Egyptian Journal of Rabbit Science, 19 (1) 51 - 70 (2009)

EFFECTS OF FEEDING SYSTEM, DIETARY COPPER SUPPLEMENTATION AND CLIMATIC CONDITIONS ON PERFORMANCE OF ADULT FEMALE AND MALE RABBITS

U.M. Abd El-Monem

Department of Animal production , Faculty of Agriculture Zagazig University, Zagazig, Egypt

One hundred and twenty New Zealand White (NZW) adult female and thirty six adult male rabbits at 6 months of age were used to study the effects of heat stress, feeding time, dietary supplementation with copper (at levels of 0.0, 75 and 150 mg / kg diet) and their interaction, under Egyptian conditions.

The results showed that the estimated Temperature – humidity index (THI) values were 18.9 at winter (mild period) and 27.4 at summer (hot period), indicating absence of heat stress during winter (less than 22.2) and exposure to severe heat stress during the hot period (23.3-25.5).

Doe performance: results revealed that, the litter size and weight at birth , 21 days and weaning, litter weight gain from birth to 21 days and from birth to weaning and calculated milk yield were significantly ($P<0.01$ or 0.05) higher in the mild period than in hot period. Feeding the doe rabbits at night only improved significantly ($P<0.05$ or 0.01) litter size and weight at birth, 21 days and at weaning, litter weight gain from birth to 21 days and from birth to weaning, calculated milk yield, feed intake and serum albumin. Water intake, water/feed ratio and serum globulin were decreased significantly ($P<0.01$or 0.05), when feeding doe rabbits at night only than feeding system all day. Dietary supplementation of doe rabbits with copper was improved significantly ($P<0.05$ or 0.01) all traits of productive and reproductive performance comparatively with those receiving unsupplemented once during the experimental periods. Dietary supplementation of doe rabbits with copper up to 150 mg /kg diet increased significantly ($P<0.05$) each of serum total protein, albumin, GOT and GPT.

Buck performance: results showed that the ejaculate volume, mass motility, sperm concentration and feed intake were decreased significantly ($P<0.01$ or 0.05), while the reaction time, abnormalities sperm and dead sperm were increased significantly ($P<0.01$) in hot period when compared with the comfort period. The water intake, *water/feed ratio, rectal temperature and respiration rate/ rectum temperature ratio were significantly (P<0.01 or 0.05) higher in hot period compared with mild period. During sever heat stress feeding the male rabbits at night only improved significantly (P<0.01 or 0.05) the ejaculate volume, reaction time, mass motility, sperm concentration and feed intake than feeding system all day. Copper supplementation up to 150 mg/kg diet significantly (P<0.05) improved ejaculate volume, sperm concentration, dead sperm percentage, reaction time and feed intake.*

Finally, during hot summer period, feeding rabbits at night only and supplementation their diets with copper at 150 mg / kg diet is very effective on rabbits production and reproduction, under Egyptian conditions.

Key words: Dietary copper, feeding system, females, males performance.

It has been recognized that the environment plays an important role in the regulation of reproductive function ant it now appears, that environmental stimulate must act through the nervous system and the hypothalamo- pituitary axis. Environmental stimulus such as changing day-length or temperature and feeding, affecting animal by stress, auditory and / or olfactory stimuli can positively or negatively modify reproductive performance (Theau-Clement, 2000).

The literature showed that the thermoneutral zone of growing rabbits at 6-12weeks of age is between 15-18C° (Rafai *et al.,* 1972). The high temperature negatively affects growth, productive and reproductive performance traits (Marai *et al.,* 1999, 2000 and 2006; Abdel–Monem, 2000 and Okab, 2007).

Restriction of feeding time to 12 hours / day during night (nocturnal feeding) decreases the sever effects of heat stress and improved the productive and reproductive performance of rabbits during summer season (Mahrose, 2000).

Copper has been used as a feed additive for rabbits and poultry to increase growth rate and reduce enteric disease (Zanaty, 2005). The favourable effects of copper addition to animals diets are due to the importance of copper as essential nutrient for the physiological functions of animal, since it may protect the animal against infection (Schurch, 1956) and is generally safe when added at levels consistent with good feeding practices. Patton *et al.*(1982) found that the response to copper addition was greater in a trial conducted during a period of high environmental temperature than in one conducted at a moderate temperature, indicating occurrence interaction between copper response and environmental temperature.

The present study was conducted to investigate the effects of period of the year (heat stress), feeding system (*ad libitum* or restricted at night only for 12 hours), dietary supplementation with copper (at levels of 0.0, 75 and 150 mg / kg diet) and their interaction on reproductive performance traits of NZW adult female and male rabbits, under the sub-tropical Egyptian conditions.

MATERIALS AND METHODS

This study was carried out at Private Farm in Zagazig City during two periods of the year, hot (from May to September, 2006) and mild (from October, 2006, to April, 2007).

Two factorial design experiment (2 X 3) were conducted to study the effect of feeding system with or without copper supplementation on performance of NZW rabbits during hot (from May to September, 2006) and mild (from October, 2006, to April, 2007) periods in Egypt. The average of ambient temperature and relative humidity at mild day inside the rabbitry building during the experimental period were 29.8 C^{o} and 79.4% in period of mild conditions and 18.6C^{o} and 61.1% in period of hot conditions, respectively.

Experiment 1:

A factorial experimental design (2X3) was performed during hot period conditions (from May to September, 2006) including two feeding system (fed *ad libitum*, whole day and fed *ad libitum* at night only from 8 pm to 8 am) and three levels of copper supplementation (0, 75 and 150 mg /kg diet).

