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PHYSIOLOGICAL AND HORMONAL RESPONSES OF EGYPTIAN BUFFALO TO DIFFERENT CLIMATIC CONDITIONS

Y.M. Hafez[1], M.O. Taki[2], A.A. Baiomy[3], M.A. Medany[2] and S. Abou-Bakr[1]

1- Department of Animal Production, Faculty of Agriculture, University of Cairo, 12613, Giza, Egypt, 2- Central Laboratory for Agricultural Climate, Agricultural Research Center, Ministry of Agriculture & Land Reclamation, Giza, Egypt, 3- Department of Animal Production, Faculty of Agriculture, University of South Valley, Qena

SUMMARY

This experiment was conducted in two farms at Qena and Giza Governorates, aiming to investigate the effect of two different climatic conditions of Egypt on some hormonal and physiological responses of Egyptian buffaloes. A total of sixteen multiparous lactating buffaloes (3 to 6 parities) were assigned to this experiment, six from Giza farm and ten from Qena farm. The physiological measurements were taken twice fortnightly at 0900 h and 1600 h. Blood samples were collected from buffaloes fortnightly at 0900 h before the morning feeding during the whole experimental period (from July to September) and analyzed for blood plasma total thyroxine (TT4), total triiodothyronine (TT3) and cortisol. Weather data were collected to calculate Temperature Humidity Index (THI) for the two relevant climatic regions.

Morning rectal temperature values were significantly the highest ($p < 0.05$) in buffaloes from Qena farm, meanwhile, evening as well as the overall mean rectal temperatures did not differ significantly. All the measures of skin temperature were significantly higher ($p < 0.05$) in buffaloes from Qena farm than those of Giza farm except ear temperature at the evening which did not differ significantly between the two regions. Respiration rate at the morning and the evening showed a reversed trend where it was significantly ($p < 0.05$) higher at the morning in the buffaloes from Qena than those from Giza farm. The Concentration of plasma total Triidothyronine (TT3) was significantly higher ($p > 0.05$) in buffaloes from Qena farm than those from Giza, but there were no significant differences in the concentration of total Thyroxin (TT4), TT4/TT3 ratio and Cortisol. The THI was positively correlated to skin temperature.

In conclusion, relevant hormonal and physiological responses of Egyptian buffalo were good indicator to the homeostatic reactions due to the climatic conditions in the current study.

Keywords: thyroxine, triiodothyronine, cortisol, THI, skin temperature, rectal temperature

INTRODUCTION

Buffalo is the main dairy cattle in Egypt, in addition to being an important source of meat. Annual milk and meat production from buffalo are 2,641,000 and 375,000 ton respectively, contributing to 44.16 and 39.02% of total milk and meat national production in Egypt, respectively (MALR, 2008). According to the agro-metrological map, Egypt was classified to nine climatic regions (CLAC, 2010), two of them were considered in this study.

The temperature–humidity index (THI) is a measurement of heat stress including the degree of temperature and relative humidity (RH %) (Mader *et al*., 2006). Body temperature and respiratory rate were recommended to be used as parameters to judge heat stress in cattle, all together with THI values to determine and evaluate heat stress in cattle (Du Perez, 2000, Verma *et al*., 2000 and Mader *et al*., 2006).

The ideal or optimum climatic conditions for growth and reproduction in buffaloes are: air ambient temperatures of 13–18°C combined with an average relative humidity of 55–65%, a wind velocity of 5–8 km/h and a medium level of sunshine. Buffaloes have less physiological adaptation to extremes of heat and cold than the various breeds of cattle and have their behavioral means toward the homeostasis (Marai and Habeeb, 2010). Body temperature of buffaloes is actually slightly lower than those of cattle. Also, buffalo skin has one-sixth of the density of sweat glands that cattle skin has, so buffaloes dissipate heat poorly by sweating. If worked or driven excessively in hot conditions, a buffalo's body temperature, pulse rate, respiration rate and general discomfort increase more quickly than those of cattle. During a trial in Egypt, 2 h direct exposure to the sun caused the temperature of the buffalo to rise by 1.3ºC, whereas temperatures of cattle rose by only 0.2-0.3ºC (Mullick, 1960).

