CHAPTER IV

RESULTS

Changes of cardiorespiratory frequency, rectal body temperature and blood volume during heat exposure.

The results in Table I show that during control period, the mean ambient temperature of dry bulb was around 27.7° C and wet bulb was 22.0° C. Relative humidity was in the range of 52 to 62%. No significant difference was observed throughout the control experimental study. The temperature humidity index (THI) was higher during heat exposure period when compared with that of control period. During the 3rd h. of heat exposure, the pulse rate of buffalo increased by approximately 9% from the mean initial pulse rate

The respiratory rate of buffaloes markedly increased by 52.7, 83.9 and 168.2% at the 1st, 2nd and 3rd h. of heat exposure respectively. However, there was not any alteration in respiratory rate of buffalo under control period. On the 3rd h. of heat exposure, the rectal temperature increased from 38.4 to 38.9° C ($P < 0.01$) while a slight increase was also observed in control period (Fig 1).

There was a positive correlation between the change of rectal body temperature and dry bulb temperature of the surrounding environment ($P < 0.01$) (Fig 2).

The mean values of plasma volume, blood volume and packed cell volume of heat exposed animals showed no alteration when compared with the preexposure values (Table II).

Table I Changes of heart rate, respiratory rate and rectal body temperature of five swamp buffalo during control and heat exposure period.

(Mean ± D.S.)

	Control period				Heat exposure period			
	0	1 h	2 h	3 h	0	1 h	2 h	3 h
Dry bulb temperature (°C)	26.5±3.3	27.7±2.9	28.5±3.3	28.3±3.6	32.1±3.4	38.1±0.7	40.8±1.3	41.1±0.5
Wet bulb temperature (°C)	21.9±3.5	21.9±3.0	22.1±3.0	22.0±2.8	27.0±1.2	30.0±1.2	31.7±1.0	31.4±0.5
Relative humidity (%)	61.3±10.7	55.4±14.1	52.6±17.5	53.8±17.0	70.0±8.8	48.4±4.7	45.6±4.5	42.0±1.7
THI (%)	75.45±4.77	76.31±3.89	77.03±3.97	76.82±4.16	84.15±2.55	89.63±1.26**	92.80±1.48**	92.80±0.72**
Heart rate (beats/min)	42±6	43±5	43±7	44±8	43±7	46±6	46±7	47±8
Respiratory rate (breaths/min)	21±7	23±7	23±6	25±6	25±9	37±10**	45±15**	58±13**
Rectal body temperature (°C)	37.9±0.7	38.0±0.8	38.2±0.8	38.2±0.8*	38.4±0.5	38.6±0.3	38.8±0.2*	38.9±0.3**

P-value with respect to t_o of the same period; * $P < 0.05$, ** $P < 0.01$.

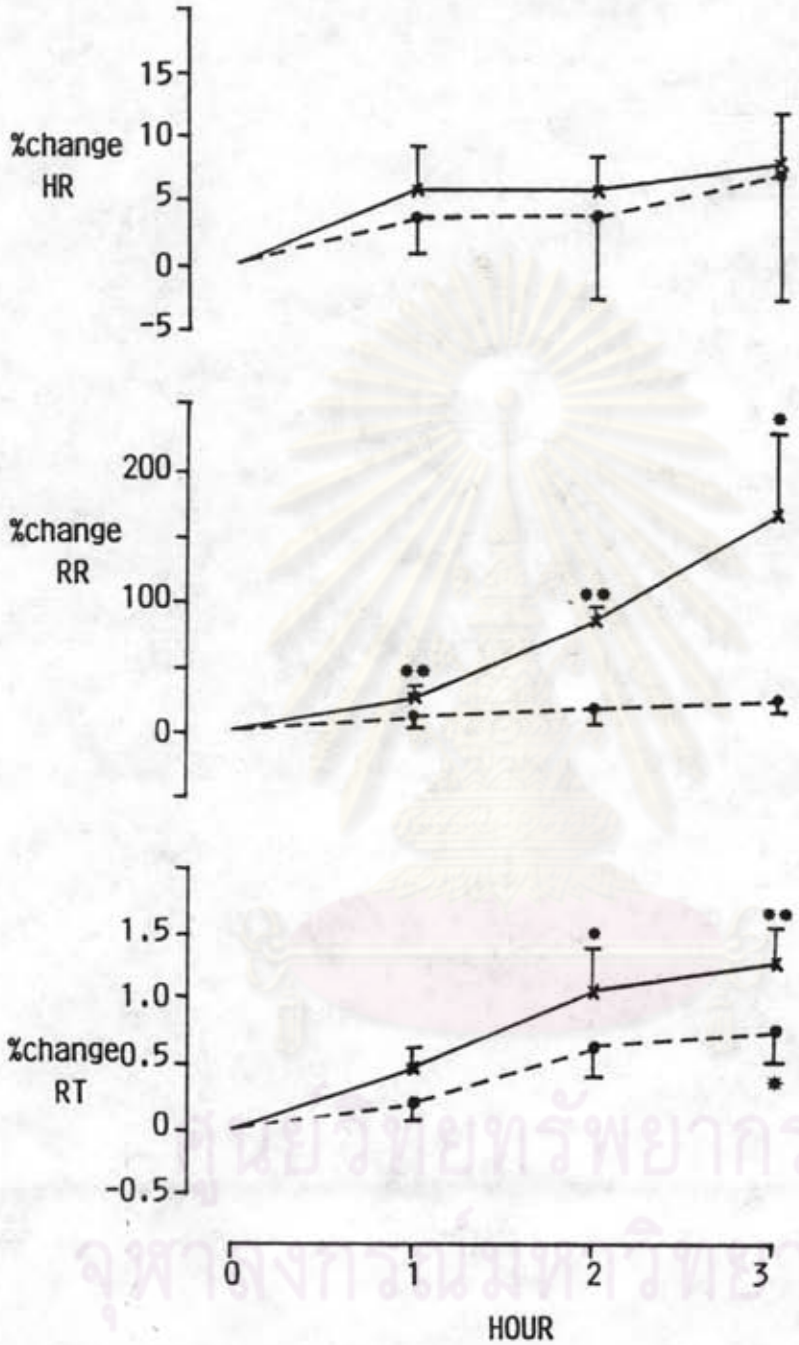

Fig 1 Mean percent changes for heart rate (HR), respiratory rate (RR) and rectal body temperature (RT) of five swamp buffaloes during control (●--●) and heat exposure (✕—✕) period. The values are mean ± S.E. P-values with respect to pre-exposure value; ● $P < 0.05$, ●● $P < 0.01$

Table II Changes of plasma volume, blood volume and packed cell volume of five swamp buffaloes before and at 2.5 hour of heat exposure. (Mean $\pm$ S.D.)

	Before heat exposure	2.5 h. of heat exposure	Before VS Heat
Plasma volume (litre)	15.647$\pm$3.190	15.665$\pm$2.940	NS
Plasma volume (ml/kg bd.wt.)	40.581$\pm$6.092	40.651$\pm$5.183	NS
Blood volume (litre)	21.864$\pm$5.028	21.761$\pm$5.035	NS
Blood volume (ml/kg bd.wt.)	56.613$\pm$9.384	56.355$\pm$9.382	NS
Packed cell volume (%)	28.2$\pm$3.2	27.5$\pm$2.7	NS

NS = Not significant

Changes of glucose metabolism during heat exposure. (Table III)

Table III provided the data of the changes of glucose metabolism. When animals exposed to heat, there was a rise in 3-^{3}H glucose pool size. A marked increase in glucose pool size coincided with an increase in plasma glucose concentration (Table VI). Moreover, there was a positive correlation between plasma glucose concentration and U-^{14}C glucose turnover rate (Fig 3). The turnover rate of both 3-^{3}H glucose and U-^{14}C glucose increased by approximately 7.1% and 81.6% respectively during animal exposed to heat. An increase in U-^{14}C glucose turnover rate was exceed so that the glucose carbon recycling decreased significantly by 98% during heat exposure when compare with the control period ($P < 0.01$).

Biological half life of U-^{14}C glucose was longer than that of 3-^{3}H glucose. During heat exposure period, the half life of 3-^{3}H glucose increased while the half life of U-^{14}C glucose was reduced. Thus, the change of turnover rate of U-^{14}C glucose was higher than that of 3-^{3}H glucose.

Changes of renal functions during heat exposure. (Table IV)

There were no significant changes in effective renal plasma flow and renal blood flow during heat exposure when compared with the value obtained either before heat or the control period of the same animal. The glomerular filtration rate slightly increased only at the 1st h. of heat exposure by approximately 6.3% and declined to preexposed value thereafter (Fig 4). However, there was no correlation between heart rate and GFR in buffalo both in the control and heat exposure period (Fig 5).

Table III Changes of glucose metabolism of five swamp buffaloes during control and heat exposure period. (Mean $\pm$ S.D.)

	Control period	Heat exposure period
Glucose pool size (gm)	112.76$\pm$32.53	157.38$\pm$99.09
Glucose pool size (mg/Kg$^{3/4}$)	1325.65$\pm$384.99	1772.28$\pm$1009.60
3-^{3}H glucose turnover rate (mg/min)	960.83$\pm$312.82	1067.39$\pm$353.17
3-^{3}H glucose turnover rate (mg/min/Kg$^{3/4}$)	11.397$\pm$4.020	12.209$\pm$3.269
U-^{14}C glucose turnover rate (mg/min)	564.79$\pm$164.66	1054.83$\pm$359.08
U-^{14}C glucose turnover rate (mg/min/Kg$^{3/4}$)	6.622$\pm$1.936	12.027$\pm$3.212
Glucose carbon recycling (%)	42.45$\pm$16.72	0.96$\pm$9.65**
$t_{1/2}$ 3-^{3}H glucose (min)	82.8$\pm$24.9	96.0$\pm$33.1
$t_{1/2}$ U-^{14}C glucose (min)	115.8$\pm$40.7	104.0$\pm$21.6

P-value with respect to control period; ** $P < 0.01$.

