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BIOLOGICAL FUNCTIONS IN YOUNG PREGNANT RABBIT DOES AS AFFECTED BY HEAT STRESS AND LIGHTING REGIME UNDER SUBTROPICAL CONDITIONS OF EGYPT

[EFECTO DEL ESTRÉS CALÓRICO Y RÉGIMEN DE ILUMINACIÓN SOBRE FUNCIONES BIOLÓGICAS DE CONEJAS JÓVENES PREÑADAS EN CONDICIONES SUBTROPICALES DE EGIPTO]

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SUMMARY

The present work was planned to study the effects of different lighting regimes under both mild and hot sub-tropical environmental conditions of Egypt on New Zealand White (NZW) young doe rabbits, directly before mating (at mating), at day 15 after mating (1st half of pregnancy) and at day 25 of pregnancy (2nd half of pregnancy). The light regimes used were natural daylight as control, 16 h light (L) and 8 h darkness (D), 12L:12D and 8L:16D. The traits studied were daily feed intake, water consumption, blood metabolites (total proteins, albumin, globulin, glucose, total lipids and cholestrol), kidney function (urea-N and creatinine), liver function (SGPT, SGOT, alkaline phosphatase and acid phosphatase) and endocrine functions (T_3 and cortisol hormones). The estimated Temperature-humidity index (THI) values were 20.2 during the mild climate and 30.1 in the hot climate period, indicating absence of heat stress in the first period and exposure of rabbits to very severe heat stress in the second one. Almost all doe traits studied were affected negatively by heat stress. Regarding the effects of light regimes, the doe rabbits exposed to long daylight (16L:8D) were deleteriously affected, while those exposed to short daylight (8L:16D) were the least affected, in most of the traits studied, although the effects were aggravated in the late stage of pregnancy. The group exposed to 8L:16D consumed more daily feed. The interactions of period of the year and light regime were not significant on most of the values of the traits examined.

Key words: NZW rabbits, heat stress, light regimes, plasma metabolite profiles and hormones

RESUMEN

El presente trabajo estudio los efectos de diferentes regimenes de iluminación en condiciones de calor moderado y elevado en el subtrópico egipcio sobre conejas jóvenes (New Zealand White) preñadas. Se estudiaron los efecto al empadre, 15 d post empadre (1ª. Mitad de la preñez) y al día 25 de preñez (2a. mitad de la preñez). Los regimenes de luz empleados fueron: luz diurna natural como control, 16h luz (L) y 8h oscuridad (D), 12L:12D y 8L:16D. Las variables estudiadas fueron consumo de alimento, consumo de agua, metabólitos sanguíneos (proteínas totales, albúmina, globulina, glucosa, lípidos totales y colesterol), función renal (N-ureico y creatinina), función hepática (SGPT, SGOT, fosfatasa alcalina y ácida) y funciones endocrinas (T_3, cortisol). El índice estimado de temperatura-humedad (THI) fue 20.2 durante el calor moderado y 30.1 durante el calor elevado, indicando ausencia de estrés calórico y estres severo respectivamente. Casi todas la variables fueron afectadas negativamente por el estrés calórico. Las conejas expuestas a días largos (16L:8D) fueron afectadas negativamente, mientras que las expuestas a días cortos fueron menos afectadas, aunque los efectos fueron más severos en las preñez tardía. El grupo expuesto a 8L:16D consumió más alimento. Las interacciones de época del año y régimen de luz no fueron significativas para la mayoría de las variables estudiadas.

Palabras clave: Conejos, estrés calórico, régimen de luz, metabolitos plasmáticos, hormonas.

INTRODUCTION

Analysis of the season is usually carried out in terms of combined effects of light and temperature, in Europe. However, reproduction problems sometimes appear at the end of summer, but without direct relation to temperature (Lebas *et al.*, 1986). In tropical climates, the temperature effect seems to be dominant, but effects due to variations in nutrition and the length of daylight cannot be excluded. In Egypt, the ambient temperature, relative humidity and diurnal light seemed to be involved (Habeeb *et al.*, 1993 and Marai *et al.*, 1996).

Regarding the effect of daylight length on reproductive activities of the rabbit, the data in the literature, are conflicting. Some studies showed that the reproductive traits increase (Lebas *et al.*, 1986; Theau-Clement *et al.*, 1990 and Uzcategui and Johnson, 1990 and 1992), others showed either no effect (El-Fouly *et al.*, 1977 and Shafei *et al.*, 1984), or negative effects (Hassanien, 1980), with exposure to long daylight, while Ibrahim (1985) and Mady *et al.* (1990) obtained favourable effects with decreasing length of day light.

Exposure of rabbits to heat stress evokes a series of remarkable changes in their biological functions which ends with impairment of production and reproduction (Marai *et al.*, 1999, 2002a,b, 2004). However, similar studies on pregnant does, are scanty.

The present study aimed to highlight the effects of climatic conditions including heat stress and light regime on the different phases of pregnant doe rabbits, under the sub-tropical environment of Egypt. Adaptability to heat stress during the three phases of pregnancy, was also estimated.