Seasonally, the rectal temperature (RT) and respiration rate (RR) were found to be significantly higher from spring to summer and in summer than that in winter in Egyptian buffaloes. The increase in ambient temperature from spring to summer (29 to 31 °C) resulted in an increase in RT from 37.9 to 39.7 °C and RR from 23.4 to 41.0 breaths/min, respectively in lactating buffaloes (Kamal and Ibrahim, 1969 a and b; Kamal *et al*., 1978 and Lacetera *et al*., 2002).

Heat stress also can affect the endocrine system, in lactating buffaloes, plasma T3 concentration decreased significantly ($P < 0.01$) by17.2% with the increase of ambient temperature from 17.5 to 37.1°C (Habeeb *et al*., 2000). Also, plasma T4 exhibited a similar trend to that of plasma T3 (Dwaraknath *et al*., 1984). Plasma cortisol concentrations have been used as a physiological marker of stress. The exposure of non-pregnant buffaloes for 2–3 h to solar radiation at 42.1 °C increased rapidly plasma cortisol concentration for 30 min, followed by a gradual fall (Zhengkang *et al*., 1994).

The objective of this study was to investigate the homeostatic reactions in some hormonal and physiological responses in Egyptian buffaloes due to two different climatic conditions of Egypt.

MATERIALS AND METHODS

This experiment was conducted at two different dairy buffalo farms located at Qena and Giza Governorates that represent two different climatic conditions of Egypt according to the weather data obtained from Central Laboratory for Agriculture Climate (CLAC, 2009). The first farm is located in Qena, Animal Production Department, Faculty of Agriculture, South Valley University. The second one is the Giza farm, the nucleus buffalo herd belonged to Cattle Information System/Egypt (CISE), Faculty of Agriculture, Cairo University.

The study was conducted during summer season from July till September 2009. The average, maximum and minimum Temperature-Humidity Index (THI, LSM ± SE) during the period of study was 74 ± 0.18, 94 ± 0.24 and 59 ± 0.27, respectively in Qena governorate, and 73 ± 0.21, 89 ± 0.25 and 60 ± 0.36, in the same respective order in Giza governorate. Furthermore, the average relative humidity was 43.9 ± 0.25 and 61.1 ± 0.34 in Qena and Giza governorate, respectively.

A total of sixteen multiparous lactating buffalos (3-6 parities) were assigned to this experiment, six from a farm located in Giza governorate and ten from a farm located in Qena governorate. The buffaloes were housed in open yards with metal roofs covered the third of the surface area of the stalls. The feeds were the same in the two farms (alfalfa, Darawa, rice straw, concentrate). Feeding allowances of the lactating buffaloes were calculated due to the production level and the changes in the live body weights according to NRC (NRC, 2001). Drinking water was available ad lib. Licking mineral blocks were made available for animals all the day.

Physiological and environmental measures:

Ambient temperature (Ta,˚C) and relative humidity (RH, %) were measured three times daily (0900h, 1200h and 1600h) during the fortnightly test day visits under the shade using digital thermometer to the nearest 0.1 ˚C and the corresponding data of the climate conditions were obtained from the Central Laboratory for Agriculture Climate (CLAC), Agriculture Research Center (ARC), Ministry of Agriculture & Land Reclamation (MALR), Giza, Egypt.