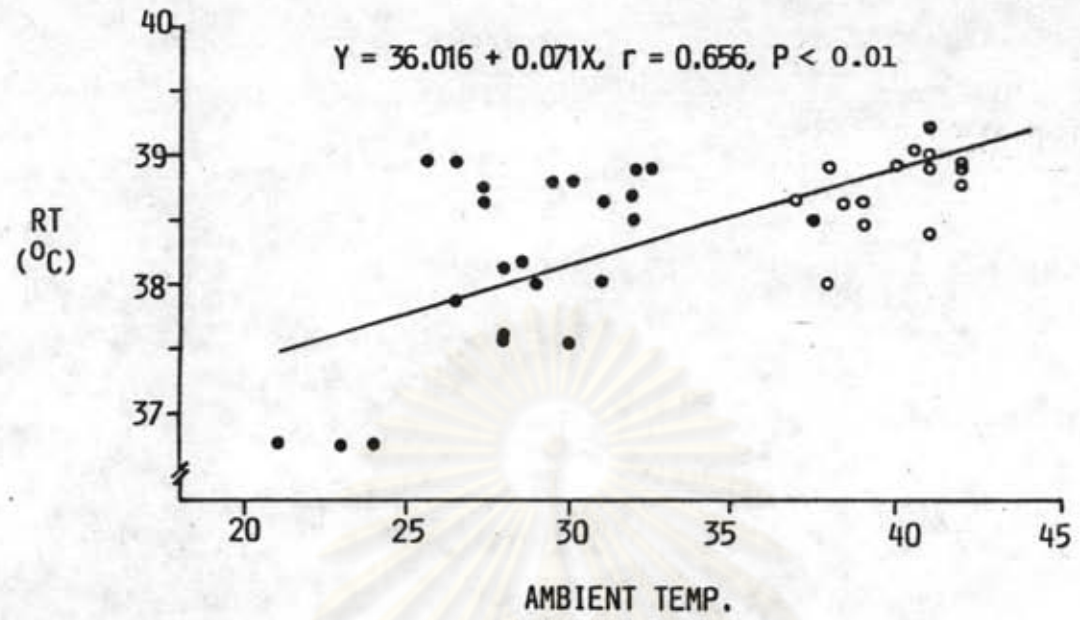

Fig 2 Relationship between dry bulb ambient temperature and rectal body temperature (RT) of five swamp buffaloes during control (●) and heat exposure (o) period.

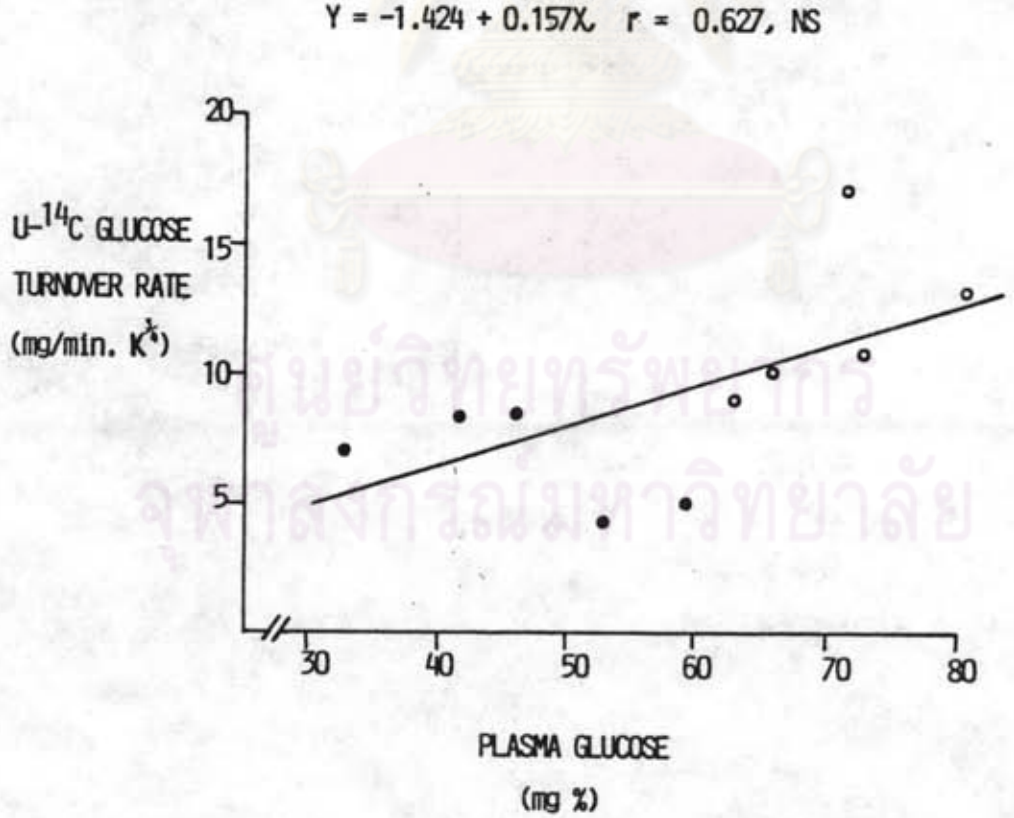

Fig 3 Relationship between plasma glucose concentration and U-^{14}C glucose turnover rate of five swamp buffaloes during control (●) and heat exposure (o) period.

Table IV Changes of renal functions of five swamp buffaloes during control and heat exposure period. (Mean ± S.D.)

	Control period			Heat exposure period			
	1 h	2 h	3 h	0	1 h	2 h	3 h
Glomerular filtration rate (ml/min)	280.24±77.73	284.27±75.47	276.79±54.82	302.24±56.74	321.42±57.09	309.97±53.41	308.90±29.68
Effective renal plasma flow (ml/min)	1165.36±419.08	1269.43±281.27	1278.50±308.15	1255.83±307.73	1301.62±246.94	1358.39±221.69	1321.97±221.22
Renal blood flow (ml/min)	1588.14±571.31	1855.85±432.23	1752.08±421.20	1751.08±434.79	1805.56±353.91	1872.28±346.63	1812.67±278.06
Filtration fraction (%)	24.82±5.10	22.27±3.03	21.91±3.10	25.10±6.73	25.30±5.45	23.20±4.03	23.76±3.72
Urine flow rate (ml/min)	9.39±8.94	9.98±7.14	8.73±5.67	7.08±2.68	8.77±4.02	7.18±3.66	5.87±2.20
Plasma urea concentration (mg%)	45.87±12.18	46.42±12.63	46.63±12.7	47.4±8.61	47.46±8.97	46.9±8.72	47.11±8.61
filtered load of urea (mg/min)	128.87±46.31	136.38±49.31	128.18±38.65	143.72±39.87	153.97±45.82	146.16±41.03	146.15±33.92
Urinary urea excretion (mg/min)	85.41±49.84	95.43±44.39	87.34±33.96	90.99±27.1	99.94±33.31	91.79±28.70	88.89±16.92
Urea reabsorption (mg/min)	43.46±24.74	40.95±17.62	40.84±19.90	52.74±20.08	54.04±20.37	54.37±21.85	57.26±25.33
Renal urea clearance (ml/min)	186.37±110.07	205.50±90.26	185.49±75.27	194.56±52.90	210.94±54.16	198.25±54.30	190.40±26.18
Urinary total nitrogen excretion (mg/min)	128.16±128.64	121.70±92.73	135.58±112.34	55.49±9.76	61.12±18.56	62.43±17.97	58.96±13.44
Urinary non urea nitrogen excretion (mg/min)	86.29±107.35	79.47±76.16	94.77±97.99	12.99±7.27	14.59±11.17	19.75±11.55	17.42±8.57
Urinary urea nitrogen excretion (mg/min)	41.87±22.97	42.22±19.92	40.81±15.89	42.50±12.51	46.53±15.61	42.68±13.38	41.54±7.78

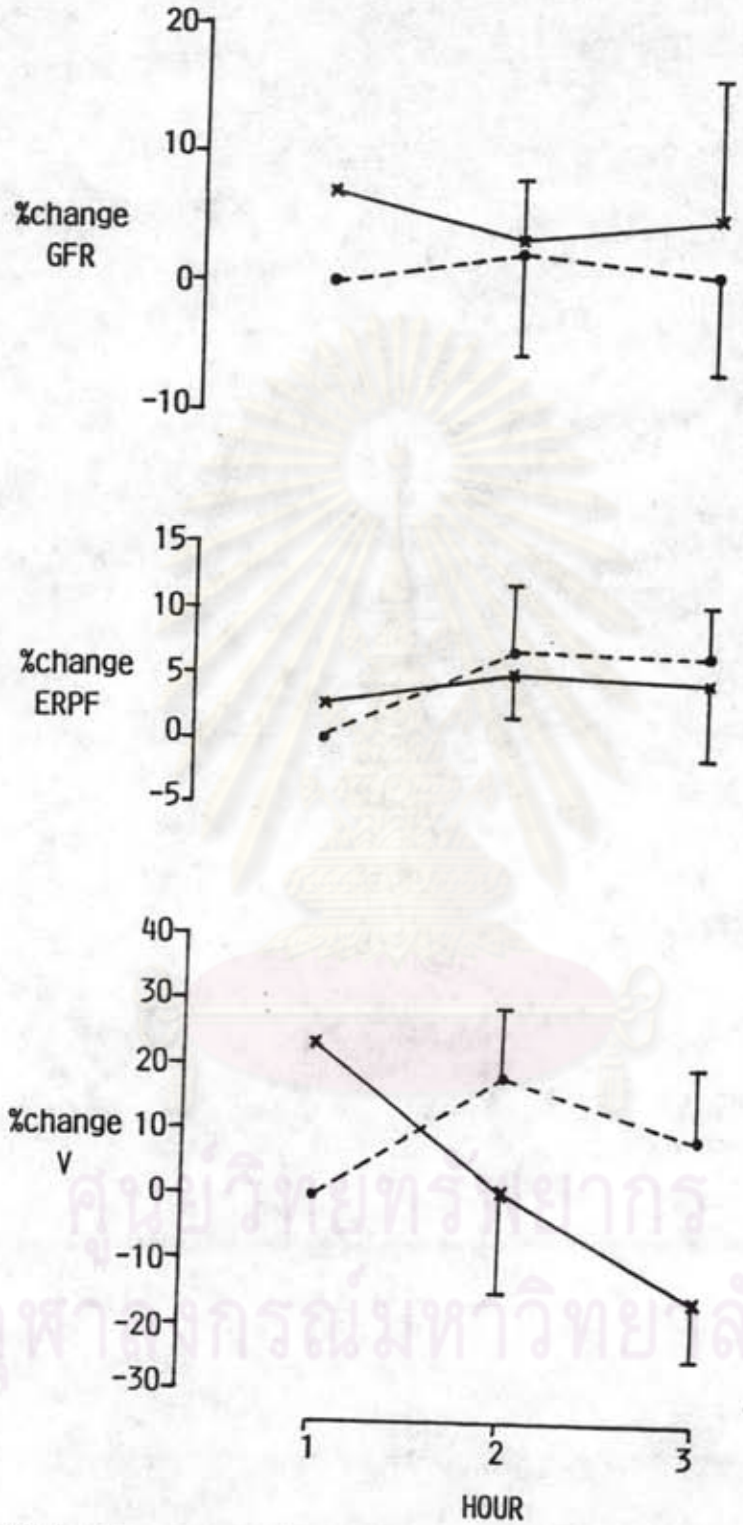

Fig 4 Mean percent changes of glomerular filtration rate (GFR), effective renal plasma flow (E RPF) and urine flow rate (V) of five swamp buffaloes during control (●--●) and heat exposure (×—×) period. The values are mean ± S.E. No significant difference ($P < 0.05$) were noted from the first hour value during control period and pre-exposure value during heat exposure period.

