GROWTH PERFORMANCE TRAITS AND THE PHYSIOLOGICAL BACKGROUND OF YOUNG DOE RABBITS AS AFFECTED BY CLIMATIC CONDITIONS AND LIGHTING REGIME, UNDER SUB-TROPICAL CONDITIONS OF EGYPT

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ABSTRACT

The present work was planned to study the effects of different lighting regimes under both mild and hot conditions on growth performance traits of young New Zealand White (NZW) doe rabbits. The light regimes used were natural daylight and was considered as control, 16 h light and 8 h darkness (long lightness 16L:8D), 12 h light and 12 h darkness (medium lightness) and 8 h light and 16 h darkness (short lightness 8L:16D).The traits studied were live body and daily gain weights, thermoregulatory parameters (respiration rate and temperatures of ear, rectum and skin), feed intake, water consumption, blood metabolites (total proteins and total lipids), kidney function (urea-N and creatinine), liver function (SGPT and SGOT) and endocrine functions (T_3 and cortisol hormones). Adaptability for hot climate conditions, was also estimated. The estimated Temperature-humidity index (THI) values were 18.5 during the mild climate and 33.9 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. The period of the year (heat stress) affected adversely many of the studied traits and the effects were significant (P<0.001, 0.01 or 0.05) on daily body weights at 12 and 20 weeks, daily gain weights during 12-16, 16-20 and 12-20 weeks of age, thermoregulatory parameters, feed intake and water consumption, blood plasma metabolites except functions of endocrines. Estimating of the adaptability to the hot conditions, showed that the young doe rabbits are more sensitive to such conditions than the young bucks. Exposure of young doe rabbits to different light regimes adversely affected many of the studied traits and the effects were significant on daily gain weight during 16-20 and 12-20 weeks of age, daily feed intake, blood plasma total proteins and cortisol hormone. The young doe rabbits exposed to long daylight (16L:8D) were deleteriously affected, while those exposed to short daylight (8L:16D) were the least affected, in the studied traits. The differences were significant (P<0.05). No significant interactions were observed, so that only the main effects were reported.

Key words: young NZW doe rabbits, growth performance traits, heat stress, light regimes, thermoregulatory parameters, blood serum components, adaptability to hot conditions.

INTRODUCTION

Age at puberty within the same breed and the same sex is affected by several environmental factors such as temperature, relative humidity, photoperiod and nutrition level, of which the temperature is the most important (MARAI *et al.,* 1991). DAADER and SELEEM (1999) revealed that rabbit puberty delayed with increasing environmental temperature. Particularly, the Egyptian native rabbit breeds such as Baladi Red, Baladi White, Baladi Black and Giza White reach puberty at about six months of age (HILMY, 1991). Age at first mating increased and the body weight decreased in heat stressed rabbits (DAADER *et al.,* 1999 a,b).

However, studies on the physiological background of young NZW doe rabbits as affected by light regime under the Egyptian sub-tropical conditions are lacking.

The aim of the study was to investigate the growth performance and the physiological background of young NZW doe rabbits as affected by period of the year, different lighting regimes and their interactions. Adaptability for hot climate conditions was also estimated.

MATERIALS AND METHODS

The present study was carried out in the Department of Animal Production, Faculty of Agriculture, Zagazig University, Egypt. The biochemical analyses of blood components and hormonal assay were conducted in Tracer Bioclimatology Unit, Biological Applications Department, Nuclear Research Centre, Atomic Energy Authority, Inshas, Cairo, Egypt.