All climatic data was used to calculate the Temperature- Humidity Index (THI) according to (Mader *et al.*, 2006) as follow:

$$THI = [0.8 \times \text{ambient temperature}] + [(\% \text{ relative humidity} \div 100) \times (\text{ambient temperature} - 14.4)] + 46.4$$

The physiological parameters were taken twice a day (0900h and 1600h) every 14 days through the period of the study. Rectal Temperature (RT) was measured by a clinical thermometer inserted into the rectum to almost its full length for one minutes toward the rectal wall to avoid the contact of the bulb with the faeces. Respiratory Rate (RR) was recorded by visual observation (counting the flank movements up's and down's) and reported as breaths per minute. Skin temperatures (ST) were measured on shaved areas of the rump (RuT), dorsal (DT), nick (NT) and ear (ErT), also, eye temperature (EyT) was measured for each buffalo using a portable infrared thermometer (IRtec Miniray 100, Eurotron, Italy) to the nearest 0.1 ˚C.

Blood samples were collected from the Jugular vein in heparinized tubes fortnightly at 0900 h before the morning feeding during the whole experimental period. Then, the samples were centrifuged at 3000 r.p.m. for 10 minutes to separate blood plasma which was stored at -20˚C for further analysis.

A single antibody radioimmunoassay (RIA) technique was performed to quantify plasma total triiodothyronine (TT3), total thyroxine (TT4) and cortisol concentration by using special kits delivered from IMMUNOTECH radiova, Czech Republic, in Hormones Lab., Faculty of Agriculture Research Park, Giza, Egypt. The technical parameters of the kits used to quantify these hormones are presented in Table 1.

Statistical analysis:

Data were statistically analyzed using the general linear model procedure of SAS (SAS, 2002) by using the following model:

$$\mathbf{Y_{ijk} = \mu + F_i + P_j (F_i) + e_{ijk}}$$

Where: Y_{ijk} = an observation
μ = overall means
F_i = fixed effect of i^{th} farm, i=1, 2 whereas; i=1 Qena farm and i=2 Giza farm
$P_j(F_i)$ = fixed effect of j^{th} visit day nested within i^{th} farm, j=1,2,3,4,5,6,7 whereas j=1 the first visit and j=2 the second visit…….etc.
e_{ijk} = experimental error assumed to be randomly distributed $(0, \sigma_e^2)$

Table 1. Immuno-radiometeric kits used to quantify the relevant hormones in blood plasma of the experimental animals

Hormone	Intra-assay C.V.	Inter-assay (C.V.)	Sensitivity	Reference
Triiodothyronine	6.3%	7.7%	0.3 nmol/L	(Nixon *et al*.,1988)
Thyroxine	6.2%	8.6%	13 nmol/L	(Nixon *et al*.,1988)
Cortisol	5.8%	9.2%	10 nmol/L	(Foster and Dunn, 1974)

RESULTS AND DISCUSSION

Table 2 shows the significance of the effect of the farm and the visit day nested within farm on the relevant studied parameters. The farm affected significantly all traits except TT4, T3/T4, cortisol, RTe and ErTe. While, the visit day nested within farm was significant with all traits except the plasma cortisol level and RRm. The accuracy of the statistical model is ranged between 0.15 and 0.65.

Environmental conditions during the experimental periods:

Mean maximum and minimum ambient temperature (Ta), relative humidity (RH) and calculated temperature humidity index (THI) by the experimental period are shown in Table 3. Qena region which is located at Upper Egypt, characterized by a high Ta and low RH and Giza region that represent the middle of Egypt and characterized by a slightly low Ta and high RH. In Qena, The overall maximum and minimum Ta were 39.3 and 15.2 ºC, respectively with an average of 27.3 ºC and low relative humidity (RH) of 43.9 %. The average THI was 74 ± 0.18 and the number of days having critical THI more than 72 (Bouraoui *et al*., 2002) was 69 days, while, the number of days which having critical THI more than 74 and 69 were 39 and 93 day, respectively. The average Ta and average THI were higher than the critical values of 25 ºC and 72, respectively during period of the study in compare to Giza region In Giza region, RH was high in compare to Qena (61.1 vs. 43.9%, in Giza and Qena, respectively) with maximum and minimum values of 83.6 and 38.6%, respectively. The average THI in Giza was 73 ± 0.21, the number of days which having critical THI more than 72 was 46 day. While, the number of days having critical THI more than 74 and 69 were 24 and 91 day. According to Hahn *et al*, 2003 buffalos in the two regions were not under heat stress, while according to or Mader *et al*., 2006 they are under heat stress in both regions which explain the insignificant difference between regions in RT, RR, cortisol and T4 the main physiological indicators for response to heat stress. The THI and RH data indicate that the buffaloes were exposed to heat stress in most time during the study especially in the Qena governorate in compare to Giza governorate. The upper critical temperature for