MATERIAL AND METHODS

The present study was carried out in the Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Experimental procedure

Fifty six New Zealand White (NZW) young doe rabbits aged 12 weeks, were used in the study, as a part of an experiment carried out on both males and females (Marai *et al.*, 2002b and 2004). The study included two periods, each was of about 5 months. The first one was from January until May, 2000 (i.e. under mild conditions) and the second was from June until October, 2000 (i.e. during hot conditions). In the first period, 32 females with 1795.7±48.3 g average body weight and in the second period, another 24 females with 1598.2±35.0 g average body weight, were used.

In each of the studied periods, the does were divided into 4 groups according to type of light regime to which it was exposed. The first group was exposed to natural daylight and was considered as control, but the animals were not the same in the two periods of the study. Average duration of daylight was 11.58 h in the mild conditions and 12.58 h during the hot conditions. The second group was exposed to 16h light and 8h darkness (long day length; 16L : 8D), the third was exposed to 12h light and 12h darkness (medium day length; 12L : 12D) and the fourth was exposed to 8h light and 16h darkness (short day length; 8L : 16D).

Mating of females was carried out at 20 weeks of age (average body weight was 3016.3±56.2 g) in mild conditions and at 22 weeks (average body weight was 2742.8±34.8 g) in hot conditions. Age at mating in males was 23 weeks in mild conditions and 25 weeks in hot conditions. The longer age at mating during the hot than in the mild conditions was due to the poor growth and the longer time that animals took to reach the suitable weight at first mating. The males used in mating of all groups were exposed to natural daylight from the beginning of the study. Buck/doe ratio was 1:2. The time of mating was in the morning between 8.00 and 9.00 h. Each doe was transferred to the buck's cage to be mated, then returned back to its own cage. Pregnancy was diagnosed by abdominal palpation at the tenth day after mating. Does failing to conceive were immediately returned after palpation to the same mating buck for another service. On the 27th day of pregnancy, the nest boxes were supplied with wheat straw litter to provide a comfortable and warm nest for the kindled rabbits. Conception rate was estimated as number of does conceived / number of does mated. Gestation period was also estimated.

The rabbits in all groups were offered food and water *ad libitum*. The chemical analysis of the commercial pelleted diet was: crude protein 18.0%, crude fibre 12.0% and ether extract 2.8%. Digestible energy (kcal DE/kg diet) was calculated as 2600.

The experimental animals were kept, maintained and treated in adherence to accepted standards for the humane treatment of animals.

Animal housing and management

The animals were housed in a part of the Rabbitry building divided by four partitions: one was exposed to the natural daylight for the control group and the other three were equipped with normal light lamps and black polyethylene sheets. The Rabbitry building was naturally ventilated through mesh windows and provided with automatically controlled sided exhaustion fans.

The animals were individually housed in galvanized wire cages (50 x 55 x 39 cm). The galvanized wire cage batteries were arranged in rows back to back and each cage was provided with a feeder and automatic nipple drinker. Urine and faeces dropped from cages on the floor, were cleaned daily. All animals were kept under the same managerial and hygienic conditions in each period.

Food consumption and water intake were estimated 4 times per doe once each week at days 7, 14, 21 and 28 during pregnancy. Each time, feed intake was measured by subtracting the residuals of feed from that offered for each animal. Water intake was estimated by measuring the difference in the water volume in the crocks (troughs).

Rectal, skin and ear temperatures were measured individually at midday by a digital thermometer. The skin temperature was measured at one location between the neck and loin on the body surface and the thermometer was fixed on the bare skin. The ear temperature was measured by placing the alcoholic thermometer into direct contact with the central area of the auricle. Respiration rate was measured by visually counting breaths per minute using a stop watch.

Lighting was provided by lamps at the beginning of the dark period of the day, while darkness was achieved by the use of black cloth curtains on the outer side of the room walls. Numbers of animals in each group were 8 and 6 females during the two periods, respectively. The natural daylight (h) was estimated daily by the difference between sunrise and sunset times. Intensity of light was estimated by a lux-meter within the Battery cages either under natural or artificial lighting. In each of the two periods, the intensity of light values were 80 and 70 lux under natural and artificial lights, respectively, at the level of the battery cages.

Air temperature (^oC) and relative humidity (%) inside the rabbitry building were measured four times each month between 12.00 to 14.00 h using automatic thermo-hygrometer (^oC 0 : 60, H 10 – 95%; HANNA Instruments, Italy). Averages of air temperature and relative humidity values at midday inside the Rabbitry building were, respectively, 21.1±1.4^oC and 60.4±1.7% during the first period and 32.0±0.8 ^oC and 63.5±2.0% during the second period The range of natural daylight length was 10.27 – 13.40 h in the first period and 10.30 – 14.00 h in the second period. The temperature-humidity index (THI) was calculated using the equation modified by Marai *et al. (*2001):

$$THI = db^oC - [(0.31 - 0.31\ RH)(db^oC - 14.4)],$$

Where:
db^oC = dry bulb temperature in Celsius
RH= relative humidity percentage/100.