Experimental procedure

Fifty six female NZW rabbits aged 12 weeks were used in the study, as a part of an experiment carried out on both females and males. The study included two periods; each was minimum of 3 months. The first was from January until March, 2000 (i.e. under mild conditions) and the second was from June until August, 2000 (i.e. during hot conditions). In the first period, 32 females with 1795.7±48.3 g average body weight were used. In the second period, another 24 females averaged 1598.3±35.0 g, body weight, were used. In each of the studied periods, the animals were divided into 4 groups according to type of light regime. The first group was exposed to natural daylight and was considered as control. The average duration of the natural daylight was 11.04 h under mild conditions and 13.41 h during hot climate conditions. The second was exposed to 16 h light and 8 h darkness (long lightness; 16L:8D), the third was exposed to 12 h light and 12 h darkness (medium lightness) and the fourth was exposed to 8 h light and 16 h darkness (short lightness; 8L:16D).
Mating of females was carried out at 20 weeks of age in mild conditions and at 22 weeks in hot conditions. Age at mating in males was 23 weeks in mild conditions and 25 weeks in hot conditions. The higher 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 rabbits in all groups were offered feed and water *ad libitum*. The chemical analysis of the commercial pelleted diet was 18.0% crude protein, 12.0% crude fibre, 2.8% Ether extract and 2600 kcal DE/kg diet digestible energy..

Animal housing and management

The animals were housed in a part of the rabbit 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 on the windows. The rabbit building was naturally ventilated through mesh windows and provided with automatically controlled side exhaustion fans.
The animals were individually housed in galvanized wire cages (50 x 55 x 39 cm) provided with a feeder and automatic nipple drinker. All animals were kept under the same managerial and hygienic conditions in each period. Lighting was provided by lamps at the beginning of the dark period, 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. Feed intake and water consumption were estimated individually once each week, during the experimental period. 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.
Rectal, skin and ear temperatures were measured individually at midday by a digital thermometer, during the experimental periods. The skin temperature was measured at one location between the neck and loin on the body surface. The thermometer was fixed on the bare skin and 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.
Adaptability for hot climate conditions was estimated as: 100 – The average of the relative deviations in all the traits studied (regardless of the minus or plus signs). The relative deviations in all the traits affected by heat stress were estimated as: (the difference in the values of the trait in the hot and mild (normal; control) conditions divided by the value of the trait in the mild conditions) x 100.
Air temperature (^{o} C) and relative humidity (%) inside the rabbit building were measured four times each month between 12.00 to 14.00 h using automatic thermo-hygrometer (^{o} C 0 : 60, H 10 – 95%; HANNA Instruments, Italy). Averages of air temperature and relative humidity values at midday inside rabbitry building were, respectively, 19.0 ± 1.4^{o}C and 65.2 ±1.7% during the first period and 33.0 ± 0.8^{o}C and 61.3 ± 2.0% during the second period. The temperature-humidity index (THI) was calculated using the equation proposed by MARAI *et al.* (2001): THI = db^{o}C – [(0.31 - 0.31 RH) (db^{o}C - 14.4)], where db^{o}C = dry bulb temperature in Celsius and 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

Blood samples were collected once at the end of the experimental periods 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^{o}) until analysis.

Estimation of hormones and biochemical components in blood plasma

Total proteins, urea nitrogen, creatinine and total lipids concentrations were estimated by the colorimetric method using commercial kits (Diamond Diagnostic, Egypt). Glutamic-pyruvate transaminase (GPT) and glutamic oxaloacetic transaminase (GOT) were assayed using commercial kits of Diamond Diagnostics, Egypt.
Triidothyronine (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 was carried out using Nuclear Enterprise, Gamma Counter, Scaler Ratemeter SR-7. The tracer in the hormones was labeled 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 using the following model according to SNEDECOR and COCHRAN (1982): $Y_{ik} = \mu + P_i + T_k + e_{ik}$, where, μ= the overall mean; P_i = the fixed effect of the ith period (i= 1, 2; 1, mild conditions and 2, hot conditions), T_k = the fixed effect of kth light regime treatment (k= 1,…4) and e_{ik} = random error. Since the interaction between the period and light regime were not significant, it was omitted from analysis. Significance of the differences in the results was tested by Duncan's New Multiple Range Test (DUNCAN, 1955).