Holsteins is ranged between 25 to 26 ºC (Berman *et al*., 1985), cows decrease milk production when THI exceeds the critical comfort level of 72 (Johnson, 1980).

Table 2. The significance of farm and visit day nested within farm on the studied traits

Traits	Farm	Visit day(farm)	R^2
Blood plasma total TT3	0.0102	0.0156	0.29
Blood plasma total TT4		0.0035	0.30
T3/T4 ratio		0.0035	0.31
Blood plasma Cortisol			0.15
Morning rectal temperature	0.0033	<.0001	0.45
Morning rump temperature	<.0001	0.0416	0.56
Morning dorsal temperature	<.0001	<.0001	0.64
Morning neck temperature	<.0001	0.003	0.51
Morning ear temperature	<.0001	0.0007	0.55
Morning eye temperature	<.0001	0.0001	0.65
Morning respiration rate	0.0555		0.19
Evening rectal temperature		<.0001	0.53
Evening rump temperature	0.0066	<.0001	0.49
Evening dorsal temperature	<.0001	<.0001	0.64
Evening neck temperature	<.0001	<.0001	0.58
Evening ear temperature		<.0001	0.48
Evening eye temperature	<.0001	<.0001	0.62
Evening respiration rate	0.0141	0.0037	0.31

Table 3. Average climatic conditions (X± SD) during the experimental periods (from July to September 2009)

Parameters	Qena	Giza
Maximum Temperature (ºC)	39.3 ± 1.79	33.4 ± 1.60
Minimum Temperature (ºC)	15.2 ± 2.48	16.3 ± 2.89
Average Temperature (ºC)	27.3 ± 1.48	24.9± 1.59
Maximum Relative Humidity (%)	63.3 ± 3.37	83.6 ± 3.21
Minimum Relative Humidity (%)	24.4 ± 2.67	38.6 ± 4.56
Average Relative Humidity (%)	43.9± 2.41	61.1 ± 3.29
Maximum daily THI	94 ± 2.30	89 ± 3.29
Minimum daily THI	59 ± 2.63	60 ± 2.40
Average daily THI	74 ± 1.76	73 ± 2.05
Number of days daily THI>74*	39	24
Number of days daily THI>72**	69	46
Number of days daily THI>69***	93	91

*according to Hahn *et al.,* 2003.
**according to Bouraoui *et al*., 2002.
***according to Mader *et al*., 2006.