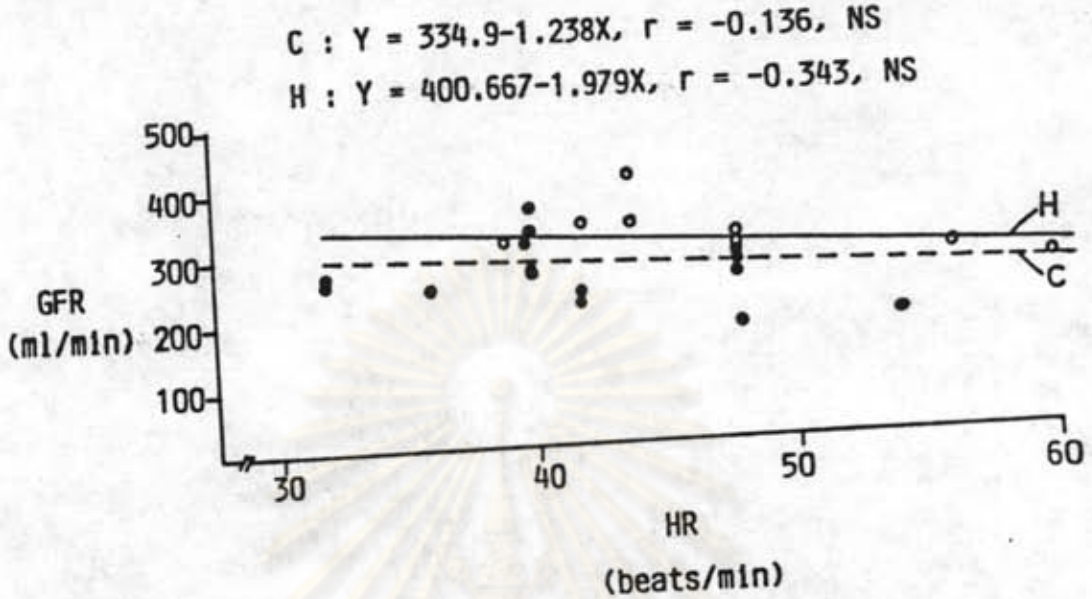

Fig 5 Relationship between heart rate (HR) and glomerular filtration rate (GFR) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant

During the 1^{st} h. of heat exposure, the urine flow rate increased by approximately 23% and it decreased gradually until on the 3^{rd} h. of heat exposure. Since there was not any alteration in plasma urea concentration throughout heat exposure period which had the mean value of 47.2 mg%, the filtered load of urea varied resemble that of GFR. The urinary urea excretion and renal urea clearance increased slightly at the 1^{st} h. of heat exposure by approximately 10% and 8.4% respectively. Therefore, the calculated urea reabsorption increased slightly during heat exposure period. There was a positive correlation between urine flow rate and renal urea clearance during control period ($P < 0.01$) (Fig 6).

Table V provided the data of renal electrolyte excretions. The significant increase in fractional K^+ excretion was determined at the 1^{st} h. of heat exposure. The similar trend were also observed for Cl^-, Ca^{2+} and P_i excretion which had the tendency to increase at the 1^{st} h. of heat exposure and decreased gradually thereafter without any alteration under control period (Fig 8, 9). It has been shown that the filtered load of Na^+, K^+, Cl^- and Ca^{2+} did not significantly change during heat exposure but the marked reduction of filtered load of phosphate coincided with the decrease in plasma P_i was determined. There was a significant positive correlation between urine flow rate and fractional excretion of K^+ during both control and heat exposure period (Fig 7). However,it has been shown that the fractional excretion of all electrolytes did not correlate with plasma glucose concentration (Fig 10, 11, 12, 13, 14).

There was an increase in osmolar clearance during animal exposed to heat without any change during control period. The free water clearance slightly decrease during heat exposure (Fig 15). The negative correlation between urea reabsorption and C_{H_2O} was determined only during

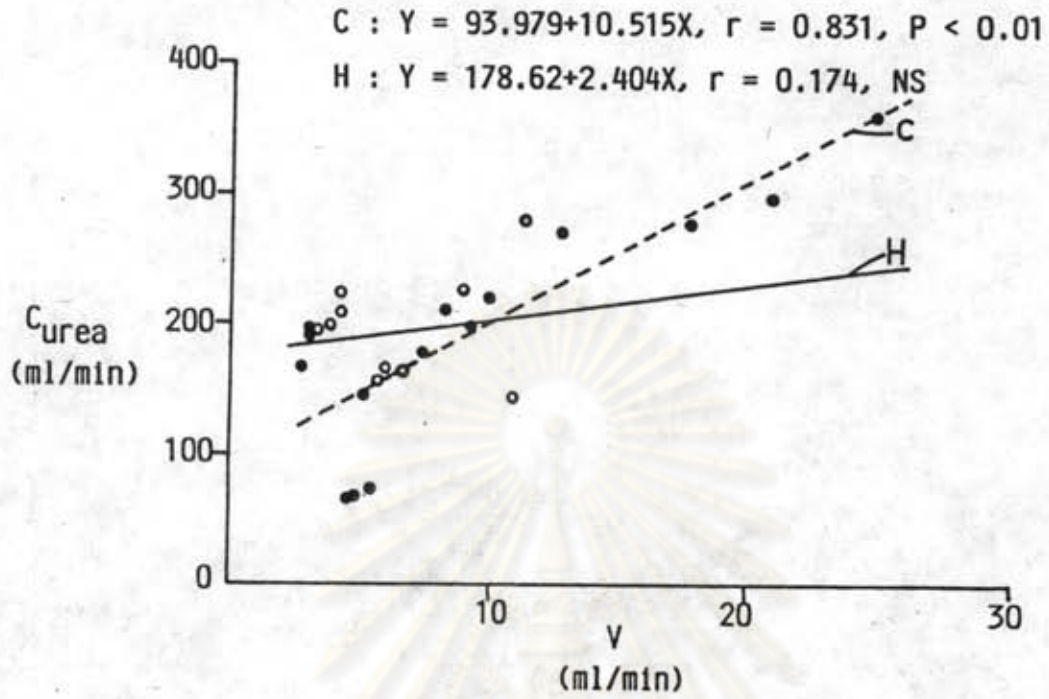

Fig 6 Relationship between urine flow rate (V) and renal urea clearance (C_{urea}) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant.

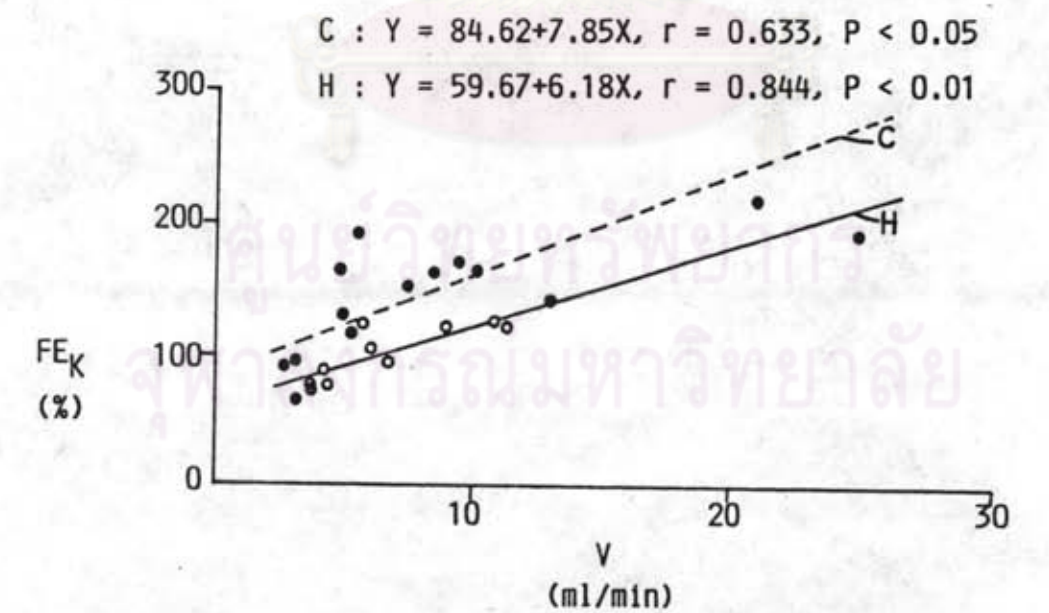

Fig 7 Relationship between urine flow rate (V) and fractional potassium excretion (FE_K) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant.