RESULTS AND DISCUSSION

Temperature-humidity index (THI)

The estimated THI values were 18.5 during the mild climate and 33.9 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.

Effect of hot climate conditions

The period of the year (heat stress) affected adversely many of the studied traits and the effects were significant on daily body weights at 12 and 20 weeks, daily gain weights during 12-16, 16-20 and 12-20 weeks of age, thermoregulatory parameters, feed intake and water consumption, blood plasma metabolites except functions of endocrines (Tables 1-3). Estimating of adaptability to the hot conditions showed that it was 78.5% for young doe rabbits.

The adverse effect of the very severe heat stress conditions on the young NZW doe rabbit growth and the physiological background traits studied were similar to the results reported by many workers and recently reviewed by MARAI *et al.* (2002).

During hot conditions, body weight decreased than in mild conditions with 11.0 and 16.0% at 12 and 20 weeks of age, respectively (Table 1). Average daily gain weight showed similar trends to that of the body weight. Daily gain weights decreased with 19.7% between 12-16 weeks, 26.7% between 16 and 20 weeks of age and 23.3% during the experimental whole period (12 to 20 weeks). These results were similar to those obtained by LEBAS *et al.* (1986), CHIERICATO *et al.* (1996) and MARAI *et al.* (2001). The reduction in live body weight and daily body gain weight due to heat-stress conditions may be attributed to the negative effects of heat-stress on appetite and consequent decrease in feed consumption.

Age at first mating was 20 weeks under mild conditions and 22 weeks under hot conditions. HILMY (1991) and DAADER *et al.* (1999a,b) revealed that rabbit puberty delayed and age at first mating increased with increasing environmental temperature due to the decline of the body weight in heat-stressed rabbits. Such effect may be due to the negative effect of heat-stress on feed intake.

The significant increase in each of the thermoregulatory parameters and water consumption and the significant decrease in feed intake was similar to the results of GONZALEZ *et al.*(1971), HABEEB *et al.* (1997), MARAI *et al.* (1994 and 2001) and CHEIRICATO *et al.* (1996). Rabbits use general body position, breathing rate and peripheral temperature, especially ears temperature, as three devices to modify heat loss. However, respiration and ear are the most important dissipation pathways. Marai and HABEEB (1994) indicated that among 0 and 30^{o}C, latent heat evacuation is only controlled by altering the breathing rate. The decrease in feed consumption is due to impairment of appetite as a result to stimulation of the peripheral thermal receptors by the environmental temperature to transmit suppressive nerve impulses to the appetite centre in the hypothalamus that causes that phenomenon. The high consumption of water under heat stress conditions helps to increase the heat loss through water respiratory vaporization (rabbits are poor sweaters) and through urine (CHIERICATO *et al.*, 1992 and MARAI and HABEEB, 1994). At the same time, such phenomenon causes a temporary water deficiency with the increase of body fluids concentration that stimulates the hypothalamic thirst centre to increase water consumption (KECHIL *et al.*, 1981).

The significant decline in plasma total proteins and total lipids concentrations was similar to the results of HABEEB *et al.* (1997) and EL-MASRY *et al.* (1994). Reductions in blood metabolites under high environmental temperatures may be due to the decrease in feed intake and subsequent reduction of metabolism or to dilution of blood and body fluids as a result to the increase in water intake. The results on urea-N and creatinine were similar to those of HABEAS *et al.* (1997). The significant increase in concentrations of the

latter metabolites may be due to the increase in protein catabolism that result in increase in the glucocorticoid hormones and to the decrease in protein anabolism as a result to the decrease in T3 level (ALVAREZ and JOHNSON, 1973). The significant increase in liver function with exposure to heat stress was similar to the results of EL-MASRY *et al.* (1994). However, SALEM *et al.* (1998) reported that SGPT was insignificantly affected by season of the year. The decrease in each of blood plasma hormones of the heat-stressed animals was similar to the results of BOITI *et al.* (1992) and HABEEB *et al.* (1997). The authors attributed such depression to the decrease of endogenous heat production by the animals as a result to the thyroid stimulation hormone which decreases the heat production.
Estimating of the adaptability to the hot conditions, showed that it was 78.5% for young doe rabbits compared to 81.7% for young bucks (Marai *et al.,* Under Publication), under the same conditions, indicating that the young doe rabbits are more sensitive to the hot conditions than the young bucks.