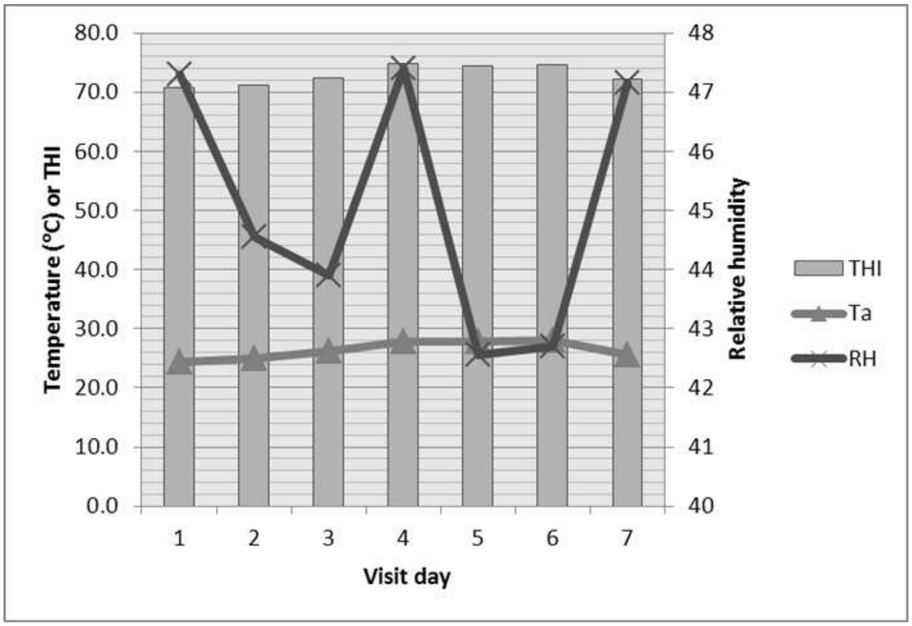

Figure 1. Average daily temperature, relative humidity and THI during the period of the study in Qena Governorate.

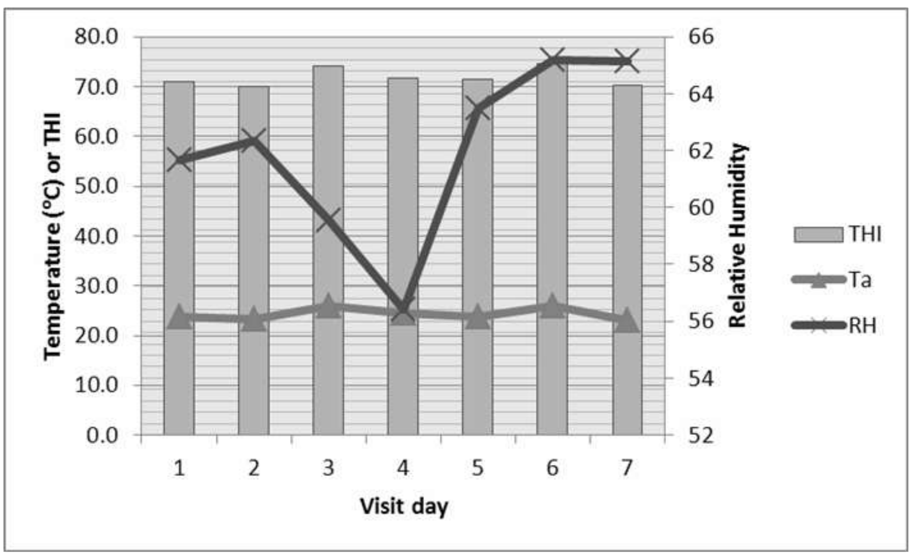

Figure 2. Average daily temperature, relative humidity and THI during the period of the study in Giza Governorate.

Physiological responses to the relevant climatic conditions:

Morning rectal temperature values of the experimental buffaloes were higher ($P<0.05$) in Qena farm than that in Giza farm (Table 4). The mean and evening rectal temperatures were not significantly differing between the two farms. Various studies under field conditions have demonstrated that the rectal temperature (RT) increased with the increase of ambient temperature (AT) (Shafie and El-Sheikh Aly, 1970; El-Gaafrawy *et al*., 2000 and Mostafa, 2007). Zahner *et al*. (2004) showed that the rectal temperature was significantly affected by the THI during the day but not during the night. Moreover, Gudev *et al*. (2007) found that rectal temperature values were higher ($P < 0.01$) during the exposure to direct solar radiation compared to the RT measured in the barn.