The THI values obtained were then classified as follows: <27.8= absence of heat stress, 27.8 - < 28.9= moderate heat stress, 28.9 - <30.0 = severe heat stress and 30.0 and more = very severe heat stress (Marai *et al.*, 2001).

Blood sampling and estimation of hormones and biochemical components in blood plasma

Blood samples were collected three times from all the does (within 0.5 to 1 h directly before mating, at day 15 and day 25 of pregnancy) from marginal ear vein in vacutainer tubes and were centrifuged for 20 minutes at 3000 rpm to obtain the serum which was kept in a refrigerator (-20 ^oC) until analysis. The animals were prevented to eat for some hours before blood sampling.

Blood serum total proteins, albumin, urea-N, total lipids and creatinine concentrations were estimated by the colorimetric method using commercial kits (Diamond Diagnostic, Egypt). Globulin was estimated by subtraction of albumin from total protein. Glucose was determined by the enzymatic method using chemical commercial kits (Stanbio Laboratory. INC-San Antonio, Texas 78202, USA). Cholesterol was estimated by enzymatic colorimetric method using chemical commercial kits (Sentinel CH. 20155 Milan, Italy). Glutamic-pyruvate transaminase (SGPT), glutamic oxaloacetic transaminase (SGOT) and alkaline phosphatase enzyme activities were assayed using commercial kits of Diamond Diagnostics, Egypt. Acid phosphatase enzyme activity was estimated using chemical commercial kits of Quimica Clinica Aplicada, Tarragona, Spain.

Triiodothyronine (T_3) and cortisol hormones were estimated by the radioimmunoassay (RIA) technique using the coated tubes kits (Diagnostic Systems Laboratories, Inc. Webster, Texas 77598-4217, USA) and counting in the Laboratory of Biological Applications Department, Atomic Energy Authority, using Nuclear Enterprise, Gamma Counter, Scaler Ratemeter SR-7. The tracer in the two hormones was labelled with iodine-125 (I^{125}).

Estimations of chemical analyses were carried out using spectrophotometer computer system (8500 Ultra violet-Visible Techcomp), Tracer Bioclimatology Unit, Department of Biological Applications, Atomic Energy Authority, Inshas.

Statistical analysis

The data were statistically analyzed by 2 X 4 factorial design (Snedecor and Cochran (1982). Significance of the differences in the results were tested by Duncan's New Multiple Range Test (Duncan, 1955).

RESULTS

Only the main factors data were recorded in the tables, since the interactions of period of the year and light regime on most of the values of the traits examined were not significant.

The biological changes during pregnancy phases

Table 2 showed that feed intake decreased at mating, while water consumption increased, during the first four weeks of pregnancy. The differences were significant (P<0.05) after the second and third weeks, respectively.

Total proteins, globulin, glucose, cholesterol, alkaline phosphatase, acid phosphates and T_3 hormone decreased (P<0.05) during 1st and 2nd halves of pregnancy, while total lipids decreased (P<0.05) during the 2nd half of pregnancy, than at mating (Tables 2– 5). Contrarily, SGPT and SGOT and Cortisol hormone increased (P<0.05) during the 2nd half of pregnancy. Meanwhile, Albumin, Urea-N, Creatinine showed no significant difference either before or during pregnancy (Tables 3–6).

Effect of period of the year (heat stress)

The estimated THI values were 20.2 during the mild climate and 30.1 in the hot climate period, indicating absence of heat stress in the first period and exposure of rabbits to very severe heat stress in the second.

The hot period conditions affected negatively almost all doe traits studied (Tables 1–6). The effects were significant (P<0.001, 0.01 or 0.05) on the thermoregulatory parameters (respiration and temperatures of ear, rectum and skin; Table 1), gestation period, daily feed intake, water consumption during pregnancy, serum total proteins, glucose, total lipids, urea-N, creatinine, SGPT and SGOT at mating and 1st and 2nd halves of pregnancy, albumin at mating, globulin during 1st half of pregnancy, cholestrol at mating and 1st half of pregnancy, alkaline phosphatase at mating and 1st half of pregnancy, acid phosphatase at mating and 2nd half of pregnancy and T_3 and cortisol hormone during 2nd half of pregnancy. Conception rate was also affected adversely by exposure to the environmental hot conditions.

Table 1. Daily feed intake and water consumption (Means ±SE), in NZW young rabbit does during the pregnancy period at 1st, 2nd, 3rd and 4th weeks as affected by period of the year and light regime.