Effect of light regime

In each of the two periods of the year, the intensities of light value were 80 and 70 lux under natural and artificial lights, respectively, at the level of the battery cages. Exposure of young doe rabbits to different light regimes affected adversely many of the studied traits and the effects were significant on daily gain weight during 16-20 and 12-20 weeks of age, daily feed intake, blood plasma total proteins and cortisol hormone (Tables 1-3). The young doe rabbits exposed to long daylight (16L:8D) were deleteriously affected, while those exposed to short daylight (8L:16D) were the least affected, in the studied traits.
Exposure of young doe rabbits to different light regimes affected adversely many of the studied traits. The young doe rabbits exposed to long daylight (16L:8D) were deleteriously affected, while those exposed to short daylight (8L:16D) were the least affected, in the studied traits. The differences were significant (P<0.05), although such effect did not reach significance, on body weight. However, THEAU-CLEMENT *et al.* (1995) reported that body weight of rabbits at 26 weeks of age was significantly higher when exposed to 8h than 16h daylight. In daily gain weight, the group exposed to 16L:8D decreased (P<0.05) than that exposed to the natural daylight (Control) with 38.8% between 16 and 20 weeks of age and with 20.3% between 12 and 20 weeks of age. The group exposed to 8L:16D increased than that exposed to the natural daylight (average duration of the natural daylight was 11.04 h under mild conditions and 13.41 h during hot climate conditions). Regarding feed consumption, UZCATEGUI and JOHNSTEN (1990) found that it was higher with 10h than with 12 and 14 h continuous light. TOUITOU *et al.* (1992) thought that circadian cortisol rhythm is synchronized by light stimulus.

CONCLUSIONS

Exposure of the young NZW doe rabbits to severe heat stress causes disturbance of the physiological background that affect their productive performance. Exposure of young NZW doe rabbits to different light regimes in the sub-tropical conditions of Egypt,

showed significant adverse effects on many of the growth performance and the physiological background traits. Estimation of the adaptability to hot conditions showed that the young doe rabbits are more sensitive under such conditions than the young bucks.
The favourable effects on some of the studied traits shown by exposure of doe rabbits to short daylight (8L:16D), may suggest its use as a light regime in commercial rabbit production in Egypt, although it should be evaluated economically.
Reduction in the traits studied by exposure of doe rabbits to long daylight (16L:8D), may be mainly due to disturbance of the physiological activities of the animals.

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Table 1. Body weight (Means ± SE) of young NZW doe rabbits, as affected by climatic conditions and light regime.

Items	Body weight (g) at ages (weeks)			Daily body gain (g) between age (weeks)			
	12	20	22	12 – 16	16 – 20	12 – 20	20 - 22
Conditions:							
Mild	1795.8±48.0	3016.3±56.2		21.8±1.5	21.7±1.2	21.0±0.8	
Hot	1598.3±35.0	2533.3±39.6	2742.8±34.8	17.5±0.8	15.9±1.1	16.3±0.6	15.1±1.1
Significance	**	***		*	***	***	
Light regime:							
Natural daylight=	1700.0±55.9	2901.8±128.3	2710.0±87.6	21.5±1.7	21.4±1.9a	20.7±1.5a	14.1±3.2
16L:8D	1737.3±52.7	2695.5±96.2	2655.0±36.6	21.1±1.6	13.1±1.7b	16.5±1.2b	17.9±2.0
12L:12D	1756±105.1	2836.1±102.3	2636.0±67.7	17.1±2.7	21.5±1.6a	18.6±1.1ab	14.3±2.9
8L:16D	1692.3±52.9	2896.2±83.2	2832.0±72.7	21.5±1.7	21.5±1.5a	20.8±1.1a	14.0±1.9
Significance	NS	NS	NS	NS	***	*	NS