All the measures of skin temperature were higher ($P<0.05$) in buffaloes from Qena farm than that in Giza farm except the evening ear temperature was not significantly affected with the climatic conditions. The effect of Ta accompanied by direct solar radiation for 3 h from 12:00 to 15:00 h during August in Egypt on the physiological responses of buffaloes resulted in an increase in absolute values of skin surface temperature by 2.3 °C, (Shafie, 1993). Zahner *et al.* (2004) reported that the THI of the surrounding climate had a significant effect on skin temperature and body surface temperature both during night and day. During the day, the skin temperature was lower at 8:00 than at 12:00 and 16:00 of which the latter two were similar, during summer conditions (Shalaby, 1985 and Yousef, 1985).

The overall average of the respiration rate during the experimental period was not significantly differing but in the morning and the evening were significantly different ($p < 0.05$). The mean of respiration rate in buffaloes from Giza farm was higher than that in Qena farm. Inside each farm, the respiration rate was increased from morning to evening. The same result was observed by Hooda *et al*. (2009). The increase of THI value from 68 to 78 leads to an increase in the respiration rate by 5 inspirations per min (Bouraoui *et al.,* 2002). Brown-Brandl *et al*., 2005 reported that the respiration rate is a more sensitive indicator of heat stress than body temperature. With regard to the effect of humidity, when a load of high relative humidity was superimposed upon an already high ambient temperature, there was a further increase in respiratory frequency in sheep, this increase the perception of warmth. However, Du Preez, (2000) reported that, it is practical to use body temperature and respiratory rate as parameters to determine heat stress in dairy cattle. These physiological parameters must always be used together with THI values to determine and evaluate heat stress in dairy cattle. Accordingly the results indicate that region had no significant effect on buffaloes because THI was almost similar (74 vs. 73).

Table 4. Average Rectal temperature (RT), skin Temperature (ST) and respiration rate (RR) of lactating buffaloes in two different climatic regions of Egypt

Parameters	Qena	Giza
Rectal Temp. (°C)	38.51 ± 0.05[a]	38.38 ± 0.11[a]
Morning Rectal Temp.	38.33 ± 0.06[a]	38.05 ± 0.11[b]
Evening Rectal Temp.	38.68 ± 0.06[a]	38.63 ± 0.14[a]
Skin Temperature		
Rump Temp. (°C)	37.26 ± 0.21[a]	34.90 ± 0.34[b]
Morning Rump Temp.	37.86 ± 0.23[a]	34.27 ± 0.39[b]
Evening Rump Temp.	36.63 ± 0.30[a]	35.49 ± 0.37[b]
Dorsal Temp. (°C)	37.16 ± 0.18[a]	34.71 ± 0.46[b]
Morning Dorsal Temp.	37.57 ± 0.18[a]	34.34 ± 0.47[b]
Evening Dorsal Temp.	36.68 ± 0.24[a]	35.05 ± 0.54[b]
Neck Temp. (°C)	36.68 ± 0.17[a]	34.92 ± 0.31[b]
Morning Neck Temp.	36.86 ± 0.17[a]	34.67 ± 0.34[b]
Evening Neck Temp.	36.43 ± 0.22[a]	35.12 ± 0.37[b]
Ear Temp. (°C)	36.94 ± 0.14[a]	35.56 ± 0.32[b]
Morning Ear Temp.	36.93 ± 0.16[a]	34.54 ± 0.37[b]
Evening Ear Temp.	36.91 ± 0.18[a]	36.55 ± 0.33[a]
Eye Temp. (°C)	36.97 ± 0.09[a]	35.39 ± 0.23[b]
Morning Eye Temp.	37.02 ± 0.12[a]	34.83 ± 0.27[b]
Evening Eye Temp.	36.91 ± 0.12[a]	35.92± 0.24[b]
Respiration Rate (Insp./min)	23 ± 0.8[a]	24 ± 1.12[a]
Morning Respiration Rate	23 ± 0.84[a]	20 ± 1.15[b]
Evening Respiration Rate	23 ± 0.94[a]	27 ± 1.54[b]

Means having different superscript letters within the same row differ significantly ($p>0.05$); Temp.: Temperature; Insp. /min: inspirations per minute.