Items	Daily feed consumption (g) at pregnancy weeks				Daily water consumption (ml) at pregnancy weeks			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Period of the year								
Mild	156.3^{a}±4.2	156.8^{a}±3.9	138.8^{a}±3.6	133.2^{a}±3.9	367.3^{b}±10.3	372.3^{b}±11.9	407.0^{b}±14.2	449.5$^{b±}$15.7
Hot	104.2^{b}±3.7	100.0^{b}±3.6	93.^{9b}±4.8	90.8^{b}±4.4	537.5^{a}±16.8	562.8^{a}±18.1	541.7^{a}±21.1	569.4$^{a±}$16.4
	***	***	***	***	***	***	***	***
Light regime								
Natural daylight	140.9^{ab}±9.8	136.8^{a}±8.7	127.3^{a} ±8.9	122.3 ^{a}±9.0	426.4±33.2	442.3±34.5	427.3±32.5	498.2±29.4
16L:8D	125.5 ^{b}±9.9	120.9 ^{b}±9.8	104.1^{b} ±8.5	99.5 ^{b}±6.7	429.5±31.3	444.5±30.4	460.5±28.2	458.2±29.7
12L:12D	131.5^{ab}±8.5	133.8^{ab} ±9.1	121.5^{a} ±8.3	117.7^{a} ±8.3	430.0±31.4	30.4±31.9	447.7±31.9	477.7±27.5
8L:16D	148.1^{a} ±9.3	148.5^{a} ±10.6	133.1^{a} ±7.2	127.7^{a} ±7.8	437.7±28.9	46.7±37.9	490.7±28.5	538.8±25.9
	*	**	***	**	NS	NS	NS	NS

*** P < 0.001, ** P < 0.01 * P < 0.05 and NS = Not significant.
Means bearing different superscripts in the same column differ significantly (P<0.05).

Table 2. Thermoregulatory parameters (Means ± SE) for doe rabbits during pre-mating, conception rate and gestation period, as affected by period of the year and light regime.

Items	Respiration rate (rpm)	Ear temperature (°C)	Rectal temperature (°C)	Skin temperature (°C)	Conception rate (%)	Gestation period (Days)
Period of the year						
Mild	81.1±1.2	27.3±0.1	38.9±0.1	38.6±0.1	63.4	31.3±0.1
Hot	96.5±1.5	38.3±0.2	40.1±0.1	39.6±0.1	56.3	31.9±0.1
	***	***	***	***		*
Light regime						
Natural daylight	68.8±4.3	31.3±1.7	39.3±0.1	38.9±0.2	65.7	31.6±0.2
16L:8D	87.9±3.4	31.3±1.7	39.4±0.2	38.9±0.2	41.1	31.6±0.2
12L:12D	86.3±3.0	31.4±1.6	39.4±0.2	39.0±0.2	55.0	31.4±0.2
8L:16D	85.2±2.6	31.7±1.5	39.3±0.2	38.9±0.2	77.5	31.3±0.1
	NS	NS	NS	NS		NS

*** P < 0.001, ** P < 0.01 P < 0.05 and NS = Not significant.

Effect of light regime

Tables 1–6 show that exposure of doe rabbit to different light regimes affected significantly (P<0.001, 0.01 or 0.05) daily feed consumption and cortisol hormone at mating and 1st and 2nd halves of pregnancy, serum total proteins at mating and 1st half of pregnancy, albumin and glucose during 1st half of pregnancy, cholestrol, creatinine and SGPT during 1st and 2nd halves of pregnancy, SGOT during 2nd half of pregnancy and acid phosphatase at mating.

The doe rabbits exposed to long daylight (16L:8D) were deleteriously affected, while those exposed to short daylight (8L:16D) were the least affected, in most of the traits studied, although the effects aggravated in the late stage of pregnancy. The group exposed to 8L:16D consumed more daily feed.
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Table 3. Blood metabolites (Means ± SE) in NZW young rabbit does at mating and 1st and 2nd halves of pregnancy period as affected by period of the year and light regime.