Table V Changes of renal electrolyte excretion, osmolar clearance and free water clearance of five swamp buffaloes during control and heat exposure period. (Mean ± S.D)

	Control period			Heat exposure period			
	1 h	2 h	3 h	0	1 h	2 h	3 h
$U_{Na}V$ (mEq/min)	0.153±0.167	0.202±0.207	0.204±0.212	0.320±0.302	0.343±0.394	0.215±0.139	0.217±0.136
$U_{K}V$ (mEq/min)	1.914±1.179	1.883±0.985	1.898±0.851	1.181±0.648	1.396±0.644	1.324±0.528	1.173±0.455
$U_{Cl}V$ (mEq/min)	1.336±1.055	1.324±0.959	1.353±0.819	1.208±0.399	1.484±0.740	1.196±0.638	1.052±0.614
$U_{Ca}V$ (mg/min)	0.387±0.378	0.406±0.424	0.445±0.532	0.929±0.391	1.091±0.551	0.872±0.688	0.730±0.448
$U_{Pi}V$ (mg/min)	0.031±0.011	0.031±0.012	0.034±0.021	0.046±0.028	0.079±0.094	0.085±0.127	0.048±0.033
FE_{Na} (%)	0.414±0.457	0.508±0.435*	0.554±0.516**	0.923±1.008	0.852±1.020	0.548±0.343	0.538±0.315
FE_{K} (%)	130.61±41.08	154.92±44.55	193.65±124.87	87.53±26.92	103.51±25.86*	106.64±22.44	93.43±20.60
FE_{Cl} (%)	4.325±2.638	4.459±2.355	4.807±2.175	4.130±1.445	4.524±2.061	3.813±1.906	3.378±1.822
FE_{Ca} (%)	1.489±1.337	0.979±1.226	1.693±1.924	4.061±2.167	5.023±3.211	3.879±3.301	2.946±1.807
FE_{Pi} (%)	0.233±0.075	0.248±0.076	0.255±0.090	0.305±0.142	0.466±0.312	0.439±0.439	0.340±0.143
C_{Osm} (ml/min)	21.886±11.954	21.153±11.371	21.837±9.869	17.070±5.495	20.020±7.679	19.027±7.604	17.381±6.038
C_{H_2O} (ml/min)	-12.342±4.331	-11.073±3.752	-13.113±4.701	-9.996±2.940	-11.253±5.160	-11.851±4.944	-11.512±4.021

P-value with respect to the first hour value during control period and pre-exposure value during heat exposure period;

* $P < 0.05$, ** $P < 0.01$.

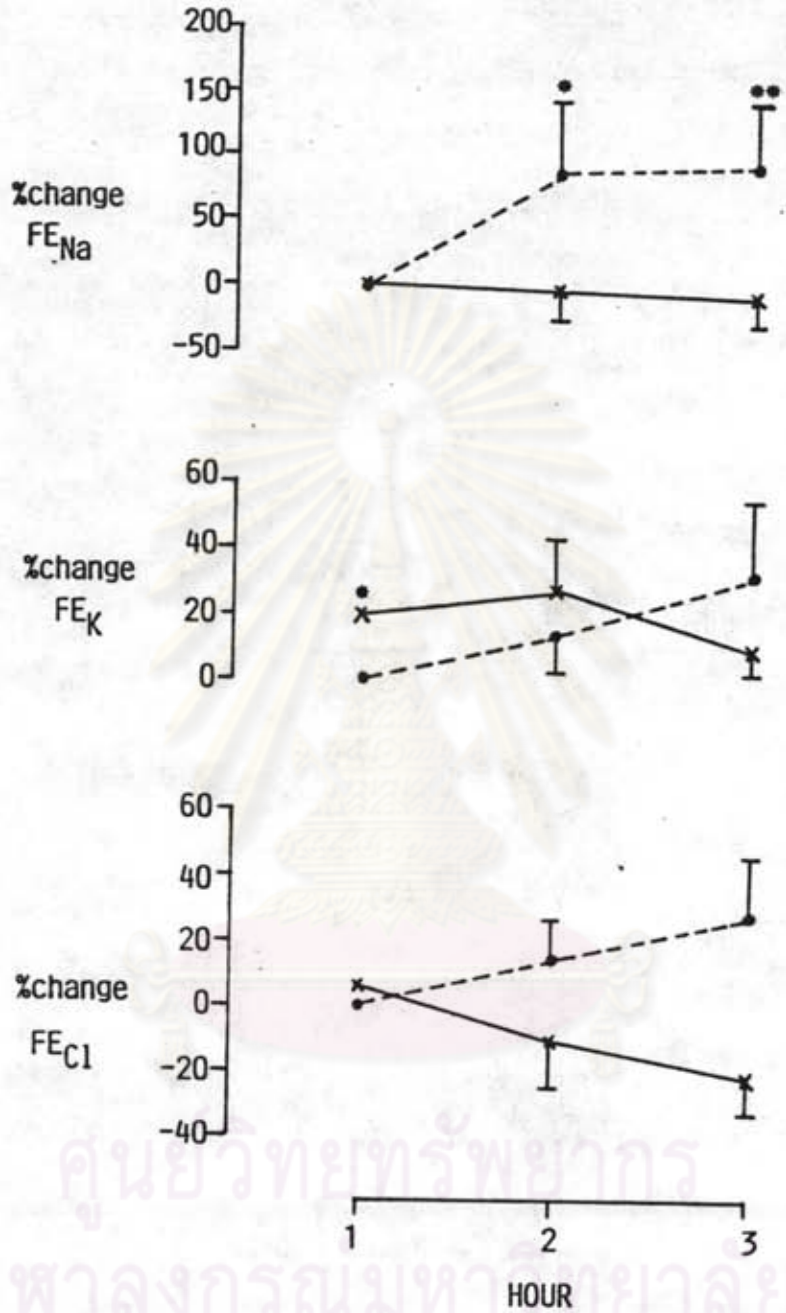

Fig 8 Mean percent changes of fractional excretion of sodium (FE_{Na}), potassium (FE_{K}) and chloride (FE_{Cl}) of five swamp buffaloes during control (●--●) and heat exposure (×—×) period. The values are mean ± S.E. P-value with respect to the first hour value during control period and pre-exposure value during heat exposure period; ● $P < 0.05$, ●● $P < 0.01$

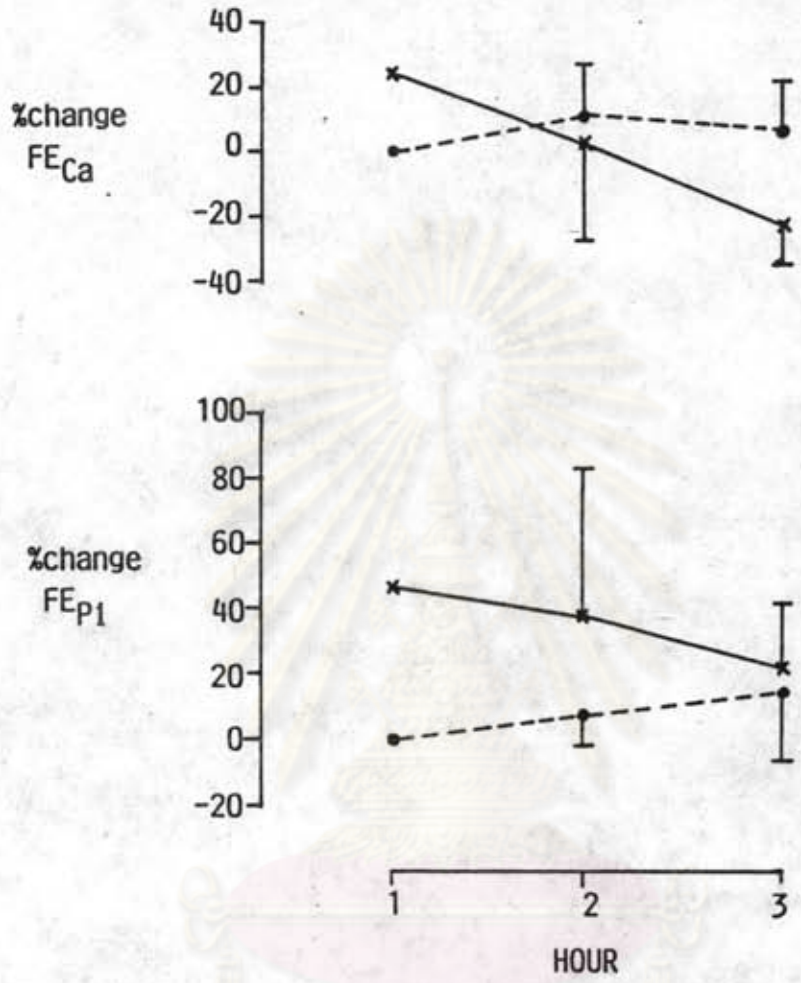

Fig 9 Mean percent changes for fractional excretion of calcium (FE_{Ca}) and inorganic phosphate (FE_{Pi}) of five swamp buffaloes during control (●--●) and heat exposure (×—×) period. The values are mean $\pm$ S.E. No significant difference ($P < 0.05$) were noted from the first hour value during control period and pre-exposure value during heat exposure period.

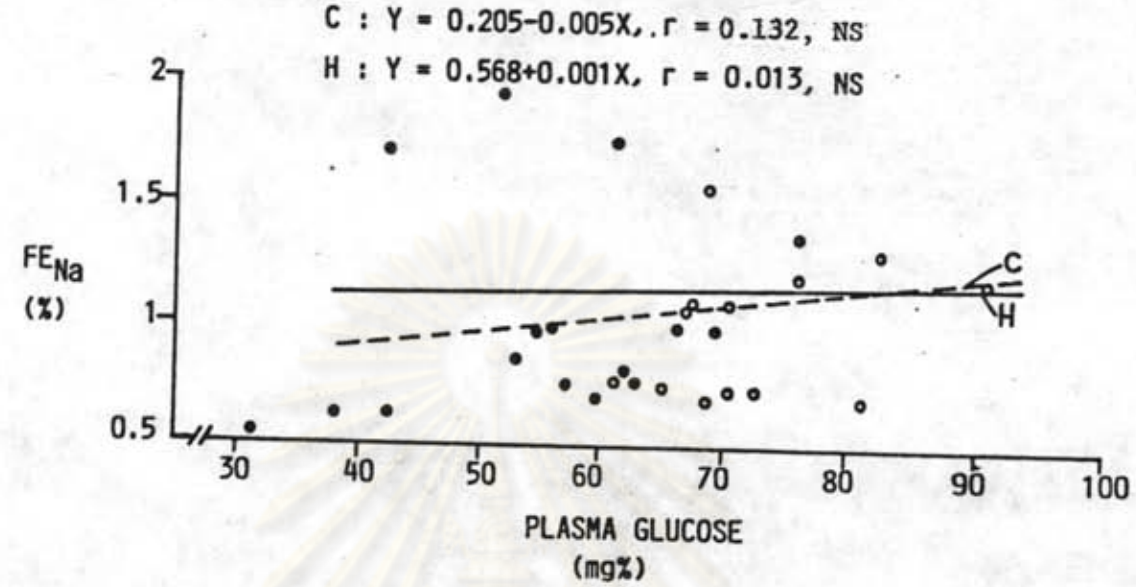

Fig 10 Relationship between plasma glucose concentration and fractional sodium excretion (FE_{Na}) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant

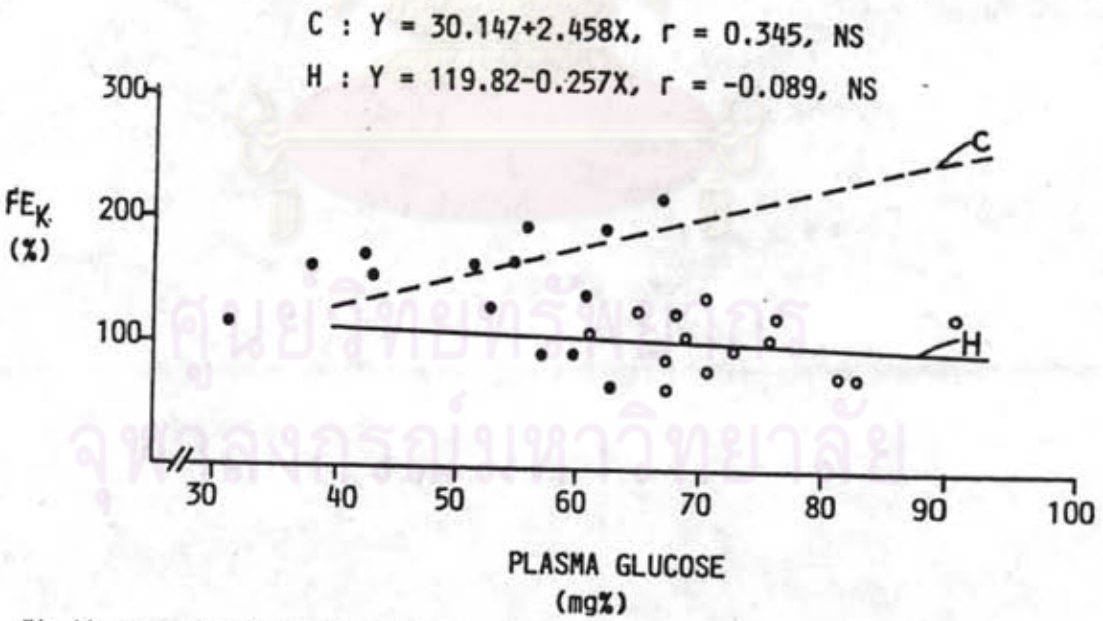

Fig 11 Relationship between plasma glucose concentration and fractional potassium excretion (FE_K) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant

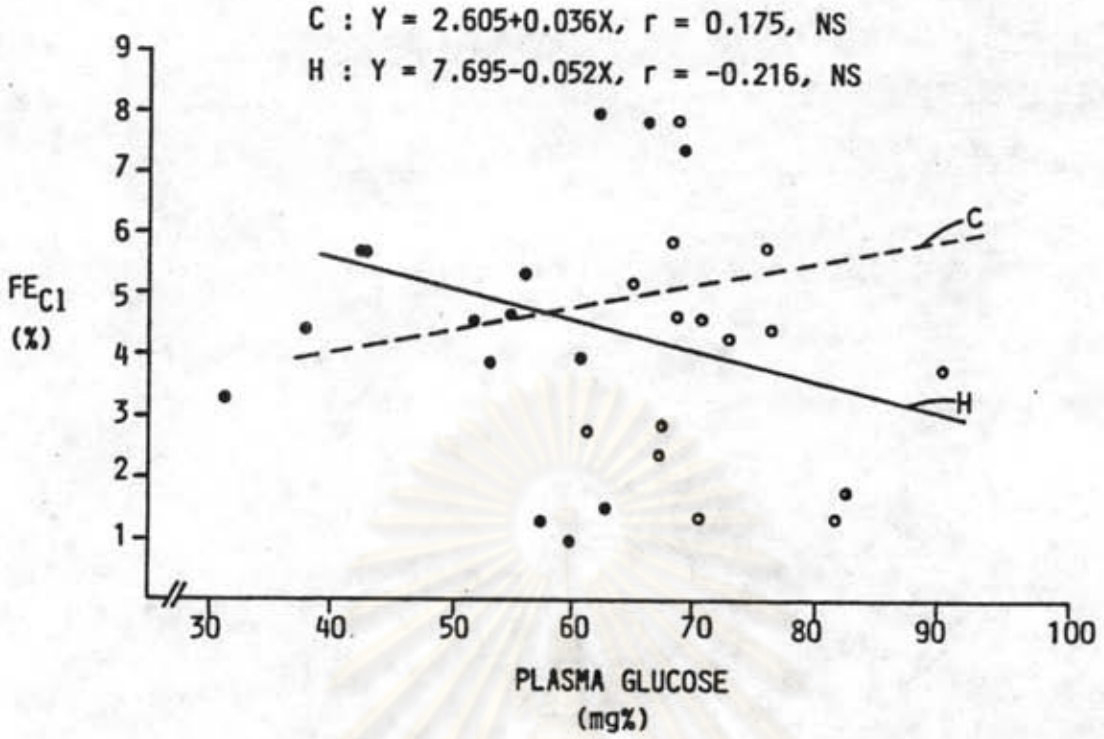

Fig 12 Relationship between plasma glucose concentration and fractional chloride excretion (FE_{Cl}) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant

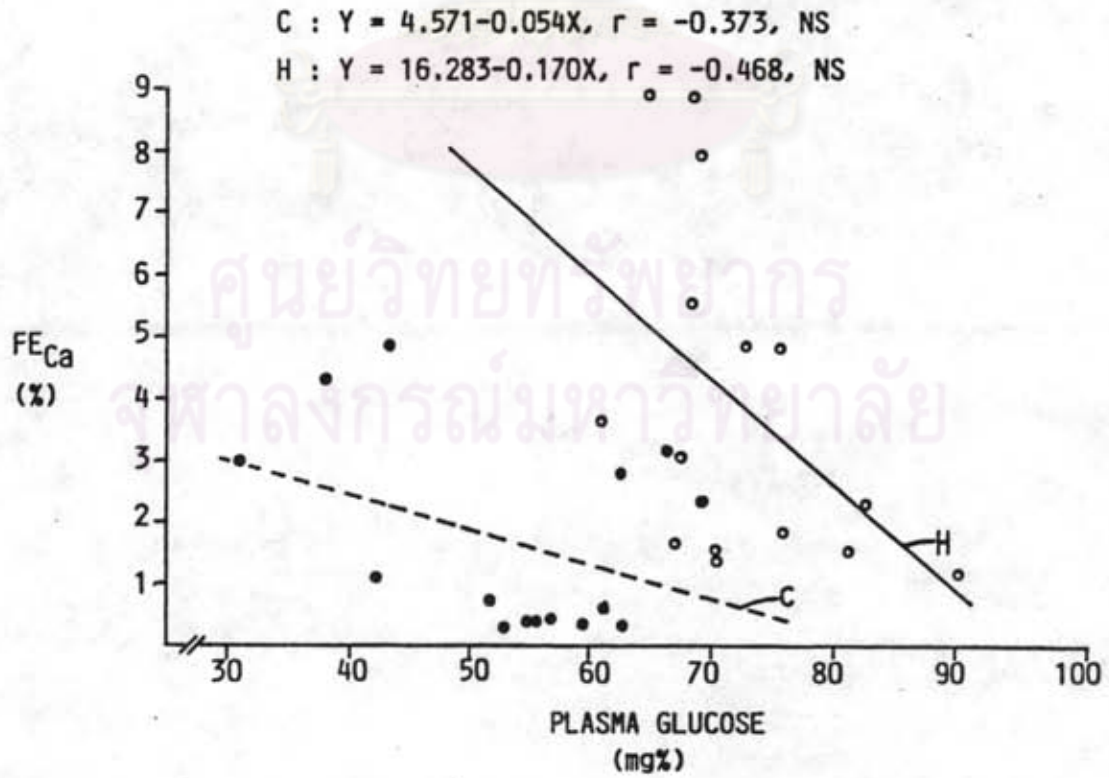

Fig 13 Relationship between plasma glucose concentration and fractional calcium excretion (FE_{Ca}) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control, H = heat exposure period, NS = not significant

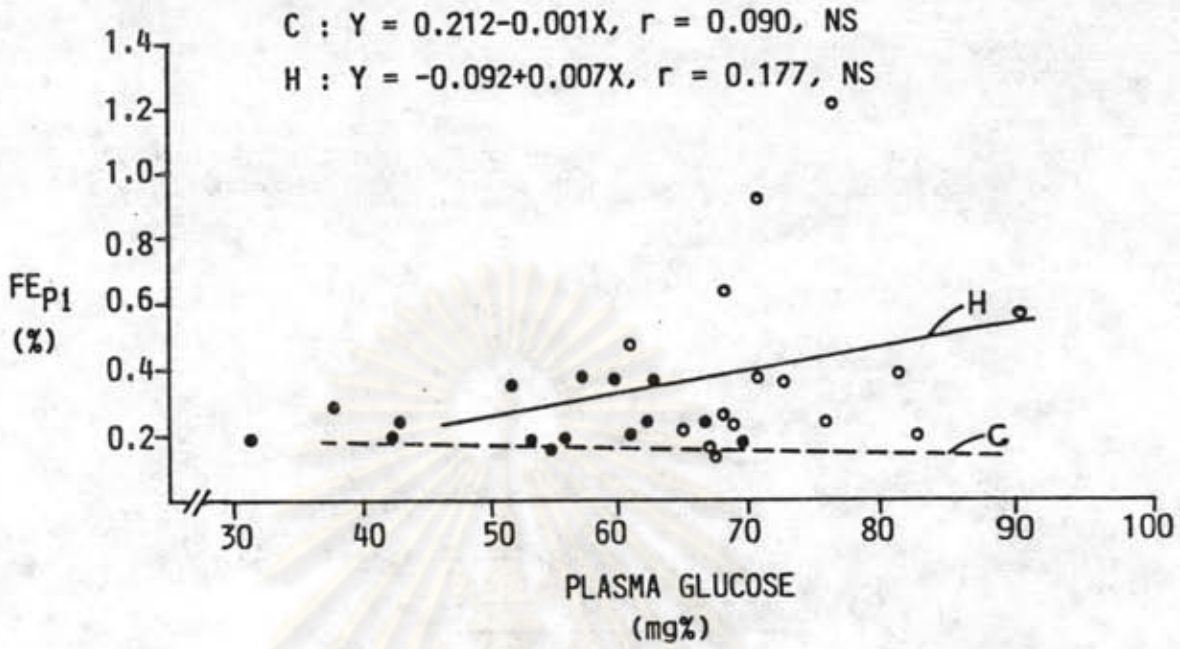

Fig 14 Relationship between plasma glucose concentration and fractional excretion of inorganic phosphate (FE_{Pi}) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant

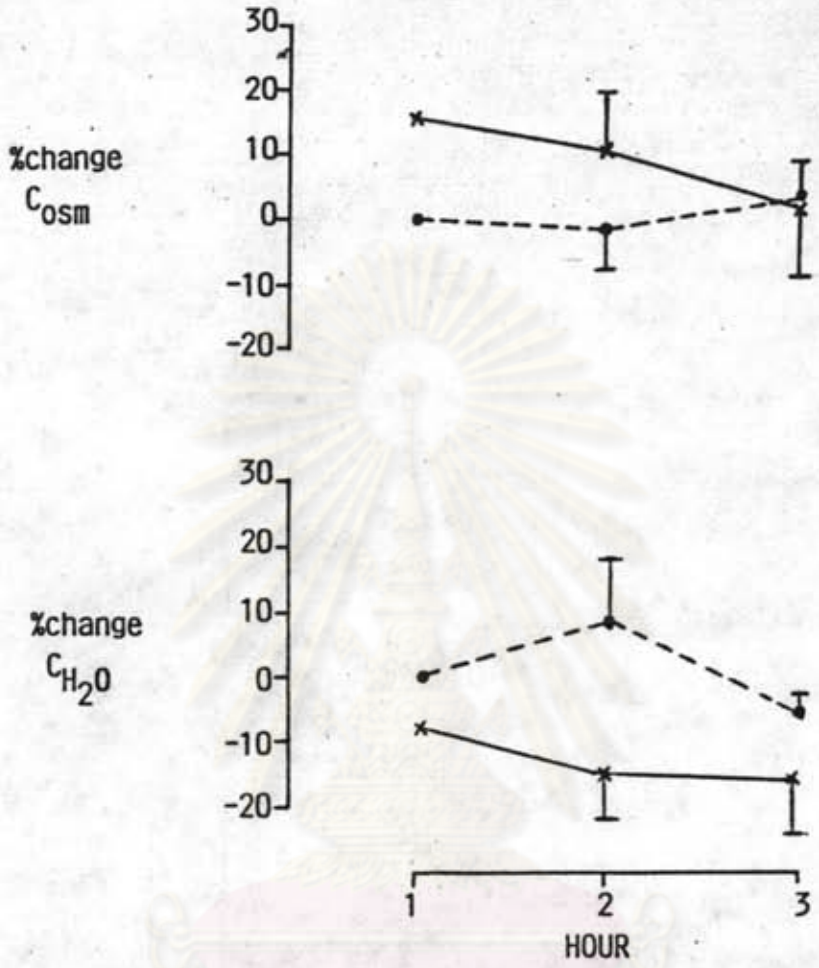

Fig 15 Mean percent changes for osmolar clearance (Cosm) and free water clearance (C_{H_2O}) of five swamp buffaloes during control (●—●) and heat exposure (×—×) period. The values are mean ± S.E. No significant difference ($P < 0.05$) were noted from the first hour value during control period and pre-exposure value during heat exposure period.

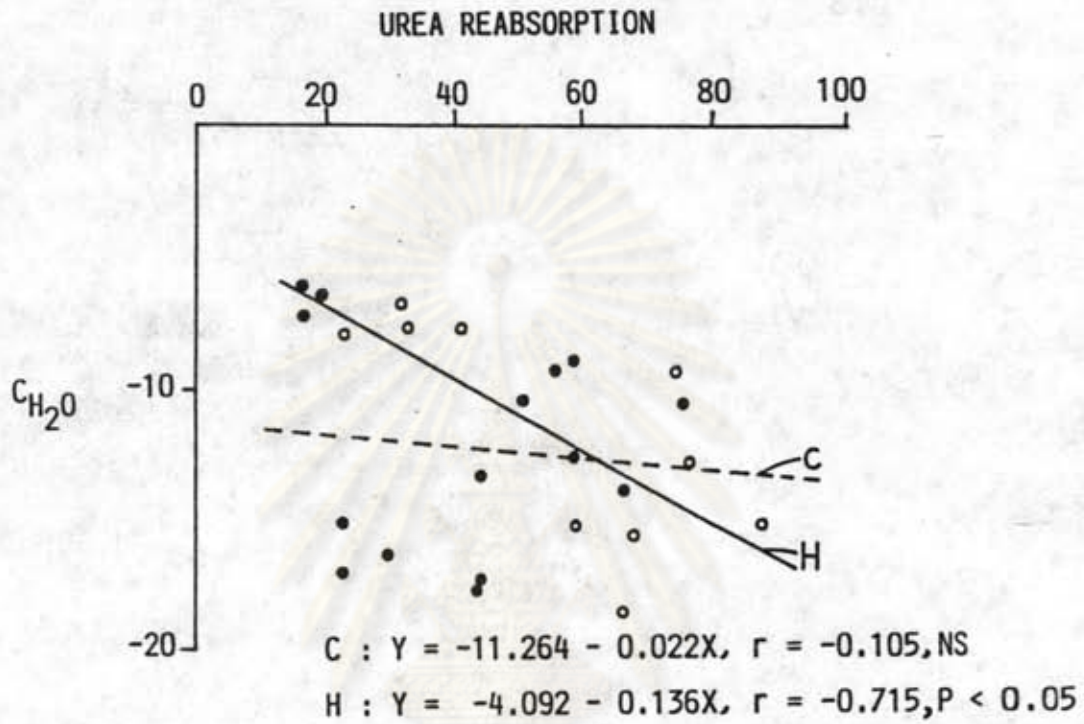

Fig 16 Relationship between urea reabsorption and free water clearance (C_{H_2O}) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant

heat exposure period ($P < 0.05$) (Fig 16).

Changes of plasma constituents during heat exposure (Table VI)

The results in Table VI indicate that a rise in body rectal temperature was consistent with a significant increase in plasma glucose concentration on the 2nd and 3rd h. of heat exposure. There was a slight increase in plasma glucose concentration during control period which was not statistically significant. A corresponding increase in total plasma protein concentration was also observed in animals exposed to heat (Fig 17). This change was obvious after 1 h. of heat exposure from 9.12 ± 0.23 gm% upto 9.58 ± 0.33 gm%. The plasma albumin concentration tended to increase by 10.3% in comparison to that from the preexposed value. However, the globulin fraction remained constant, thus A/G ratio exhibited a tendency to increase. No remarkably changes of plasma protein, globulin and albumin concentration have been noted in animals during control period.(Fig 18).

There was a negative correlation ($P < 0.01$) between total plasma protein concentration and urinary total nitrogen excretion in buffalo during control period ($P < 0.01$) (Fig 20). However, this relationship did not occur during heat exposure period.

Plasma creatinine concentration showed a gradual increase during the first 2 h. of heat exposure. The marked increase was observed at the 3rd h. of heat exposure from 1.54 ± 0.30 mg% to 1.64 ± 0.30 mg% which was about 10% increase prior to heat exposure ($P < 0.05$). No significant change of plasma creatinine concentration was noticed in the control period. The positive correlation of plasma creatinine concentration and urinary non urea nitrogen excretion was determined during control period (Fig 19). The pattern of relationship was the same as that between

Table VI Changes of plasma constituents of five swamp buffaloes duirng control (C) and heat exposure period (H).

(Mean ± S.D.)

		time (min)					
		0	30	60	90	120	150
Plasma glucose concentration	C	49.1±7.3	51.8±3.1	49.6±12.9	55.2±11.1	55.3±10.7	56.3±10.1
(mg%)	H	59.8±8.6	63.3±9.6	67.3±3.6	66.9±7.2	64.4±4.2*	80.6±6.8**
Total protein concentration	C	9.78±0.98	9.87±1.10	9.70±0.69	9.72±0.99	9.87±0.92	9.68±0.91
(gm%)	H	9.12±0.28	9.14±0.48	9.50±0.36	9.59±0.36*	9.55±0.26**	9.58±0.33
Plasma globulin concentration	C	5.40±0.70	5.21±0.55	5.41±0.56	5.22±0.68	5.27±0.68	5.27±0.74
(gm%)	H	5.12±0.46	5.28±0.33	5.27±0.25	5.26±0.17	5.14±0.41	5.25±0.48
Plasma albumin concentration	C	4.38±0.62	4.66±0.62	4.28±0.58	4.50±0.37	4.59±0.79	4.40±0.49
(gm%)	H	4.00±0.38	3.86±0.61	4.23±0.57	4.33±0.26	4.41±0.30	4.34±0.44
A/G ratio	C	0.820±0.147	0.895±0.076	0.800±0.157	0.869±0.080	0.888±0.225	0.853±0.155
	H	0.791±0.147	0.737±0.148	0.809±0.147	0.822±0.043	0.866±0.116	0.836±0.143
Plasma creatinine concentration	C	1.42±0.25	1.39±0.27	1.39±0.30	1.41±0.23	1.35±0.25	1.41±0.23
(mg%)	H	1.54±0.28	1.58±0.28	1.56±0.35	1.55±0.37	1.61±0.32	1.64±0.28*
Plasma Triacylglycerol concentration	C	18.50±7.66					16.53±3.77
(mg%)	H	14.79±5.61					11.62±4.58

P-value with respect of t_o of the same period; * $P < 0.05$, ** $P < 0.01$.