*** P < 0.001, ** P < 0.01 P < 0.05 and NS = Not significant. Means bearing different letters in the same column differ significantly (P<0.05). + Length in mild water natural daylight averages were 11.04 h and 13.41 h in summer.

Table 2. Thermoregulatory parameters, daily feed intake and daily water consumption (Means ± SE) of young NZW doe rabbits, as affected by climatic conditions and light regime.

Items	Respiration rate (rpm)	Ear temperature (° C)	Rectal temperature (° C)	Skin temperature (° C)	Feed intake (g)	Water intake (ml)
Conditions:						
Mild	81.1+1.2	27.3+0.1	38.9+0.1	38.6+0.1	156.3+4.2	367.3+10.3
Hot	96.5±1.5	38.3±0.2	40.1±0.1	39.6±0.1	104.2±3.7	537.5±16.8
Significance	***	***	***	***	***	***
Light regime						
Natural daylight+	88.4±2.6	31.3±1.7	39.3±0.1	38.9±0.2	140.9±9.8ab	426.4±33.2
16L:8D	87.9±3.4	31.3±1.7	39.4±0.2	38.9±0.2	125.5±9.9b	429.5±31.3
12L:12D	86.3±3.0	31.4±1.6	39.4±0.2	39.0±0.2	131.5±8.5ab	430.0±31.4
8L:16D	85.2±2.6	31.7±1.5	39.3±0.2	38.9±0.2	148.1±9.3a	437.7±28.9
Significance	NS	NS	NS	NS	*	NS

*** P < 0.001, ** P < 0.01 P < 0.05 and NS = Not significant. + Natural daylight in mild weather were average 11.04 h and in summer were average 13.41 h light daily. Means bearing different letters in the same column differ significantly (P<0.05).

Table 3. Blood metabolites, kidney function, liver function and endocrine function (Means ± SE) in young NZW buck rabbits , as affected by climatic conditions and light regime.

Items	Total proteins (g/dl)	Total lipids (g/dl)	Urea-N (mg/dl)	Creatinine (mg/dl)	SGPT (u/l)	SGOT (u/l)	T_3 Hormone (ng/dl)	Cortisol hormone (ng/ml)
Conditions:								
Mild	8.3+0.1	4.0+0.2	38.2+0.9	1.4+0.1	7.6+0.3	7.9+0.2	124.6+5.8	7.7+0.4
Hot	7.8±0.1	3.4±0.1	47.0±2.1	1.6±0.1	12.0±0.9	13.1±1.0	112.1±4.4	7.1±0.4
Significance	***	**	***	*	***	***	NS	NS
Light regime:								
Natural daylight[+]	7.8±0.1c	3.5±0.2	43.1±1.6	1.5±0.1	8.8±0.9	9.9±0.9	110.8±3.8	9.3±0.4a
16L:8D	8.4±0.2a	3.7±0.2	43.3±1.5	1.4±0.1	8.2±1.3	10.2±1.6	139.9±9.7	7.5±0.4b
12L:12D	8.4±0.2a	4.2±0.2	41.5±3.0	1.6±0.1	10.5±1.2	9.3±0.9	118.2±5.5	7.5±0.2b
8L:16D	8.0±0.1bc	3.6±0.3	39.0±2.7	1.6±0.1	9.5±0.7	10.2±1.0	111.3±9.7	5.6±0.4c
Significance	**	NS	NS	NS	NS	NS	NS	***

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

+ Means bearing different letters in the same column differ significantly ($P<0.05$).