Items	Total proteins (g/dl)			Albumin (g/dl)		
	0	1	2	0	1	2
Period of the year						
Mild	$8.3^{a}\pm0.1$	$7.9^{a}\pm0.1$	$7.8^{a}\pm0.1$	$4.4^{a}\pm0.1$	4.5±0.1	4.3±0.1
	$7.8^{b}\pm0.1$	$7.4^{b}\pm0.1$	$7.3^{b}\pm0.1$	$3.9^{b}\pm0.1$	4.3±0.1	4.2±0.1
Significance	***	***	**	***	NS	NS
Light regime						
Natural daylight	$7.8^{c}\pm0.1$	$7.4^{c}\pm0.1$	7.5±0.1	4.1±0.1	$4.1^{b}\pm0.1$	4.2±0.1
16L:8D	$8.4^{a}\pm0.2$	$8.2^{a}\pm0.2$	8.0±0.2	4.1±0.1	$4.5^{a}\pm0.1$	4.5±0.3
12L:12D	$8.2^{ab}\pm0.1$	$7.7^{b}\pm0.1$	7.4±0.2	4.3±0.1	$4.5^{a}\pm0.1$	4.2±0.1
8L:16D	$8.0^{c}\pm0.1$b	$7.7^{c}\pm0.1$b	7.7±0.2	4.1±0.1	$4.5^{a}\pm0.1$	4.1±0.1
Significance	**	***	NS	NS	**	NS
Items	Globulin (g/l)			Glucose (mg/dl)		
	0	1	2	0	1	2
Period of the year						
Mild	3.9±0.1	$3.5^{a}\pm0.1$	3.5±0.2	$126.2^{a}\pm3.6$	$115.5^{a}\pm1.9$	$100.4^{a}\pm1.6$
Hot	3.9±0.1	$3.^{1b}\pm0.1$	3.2±0.1	$92.8^{b}\pm1.2$	$88.4^{b}\pm1.4$	$84.7^{b}\pm1.9$
Significance	NS	**	NS	***	***	***
Light regime						
Natural daylight	3.7±0.1	3.3±0.1	3.3±0.2	111.8±4.8	$99.8^{b}\pm3.5$	88.9±4.1
16L:8D	4.2±0.2	3.7±0.2	3.4±0.4	116.7±10.5	$98.3^{b}\pm4.0$	97.7±8.6
12L:12D	3.9±0.2	3.2±0.1	3.2±0.2	110.6±4.9	$109.8^{a}\pm4.4$	93.9±2.1
8L:16D	3.8±0.2	3.2±0.1	3.6±0.2	114.3±5.8	$110.7^{a}\pm5.4$	96.8±3.7
Significance	NS	NS	NS	NS	***	NS
Items	Total lipids (g/dl)			Cholesterol (mg/dl)		
	0	1	2	0	1	2
Period of the year						
Mild	$4.0^{a}\pm0.2$	$3.8^{a}\pm0.1$	$3.4^{a}\pm0.1$	$135.3^{a}\pm3.9$	$117.7^{a}\pm2.7$	109.9±3.1
Hot	$3.4^{b}\pm0.1$	$3.4^{b}\pm0.1$	$3.1^{b}\pm0.1$	$118.3^{b}\pm6.3$	$108.9^{b}\pm3.5$	110.3±6.0
Significance	**	*	*	**	*	NS
Light regime						
Natural daylight	3.5±0.2	3.5±0.2	3.2±0.2	135.4±5.4	$115.8^{a}\pm3.3$	$116.0^{a}\pm9.0$
16L:8D	3.7±0.2	3.5±0.1	3.3±0.1	116.2±7.1	$99.2^{b}\pm2.8$	$95.2^{b}\pm3.6$
12L:12D	4.2±0.2	3.9±0.1	3.4±0.1	138.5±7.8	$124.4^{a}\pm2.7$	$108.1^{ab}\pm5.2$
8L:16D	3.6±0.3	3.5±0.2	3.2±0.1	123.3±6.8	$115.7^{a}\pm5.1$	$119.0^{a}\pm2.1$
Significance	NS	NS	NS	NS	***	*

*** P < 0.001, ** P < 0.01 * P < 0.05 and NS = Not significant.
Means bearing different superscripts in the same column differ significantly (P<0.05).
0 = At directly before mating, 1 = At day 15 of mating (1st half of pregnancy) and 2= At day 25 of pregnancy (2nd half of pregnancy).

Table 4. Kidney functions (Means ± SE) in NZW young rabbit does at mating and 1st and 2nd halves of pregnancy period halves as affected by period of the year and light regime.

Items	Urea-N (mg/dl)			Creatinine (mg/dl)		
	0	1	2	0	1	2
Period of the year						
Mild	38.2^{b}±0.9	38.2^{b}±1.2	35.2^{b}±0.7	1.4^{b}±0.1	1.3^{b}±0.0	1.5^{b}±0.0
Hot	47.0^{a}±2.1	45.0^{a}±1.5	42.5^{a}±1.3	1.6^{a}±0.1	1.6^{a}±0.1	1.6^{a}±0.1
Significance	***	***	***	*	***	***
Light regime						
Natural daylight	43.1±1.6	39.4±1.9	37.7±1.4	1.5±0.1	1.4^{ab}±0.1	1.8^{a}±0.1
16L:8D	43.3±1.5	42.8±2.0	38.3±1.2	1.4±0.1	1.3^{b}±0.1	1.4^{b}±0.1
12L:12D	41.5±3.0	43.7±2.3	38.3±2.0	1.6±0.1	1.5^{ab}±0.1	1.6^{a}±0.1
8L:16D	39.0±2.7	37.8±2.0	37.8±1.9	1.6±0.1	1.6^{a}±0.1	1.6^{a}±0.1
Significance	NS	NS	NS	NS	*	**

*** P < 0.001, ** P < 0.01 * , P < 0.05 and NS = Not significant.
Means bearing different superscripts in the same column differ significantly (P<0.05).
0 = At directly before mating, 1 = At day 15 of mating (1st half of pregnancy) and 2= At day 25 of pregnancy (2nd half of pregnancy).