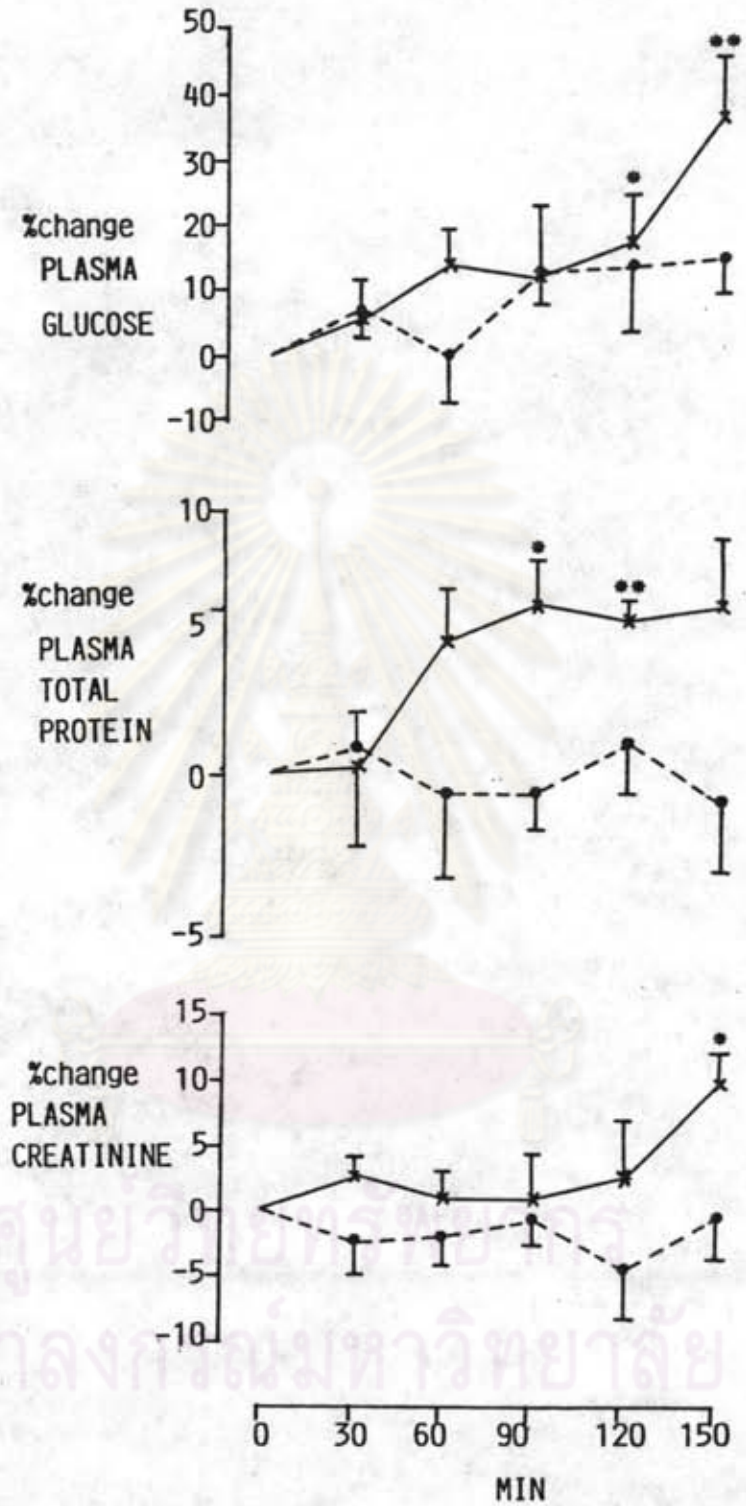

Fig 17 Mean percent changes for plasma glucose, plasma protein and plasma creatinine concentration of five swamp buffaloes during control (●--●) and heat exposure (✕—✕) period. The values are mean ± S.E. P-values with respect to pre-exposure value; ● $P < 0.05$, ●● $P < 0.01$

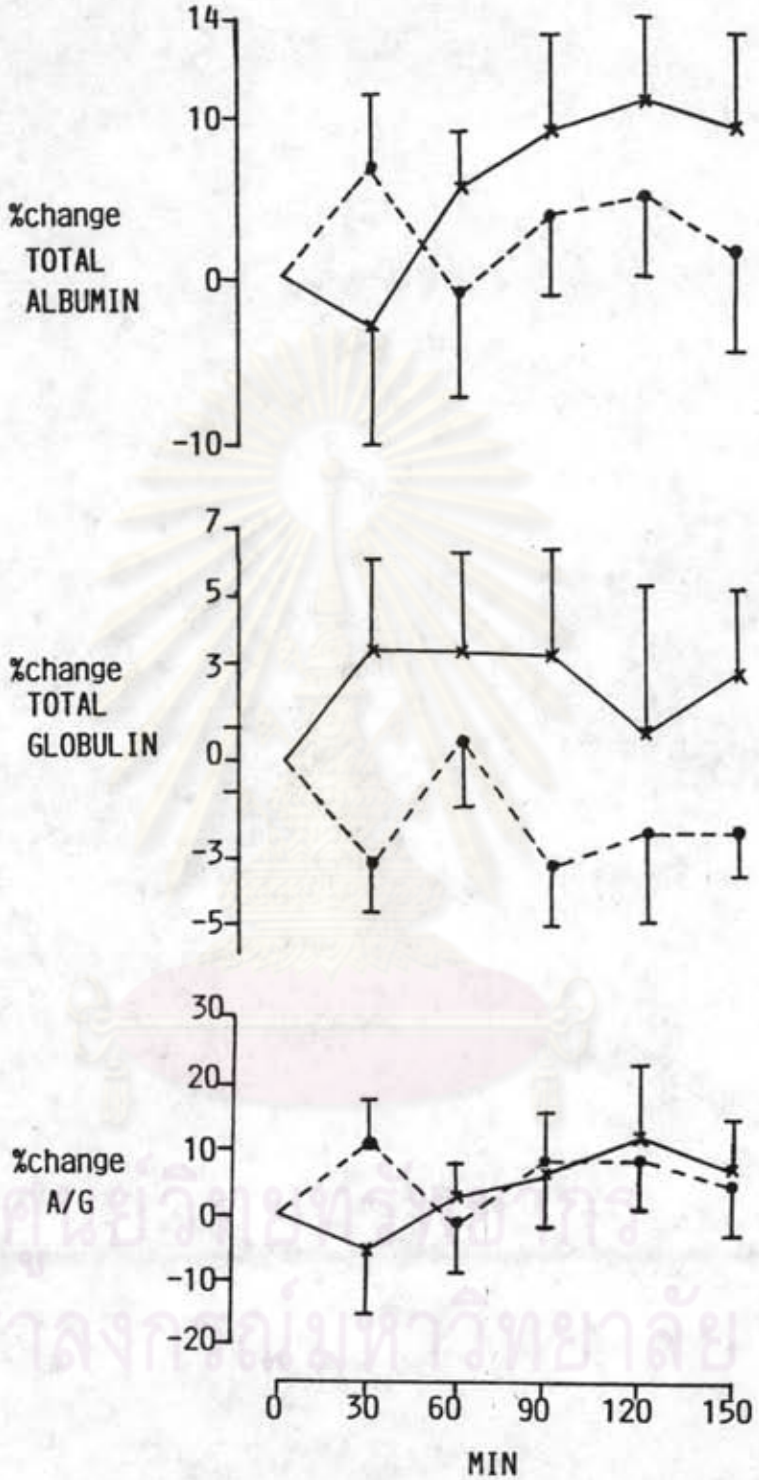

Fig 18 Mean percent changes for plasma albumin concentration, plasma globulin concentration and albumin-globulin ratio (A/G) of five swamp buffaloes during control (●--●) and heat exposure (✱—✱) period. The values are mean ± S.E. No significant differences ($P < 0.05$) were noted from the initial value during control period and pre-exposure value during heat exposure period.

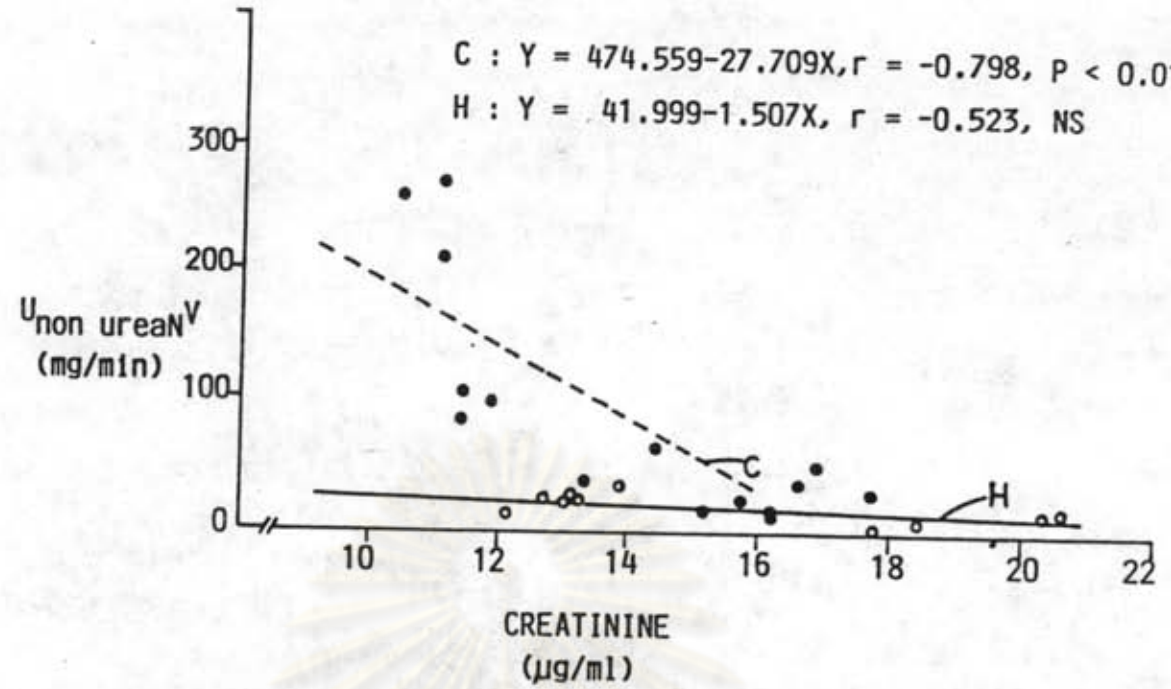

Fig 19 Relationship between plasma creatinine concentration and urinary non urea nitrogen excretion ($U_{\text{non ureaN}}V$) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant.

