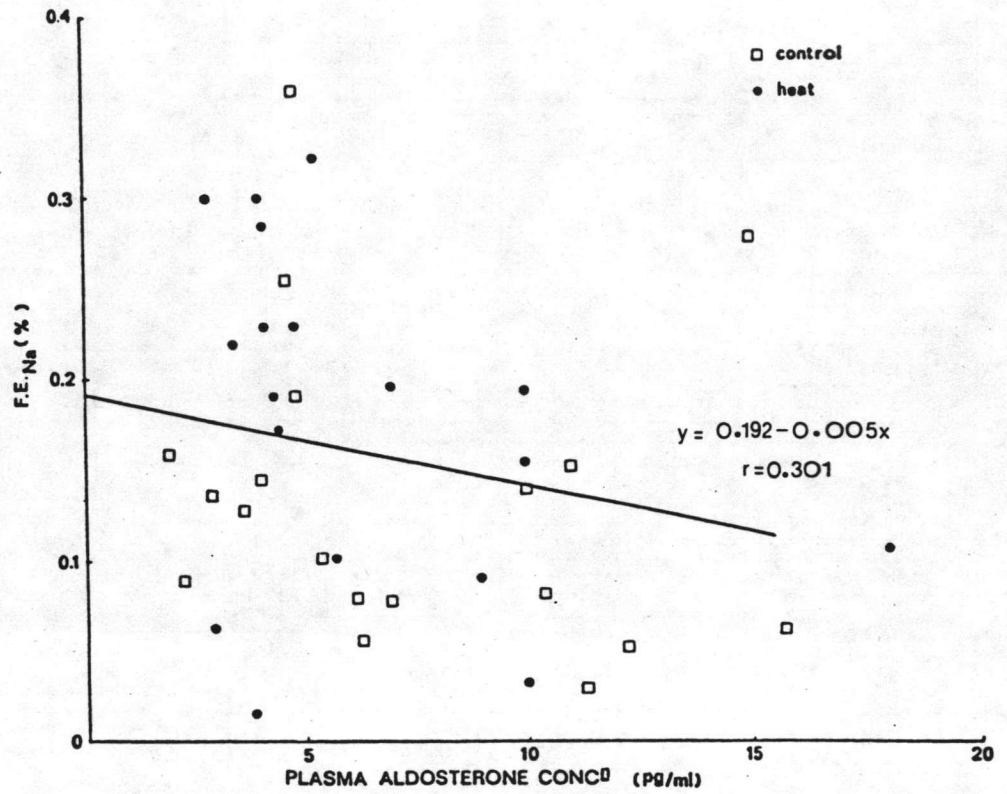


Figure 5 Correlation of plasma aldosterone levels and fractional excretion of sodium of six swamp buffaloes. The values are mean \pm S.D.