Table 5. Liver function (Means ±SE), in NZW young rabbit does at mating and pregnancy period at 1st and 2nd halves as affected by period of the year and light regime

Items	SGPT (u/l)			SGOT (u/l)		
	0	1	2	0	1	2
Period of the year						
Mild	7.6^{b}±0.3	10.2^{b}±0.4	14.1^{b}±0.8	7.9^{b}±0.2	9.4^{b}±0.4	12.2^{b}±0.8
Hot	12.0^{a}±0.9	13.8^{a}±0.9	18.^{6a}±1.1	13.1^{a}±1.0	16.2^{a}±1.0	18.5^{a}±0.8
Significance	***	***	***	***	***	***
Light regime						
Natural daylight	8.8±0.9	10.9^{ab}±0.5	17.0^{a}±1.3	9.9±0.9	13.2±0.9	18.2^{a}±1.1
16L:8D	8.2±1.3	10.1^{b}±1.2	11.6^{b}±1.0	10.2±1.6	12.1±1.9	13.8^{b}±1.8
12L:12D	10.5±1.2	13.1^{a}±1.3	18.2^{a}±1.6	9.3±0.9	11.8±1.3	13.6^{b}±1.4
8L:16D	9.5±0.7	12.2^{ab}±0.8	15.9^{a}±0.9	10.2±1.0	11.2±1.1	13.2^{b}±0.9
Significance	NS	*	***	NS	NS	**
Items	**Alkaline phosphatase (u/l)**			**Acid phosphatase (u/l)**		
	0	1	2	0	1	2
Period of the year						
Mild	96.0^{b}±2.9	84.6^{b}±2.5	81.7±2.9	27.9^{a}±1.3	17.8±0.5	16.7^{a}±0.7
Hot	108.0^{a}±6.1	96.2^{a}±3.1	89.1±3.2	19.4^{b}±0.8	16.1±0.9	14.5^{b}±0.9
Significance	*	**	NS	***	NS	*
Light regime						
Natural daylight	101.3±7.3	92.0±2.7	89.4±2.2	21.8^{b}±1.4	16.2±1.1	14.8±1.2
16L:8D	112.5±4.6	84.5±6.7	75.5±7.8	29.3^{a}±2.8	17.0±1.2	15.2±1.2
12L:12D	97.8±6.7	92.1±3.7	86.1±4.3	21.9^{b}±1.5	16.5±0.8	16.4±0.8
8L:16D	93.0±4.5	87.4±3.5	86.3±1.5	25.9^{ab}±1.9	18.8±0.6	16.8±1.2
Significance	NS	NS	NS	*	NS	NS

Means bearing different superscripts in the same column differ significantly (P<0.05).
*** P < 0.001, ** P < 0.01 * P < 0.05 and NS = Not significant.
0 = At directly before mating, 1 = At day 15 of mating (1st half of pregnancy) and 2= At day 25 of pregnancy (2nd half of pregnancy).

Table 6. Endocrine functions (Mean ± SE) in NZW young rabbit does at mating and, 1st and 2nd halves of pregnancy period as affected by period of the year and light regime.

Items	T3 hormone (ng/dl)			Cortisol hormone (ng/ml)		
	0	1	2	0	1	2
Period of the year						
Mild	124.6±5.8	92.9±3.5	79.6^{a}±2.9	7.7±0.4	8.1±0.3	9.8^{a}±0.5
Hot	112.1±4.4	87.2±2.2	67.9^{b}±3.8	7.1±0.4	7.5±0.5	8.7^{b}±0.6
Significance	NS	NS	**	NS	NS	**
Light regime						
Natural daylight	110.8±3.8	96.7±3.2	77.8±4.9	9.3^{a}±0.4	9.8^{a}±0.5	12.2^{a}±0.5
16L:8D	139.9±9.7	89.3±4.4	75.7±4.5	7.5^{b}±0.4	7.7^{b}±0.3	8.4^{b}±0.4
12L:12D	118.2±5.5	96.0±2.9	79.9±2.8	7.5^{b}±0.2	8.3^{b}±0.3	10.4^{b}±0.4
8L:16D	111.3±9.7	81.0±6.1	67.2±6.2	5.6^{c}±0.4	5.9^{c}±0.4	6.4^{c}±0.4
Significance	NS	NS	NS	***	***	***

*** P < 0.001, ** P < 0.01 * P < 0.05 and NS = Not significant.
Means bearing different superscripts in the same column differ significantly (P<0.05).
0 = At directly before mating, 1 = At day 15 of mating (1st half of pregnancy) and 2= At day 25 of pregnancy (2nd half of pregnancy).

DISCUSSION

The biological changes during pregnancy phases

The decrease in feed intake during the late phases of pregnancy may be due to the increase in each of faetal size and water consumption. The increase in water consumption during pregnancy may be due to the increase in dam's body water retention (Guyton, 1992 and Marai *et al*.,1994).