Hormonal responses to climatic conditions:

The average concentrations of TT4, TT3 and cortisol level in buffaloes from Qena farm were insignificantly high in compare to Giza farm. In contrast, the TT4/TT3 ratio was lower in buffaloes from Qena farm than Giza farm. Magdub, (1982) showed that plasma thyroxine (T4) and triiodothyronine (T3) concentration were lower ($p<0.05$) in cows that are heat stressed (Magdub, *et al*., 1982). However, Rasooli *et al.* (2004) reported that although T3 and T4 both decrease in summer, only T3 had significant negative correlation with mean environmental temperature. Aggarwal and Singh (2010) reported that the average plasma T4 during the hot-dry season was higher in wallowing buffaloes than hot-humid season and T3 also was higher in wallowing buffaloes in hot-dry season than hot-humid season. Khurana (1983) reported that decreased plasma T4 concentration (39.10 ng/ml) in buffaloes during the hot-dry season compared to 41.44 ng/ml during hot-humid season. During hot conditions animals in early lactation have lower level of T4 and T3. Contrary to this, in present study, the plasma T4 and T3 were higher in Qena farm than Giza farm although the ambient temperature was higher in Qena farm than Giza farm but the relative humidity in Giza farm was higher than Qena farm.

Bouraoui *et al*. (2002) showed that THI was positively correlated to cortisol concentration (r = 0.31). As THI increased from 68 to 78, the average cortisol concentration went from 21.75 to 23.5 nmol· L–1. Furthermore, Aggarwal and Singh (2010) found that the average plasma cortisol was higher in hot-dry season than hot-humid season. Gudev *et al*. (2007) reported the unchanged plasma cortisol level in the buffaloes under heat is interpreted within the context of the hormonal integration and the modulating effect of hypothalamic-pituitary-adrenal axis on the other endocrine glands involved in the thermal homeostasis maintenance. For practical purposes, plasma cortisol concentration and milk composition cannot be used as parameters to determine heat stress in dairy cattle although good indication of acute and chronic heat stress can be obtained (Du Preez, 2000).

Table 5. Hormonal responses of lactating buffaloes in the relevant climatic conditions

Blood Hormonal responses	Qena	Giza
Thyroxin (nmol/l), TT4	$47.19^{a} \pm 1.41$	$44.32^{a} \pm 1.20$
Triidothyronine (nmol/l), TT3	$1.11^{a} \pm 0.05$	$0.90^{b} \pm 0.03$
TT4/TT3	$47.19^{a} \pm 1.42$	$52.05^{a} \pm 3.12$
Cortisol (nmol/l)	$81.12^{a} \pm 4.59$	$69.81^{a} \pm 5.93$

Means having different superscript letters within the same row differ significantly ($p < 0.05$).
- Between parentheses is the range.

Table (6) shows the correlation coefficients between the relevant physiological parameters and temperature humidity index. All the correlations were highly significant except the correlation between THI with RT and THI with RR. Bouraoui *et al*., (2002) showed that THI was positively correlated to respiration rate and rectal temperature. Silva *et al.* (2007) reported that both Temperature-Humidity Index (THI) and Black Globe-Humidity Index (BGHI) had the lowest correlations with animal RT and RR. The BGHI is the index to measure the thermal environment, incorporating the effects of humidity, air velocity, dry-bulb temperature, and radiation data (Buffington *et al*., 1981).