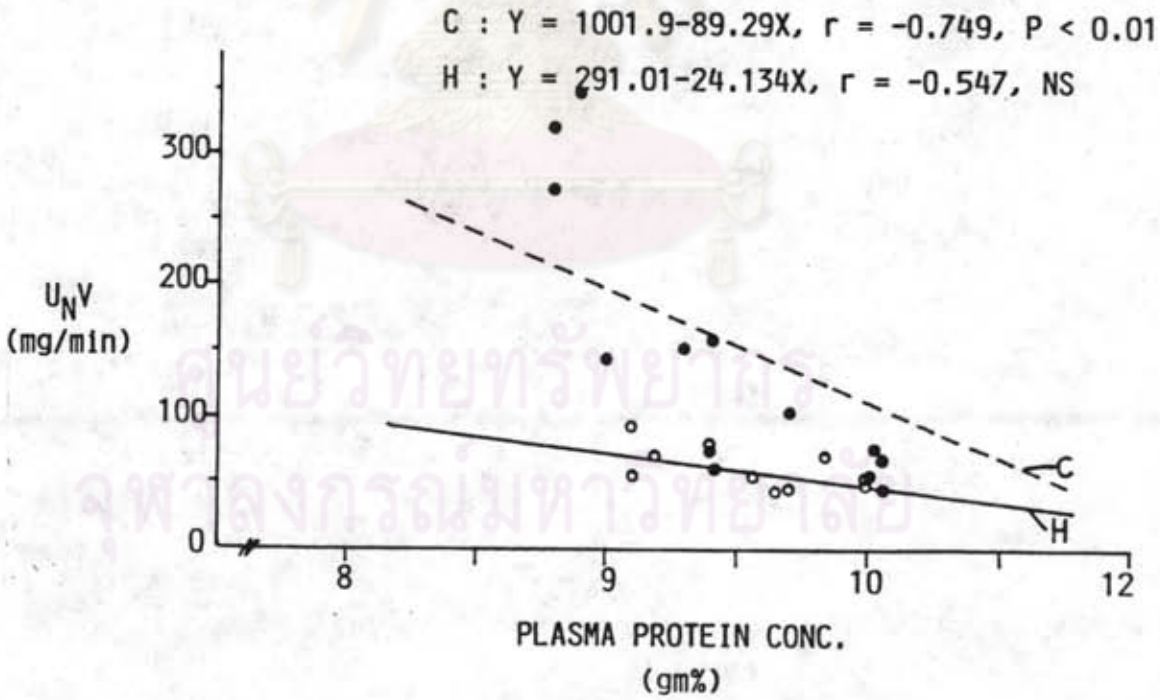

Fig 20 Relationship between plasma protein concentration and urinary total nitrogen excretion ($U_N V$) of five swamp buffaloes during control (●) and heat exposure (○) period. C = control period, H = heat exposure period, NS = not significant.

plasma protein concentration and $U_N V$.

Plasma triacylglycerol concentration tended to decrease though not statistically significant during 3 h. of acute heat exposure by approximately 21.4% in comparison with the preexposure period. The results from Table VII show that plasma Na^+ and Cl^- concentration exhibited no change during both control and heat exposure period. However, plasma K^+, Ca^{2+} and P_i apparently reduced during heat exposure. Plasma inorganic phosphate decreased significantly by approximately 14% at the 3^{rd} h. of heat exposure ($P < 0.05$). No significant decrease of plasma inorganic phosphate was apparent in the control period (Fig 21, 22).

Table VII Changes of plasma electrolytes (Na^+, K^+, Cl^-, Ca^{2+} and P_i) concentrations of five swamp buffaloes during control (C) and heat exposure period (H). (Mean $\pm$ S.D.)

		time (min)					
		0	30	60	90	120	150
P_{Na}	C	127.4±12.9	132.8±4.8	134.2±5.5	133.0±7.1	132.6±8.6	133.4±9.7
(mEq/l)	H	138.2±4.0	133.8±2.6**	137.0±3.4	136.2±3.5	137.0±4.6	135.4±3.9
P_K	C	4.38±0.66	4.70±0.32	4.72±0.38	4.22±0.28	4.36±0.47	4.16±0.39
(mEq/l)	H	4.62±0.34	4.22±0.44	4.46±0.26*	4.16±0.54	4.32±0.31	4.22±0.42
P_{Cl}	C	93.8±6.7	90.6±8.0	96.2±6.5	97.6±4.2	96.6±6.3	100.0±5.8
(mEq/l)	H	99.6±5.7	99.0±7.1	102.0±2.3	99.4±3.8	97.6±4.0	99.2±6.5
P_{Ca}	C	8.13±0.73	7.82±0.44	8.04±0.95	7.71±0.52	7.78±0.30	7.91±0.67
(mg%)	H	8.63±0.44	8.45±0.51	8.55±0.49	8.48±0.50	8.45±0.33	8.26±0.37
P_{Pi}	C	4.84±1.37	4.44±1.18	4.55±1.01	4.16±0.82	3.97±0.98	4.09±1.45
(mg%)	H	4.68±0.82	4.41±0.82	4.48±0.97	4.42±1.08	4.34±0.64	4.02±0.71*

P-value with respect to t_o of the same period; * $P < 0.05$, ** $P < 0.01$.

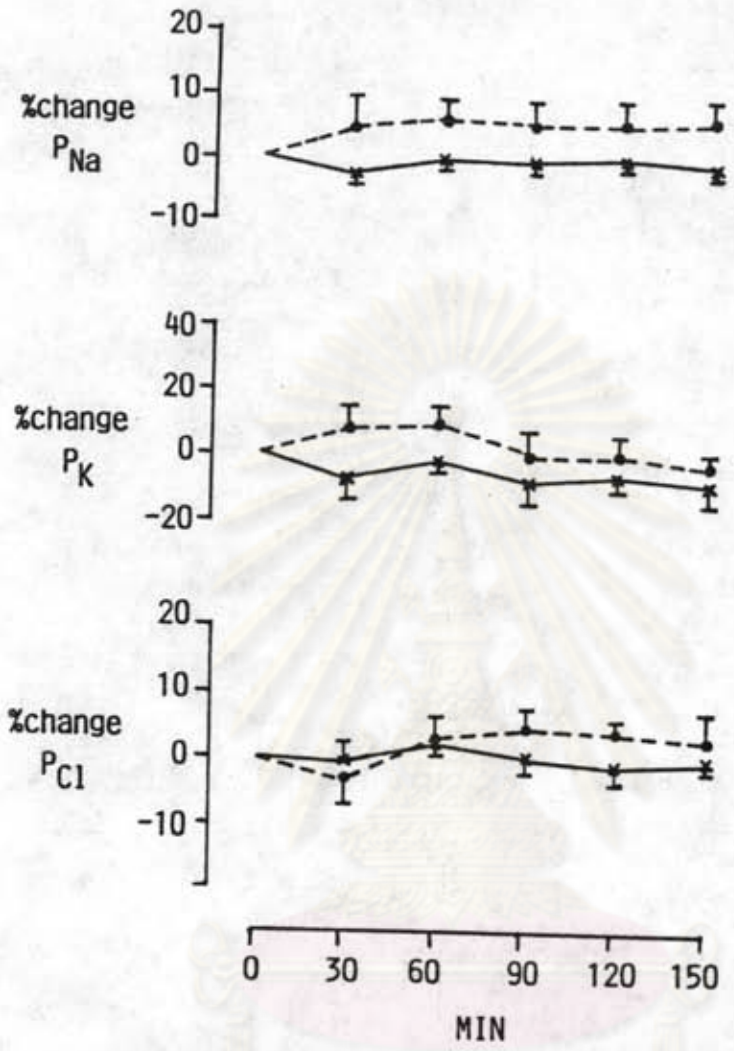

Fig 21 Mean percent changes for plasma sodium (P_{Na}), plasma potassium (P_K) and plasma chloride (P_{Cl}) concentration of five swamp buffaloes during control (●---●) and heat exposure (✱—✱) period. The values are mean ± S.E. No significant differences ($P < 0.05$) were noted from the initial value during control period and pre-exposure value during heat exposure period.

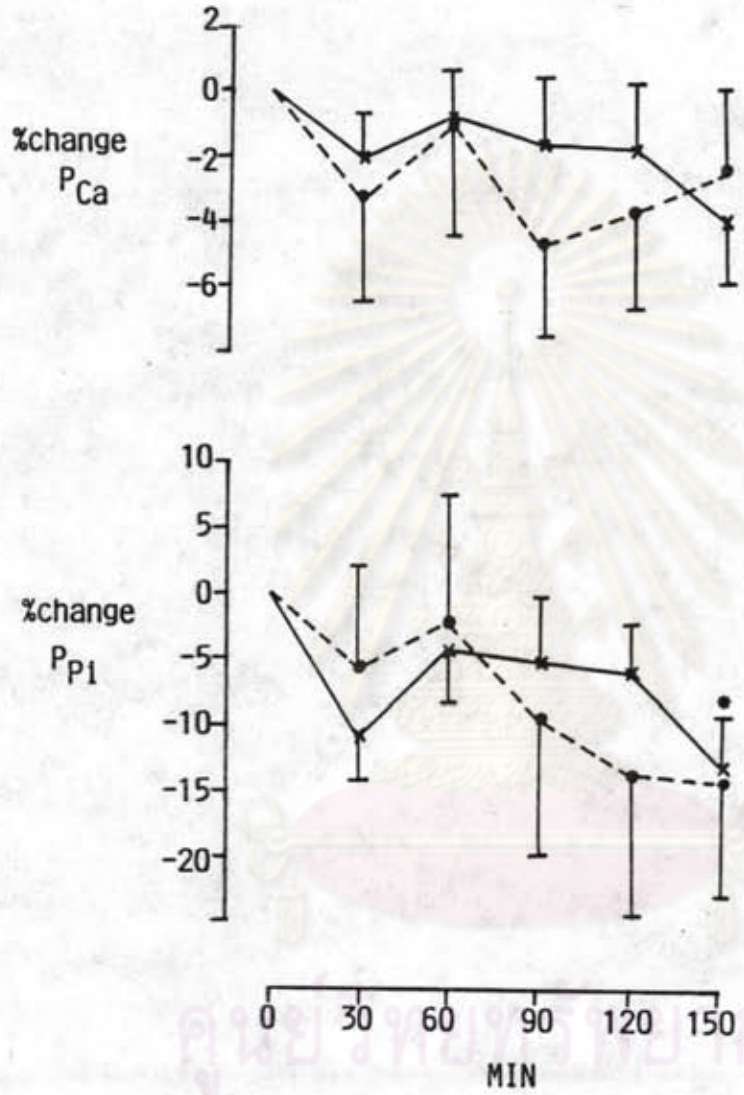

Fig 22 Mean percent changes for plasma calcium (P_{Ca}) and plasma inorganic phosphate (P_{Pi}) concentration of five swamp buffaloes during control (●---●) and heat exposure (✱—✱) period. The values are mean ± S.E. P-values with respect to pre-exposure value; ● $P < 0.05$