During pregnancy, reductions in blood serum total proteins, globulin, glucose, cholesterol, alkaline phosphatase, acid phosphates and T_3 hormone may be due to the decrease in food intake of dams (Marai *et al.*,1994) and increase in water retention (Guyton, 1992 and Marai *et al.*,1994) and the high demand of the foetus at late stages of pregnancy (Marai *et al.*,1994). Particularly, the decrease in glucose in blood (and in urine) is due to the increase in each Glomerular filtration rate (GFR) (Guyton, 1992) and foetal consumption and conversion of glucose to lactose of milk (Marai *et al.*, 1994) and the decrease in each of renal threshold of glucose and capacity of renal tubules to absorb the glucose. The decrease in cholesterol level may be due to the decrease in protein synthesis (lipid is transported as lipoprotein). Increase in each of SGOT and SGPT is due to pregnancy as a physiological stress. El-Masry and Habeeb (1989) reported that thyroxine is considered necessary for cellular metabolism of the mammary gland and energy utilization which could be considered as important factors in milk biosynthesis. The increase in cortisol hormone level during pregnancy than at mating may be due the important role of cortisol in protein, fat and carbohydrate metabolism to fulfill the high demand of the foetus from glucose and other components.

Effect of period of the year (heat stress)

Exposure of NZW young doe rabbits to severe heat stress under the warm sub-tropical environmental conditions of Egypt, affected negatively most of the traits studied and the effects were more deleterious during the 2nd half when compared to the 1st half of pregnancy.

The highly significant increase in thermoregulatory parameters (respiration and temperatures of ear, rectum and skin) due to exposure of the animals to severe heat stress were similar to those reported by other workers (Rich and Alliston, 1970; Shafie *et al.*, 1982 and Marai *et al.*, 2001). The increase in respiration frequency and evaporative water loss is linearly related to the increase in ambient temperature above the panting threshold (Richards, 1976) and thus enables the animals to dissipate heat by vaporizing high moisture through the respiratory air, which accounts to about 30% of total heat dissipation. Respiration becomes the main pathway for loss of the latent heat, since most sweat glands in rabbits are not functional and perspiration is not great due to the fur (Marai and Habeeb, 1994 and Marai *et al.*, 2001). The ear plays an important role in thermoregulation of rabbits, since its function is like a radiator. When the temperature is above 25-30°C, the heat load on rabbits increases and the animals stretch and extend their ears to loose as much heat as possible by radiation and convection (Lebas *et al.*, 1986). The increase in rectal temperature of the heat-stressed rabbits may be due to failure of the physiological mechanisms of the animals to balance the excessive heat load caused by exposure to high ambient temperature (Habeeb *et al.*, 1992 and 1998). Skin temperature is directly affected by body temperature and it increases in hot conditions compared to mild conditions, due to the insulation effect of the coat. The high skin temperature in hot conditions was also previously observed in rabbits by Shafie *et al.* (1970).

The low conception rate during the hot conditions may be due to a complex set of events which are expressed in to the adversely affects on growth and reproductive rates (Marai *et al.*, 2001), although Lebas *et al.* (1986) clarified that the lower prolificacy of does reared in hot climates (30-31^{o}C) would appear to be due to a reduction in body weight and not so much to the temperature itself. Particularly, such phenomena may be due to the marked decline in post-coital ovulation (El-Fouly *et al.*, 1976; Dollah *et al.*, 1990), ovulation rate (Hahn and Gabler, 1971), number of implantation sites per doe and number of viable embryos per doe (El-Fouly *et al.*, 1977). The low conception rate may also be a result of either fertilization failure or early embryonic mortality (Marai and El-Kelawy, 1999). The decrease in receptivity and percentage of voluntary mating may be another reason of decline in fertility during hot conditions, in addition to that the conception rate from forced matings which are practised in such cases is, generally, low and inversely proportional to the seasonal frequency of this type of mating.

The significant ($P<0.05$) increase in gestation period in the hot period is similar to that reported by Marai *et al.* (2000) (31.6 d in summer vs 31.2 d in winter). McNitt and Moody (1991) and Marai *et al.(* 1996) attributed the increase in gestation period to the decrease in each of feed intake and T_3 hormone level and consequently the decrease of protein biosynthesis, that result in that the foetus requiring more time to reach full term, under hot conditions.

Under heat stress conditions, depression in feed consumption is the most important reaction to exposure to elevated temperature (Marai and Habeeb, 1998 and Marai *et al*., 2002b and 2004). Such phenomenon is due to that environmental temperature stimulates the peripheral thermal receptors to transmit suppressive nerve impulses to the appetite centre in the hypothalamus causing the decrease in feed consumption, i.e. dry matter intake and consequently fewer substrates become available for enzymatic activities, hormone synthesis and heat production (Kamal, 1975).

Delay of doe rabbit puberty and increase in age at first mating with increasing environmental temperature may be due to the decline in body weight (Hilmy, 1991 and Daader *et al*., 1999a,b) and deficiency of thyroid secretions (Dickson (1982), in heat-stressed rabbits.

The high consumption of water in the hot period helps the animal to increase the heat loss through water respiratory vaporization. Stephan (1980) estimated the increase in water requirement by 50% at 38˚C than at 18.0˚C.