In conclusion, relevant hormonal and physiological responses of Egyptian buffalo were good indicator to the homeostatic reactions due to the climatic conditions in the current study

Table 6. Simple correlation coefficients among some physiological parameters and temperature humidity index

Items	RT	RuT	DT	NT	ErT	EyT	RR
THIavg	0.18 (0.0998)	0.45 (<.0001)	0.35 (0.0012)	0.39 (0.0003)	0.40 (0.0001)	0.38 (0.0003)	0.10 (0.3894)
Items	**RTm**	**RuTm**	**DTm**	**NTm**	**ErTm**	**EyTm**	**RRm**
THImax	0.49 (<.0001)	0.62 (<.0001)	0.63 (<.0001)	0.56 (<.0001)	0.60 (<.0001)	0.60 (<.0001)	0.23 (0.0275)
Items	**RTe**	**RuTe**	**DTe**	**NTe**	**ErTe**	**EyTe**	**RRe**
THImin	-0.34 (0.0016)	-0.17 (0.1307)	-0.34 (0.0014)	-0.33 (0.0022)	-0.20 (0.0565)	-0.39 (0.0002)	0.12 (0.2882)

Between parentheses is the probability.

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الإستجابات الفسيولوجية والهرمونية للجاموس المصري لظروف مناخية مختلفة

ياسين محمد حافظ[١]، محمد عمر تقى[٢]، أحمد عبد الجليل بيومى[٣]، محمود عبد الله مدنى[٢]، سامى أبو بكر محمود[١]

١ - قسم الإنتاج الحيوانى، كلية الزراعة- جامعة القاهرة، ٢ - المعمل المركزى للمناخ الزراعى، مركز البحوث الزراعية ، وزارة الزراعة وإستصلاح الأراضى، ٣ - قسم الإنتاج الحيوانى، كلية الزراعة، جامعة جنوب الوادى، قنا

تم إجراء هذه الدراسة فى مزرعتين من مزارع الألبان تقعان في محافظتي قنا والجيزة, وتهدف هذه الدراسة إلى دراسة تأثير اثنين من الظروف المناخية المختلفة في مصر على بعض الاستجابات الفسيولوجية والهرمونية في الجاموس المصري. تم اختيار ١٦ جاموسة حلاب متعددة المواسم الإنتاجية (٣-٦ موسم), حيث تم اختيار عدد ٦ حيوانات من مزرعة الجيزة و ١٠ حيوانات من مزرعة قنا. تم أخذ القياسات الفسيولوجية مرتين في يوم الاختبار في الساعة التاسعة صباحاً والساعة الرابعة عصراً. تم جمع عينات الدم من الحيوانات كل أسبوعين في الساعة التاسعة صباحاً قبل التغذية الصباحية على مدار فترة التجربة (من شهر يوليو حتى شهر سبتمبر) وذلك لتقدير كلا من هرمون الثيروكسين, الترای ايودوثيرونين والكورتيزول. تم تجميع البيانات المناخية لحساب دليل الحرارة والرطوبة للمنطقتين المناخيتين مصر الوسطى والعليا.

وجد أن درجة حرارة المستقيم في الصباح إرتفعت ($P > 0.05$) في حيوانات مزرعة قنا عن الحيوانات بالمزرعة الأخرى. جميع قياسات درجة حرارة الجلد كانت ذات فروق معنوية في مزرعة قنا عند مقارنتها بمزرعة الجيزة, وقد لوحظ أن درجة حرارة الأذن في المساء لم تختلف معنوياً بين المزرعتين. أظهر معدل التنفس في الصباح والمساء فروق معنوية بين المزرعتين ($P > 0.05$). وقد أظهرت تحاليل الهرمونات أن تركيز الترای ايودوثيرونين في البلازما أعلى ($P > 0.05$) في الجاموس بمزرعة قنا عن الأخرى, ولكن لم تكن هناك فروق معنوية بين المزرعتين في تركيز هرمون الثيروكسين, نسبة الثيروكسين إلى الترای ايودو ثيرونين والكورتيزول. كما أظهر دليل الحرارة والرطوبة ارتباطاً موجباً مع درجة حرارة المستقيم, درجة حرارة الجلد ومعدل التنفس.

نستنتج من هذه الدراسة أن الاستجابات الفسيولوجية والهرمونية للجاموس المصري محل الدراسة مؤشرً جيداً للتغير في الظروف المناخية بين المناطق محل الدراسة.