The decrease in serum total proteins may be due to the decrease in feed nitrogen intake which occurs under heat-stress conditions, decrease of protein synthesis as a result of the depression of anabolic hormonal secretion and/or dilution of plasma proteins caused by the increase of the water consumed (El-Masry and Habeeb, 1989). The decrease in plasma glucose could be due to the increase in glucose utilization to produce more energy for greater muscular expenditure required for high respiratory activity and/or the marked dilution of blood and body fluids as a whole caused by increase in water consumption (Habeeb *et al*., 1992). The decline of serum total lipids concentrations due to exposure to high ambient temperature may be attributed to the increase in either utilization of fatty acids for energy production and as a consequence of the decrease in glucose concentration or increase in body water content (Habeeb *et al*., 1992 and Marai and Habeeb, 1998). The decline in cholesterol concentration during exposure to heat stress may be due to the decrease in acetate concentration which is the primary precursor for the synthesis of cholesterol or to the increase in total body water (Marai and Habeeb, 1998).

The blood enzymes are easily and often influenced by the external environment including feeding practices, type of shelter and many other aspects of hard management, since they are intimately related to metabolism (Marai and Habeeb, 1998).The low plasma T_3 concentration during the hot period may reflect well the hormonal response of rabbits to prolonged heat exposure and to the marked decrease in feed intake (Boiti *et al*., 1992), since T_3 is more concerned with thermogenesis and was found to decline significantly in heat-stressed animals (Habeeb *et al*., 1997). It is well known that thyroid hormones, either T_4 or T_3, play an important role in the animals adaptation to environment changes (Marai and Habeeb, 1998). The decline which occurs in cortisol during the chronic heat-stress is attributed to the fact that it is thermogenic in animals and, consequently, the reduction of adrenocortical activity under thermal stress is a thermoregulatory protective mechanism preventing metabolic heat production in a hot environment. This indicates the role of the adrenal cortex gland in adaptation to stress (Alvarez and Johnson, 1973).

The increase in Urea-N and creatinine concentrations in plasma of rabbits exposed to heat-stress may be attributed to the increase in protein catabolism due to the increase in the glucocorticoid hormones and to the decrease in protein anabolism as a result to the decrease in T_3 level (Alvarez and Johnson, 1973; Habeeb *et al*., 1999). The increase of SGPT and SGOT levels with exposure to hot temperature may be due to increase in stimulation of gluconeogenesis by corticoids (increase in cortisol, cortison or adrenocorticotrophic hormones; Thompson, 1973).

The above mentioned detrimental effects were reflected in non significant decrease in pregnancy rate and litter size and significant (P<0.001, 0.01 or 0.05) decrease in litter weight, kit body weight at birth, milk yield, milk efficiency (kits' weight gain/milk intake per kit) and mortality at birth and pre-weaning (Marai *et al*., 2004).

Effect of light regime

Exposure of the does to long daylight (16L : 8D) showed negative effects on most of the traits studied, when compared to exposure to short daylight (8L : 16D). Such effects may be mainly due to disturbance of the physiological activities of the animals as a function of elevated temperature, since exposure of the animals to lamps radiation in the warm sub-tropical conditions increases the perception of warmth and such feeling aggravates during the hot climate conditions in summer.

The group exposed to 8L:16D consumed more feed when compared to the increase in eating frequency, since rabbits are nocturnal and tend to increase feed intake during darkness (Lebas *et al*., 1986). Touitou *et al*. (1992) reported that light stimulus synchronizes the circadian cortisol rhythm. The remarkably increase in cortisol hormone in does exposed to natural daylight may be due to activation of the hypothalamic-pituitary-adrenal axis and the consequent increase of plasma glucocorticoid concentrations (Christison and Johnson, 1972).

The negative effects which were more remarkably observed on doe rabbit traits exposed to long daylight (16L : 8D) when compared to those exposed to short daylight (8L : 16D) and its aggravation during the hot period of the year may be due to the increase in the heat load that caused by exposure to lamps light radiation, under the warm and bright days of the sub-tropical environment of Egypt. Such effects may be mainly due to disturbance of the physiological activities of the animals as a function of elevated temperatures (Marai *et al*., 2002a).

The above mentioned detrimental effects were reflected in significant (P<0.001, 0.01 or 0.05) decrease in litter size, litter weight, milk yield, milk efficiency (kits' weight gain/milk intake per kit) and mortality at birth and pre-weaning (Marai *et al*., 2004). Such results may suggest to carry out further economic studies on feasibility of applying light regime technology under the sub-tropical conditions (average duration of daylight is 11.58 h in mild conditions and 12.58 h during hot conditions).

CONCLUSIONS

Exposure of NZW young doe rabbits to severe heat stress under the warm sub-tropical environmental conditions of Egypt, affected negatively most of the traits studied and the effects were more deleterious during the 2nd half when compared to the 1st half of pregnancy. Exposure to the long daylight (16D : 8D) also showed more negative effects on most of the traits studied, when compared to the short daylight (8L : 16D). Exposure to lamps radiation increases the perception of warmth, specially during the hot climate conditions in summer. This is confirmed in the present work by the nonsignificant interaction of the climatic conditions and light regime on most of the studied traits, which show that both factors (i.e. climatic conditions and light regime) act additively. Further economic studies are needed on feasibility of applying light regime technology under the sub-tropical conditions (average duration of daylight is 11.58 h in mild conditions and 12.58 h during hot conditions).

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