A total number of 120 doe and 36 buck New Zealand White (NZW) rabbits at 6 months of age were randomly divided into 6 treatment groups (10 does and 3 bucks /each treatment group). Animals in each group were nearly similar in average initial body weight. The basal experimental diet was formulated to cover the nutrient requirements during gestation and suckling periods. The same diet was fed without and with supplementation of copper sulphate ($Cu\ SO_4$-5 H_2O) to provide copper at the level of 0, 75 and 150 mg /kg diet. The composition and calculated chemical analysis of the experimental basal diet are presented in Table 1.

All rabbits were kept under the same managerial, hygienic and environmental conditions. Does and bucks were individually reared in wire cages and their offspring's were collectively raised in cages in the same batteries in a well ventilated building and fresh water was automatically available all the time by stainless steel nipples fixed in each cages. All doe cages were equipped with

Table 1: Composition and calculated chemical analysis of the experimental basal diet

Ingredients	%
Alfalfa hay	28.0
Barley	18.0
Soybean meal(44%)	18.0
Wheat bran	25.0
Yellow corn	6.0
Molasses	3.0
Limestone	1.1
Sodium chloride	0.3
Vitamin and mineral premix*	0.6
Total	**100**
Calculated analysis according to NRC(1977)	
Crude protein%	18.18
Crude fiber%	13.43
Ether extract%	2.29
Digestible energy(kcal/kg)	2656.00

*Each kg of premix contain vit. A 1200 IU; vit. D3 2000IU; vit. E40 mg, vit. K3 4 mg, Riboflavin 6mg; Pantothenic acid 10 mg; Niacine 30 mg; vit.B1 3mg, vit. B6 4 mg; Folic acid 1.5 mg; vit.B12 30 Ug ; Biotin 80 Ug; Choline chloride (50%) 700 mg; Mn 80 mg; Mg 70 mg ; Cu 10 mg; Fe 40 mg ;I 1.5 mg; Co 0.25 mg and Se 200Ug.

feeders and nipples. During the experiment, the total artificial light was about 16 hours/day. At mating rabbits were individually transferred to the buck cages and returned to their own hatches copulation, each doe was palpated 10 days post-mating to be rebred until pregnancy was establish. Within 12 hours after kindling, litter kits were recorded and weaned at 30 days of age.

The traits studied for does were feed and water consumption during gestation and suckling period, litter sizes and weight at each of birth, 21 and 30 days (weaning) of age, litter weight gain and mortality rate of pups from birth to 30 days of age were recorded. Doe milk consumed by the pups from birth to 21 days of age was estimated by the following equation:.

Y = Litter weight gain during the period 0-21days (kg) / 0.56

Where, Y was the milk consumed by pups during the period 0-21days of age, 0.56 was standard figure given by Cowie (1969) for the NZW strain and Partridge and Allain (1982) for crossbred does depending on the linear relationship between the litter weight gain (kg) and doe milk consumed.

The bucks were trained for artificial collection of semen by using the artificial vagina to study the semen traits. Semen was collected once weekly at 8 a.m from each buck. A total of 180 ejaculates were collected from the bucks during the period. The gel mass was removed from semen samples before examination. Ejaculate volume and density were recorded. Sperm motility was microscopically estimated just after semen collection. Advanced motility was expressed as a percentage of actual progressive motion. Sperm cell concentration was estimated by using haemo cytometer. The percentage of dead sperm was detected by using Eosin + Nigrosin stain described by Salisbury *et al.*(1978).

The rectal temperature and respiration rate were measured in both does and bucks once every two weeks at 9-11 a.m. Respiration rate was recorded by a hand counter, which counts the frequency of the flank movement per minute. Internal body temperature was taken by medicine thermometer inserted into the rectum for 2 minutes at depth of cm.

At the end of the experimental period, blood samples were collected from three does and three bucks in each treatment groups. Blood was collected from the marginal ear vein after shaving and cleaning with alcohol in less than 2 minutes into dry clean centrifuge tubes containing some drops of heparin. Plasma was separated by centrifugation at 3000 rpm for 20 minutes and kept in a deep freezer at -20 C^o until the time of analysis . Serum total protein, albumin, GOT and GPT concentrations were estimated using commercial kits according to the procedure outlined by the manufacturer. The serum globulin values were obtained by subtracting the values of serum albumin from the corresponding values of serum total protein.

In order to study the combined effects of temperature and humidity, temperature humidity index (THI) was calculated according to the formula of Marai et al. (2001) as follows:

THI= db C^o -{(0.31-0.31RH)(db C^o -14)}, where db C^o = dry bulb temperature in Celsius and RH = RH % /100. The estimated values of THI were classified as follows: <22.2 = Absence of heat stress, 22.2 – 23.2= Moderate heat stress, 23.3 -25.5 = Severe heat stress and > 25.5= Very severe heat stress.

Experiment 2:

Another factorial experimental design (2 x 3) was conducted to study the effect of feeding system with or without copper supplementation on the performance of NZW rabbits under Egyptian mild conditions (from October to April).

The obtained data from all does, bucks and their litters (offspring) until the end of the 1st experiment (hot period conditions) were pooled with those obtained from the 2nd experiment (mild period conditions) and then subjected to the statistical analysis.

The obtained data were statistically analyzed by using (2 x 2 x3) factorial design according to Snedecor and Cochran (1982) by the following model:

$$Y_{ijkl} = \mu + P_i + F_j + N_k + PF_{ij} + FN_{jk} + PN_{ik} + PFN_{ijk} + e_{ijkl}$$

Where, Y_{ijkl} = An observation, μ = General mean, P_i = Fixed effect of i^{th} period (hot period and comfort period),. F_j =fixed effect of j feeding time (all day and at night), N_k = fixed effect of k copper supplementation (1,.....3), PF_{ij} = Interaction between period and feeding time, FN_{jk} =Interaction between feeding time and copper, PN_{ik}= Interaction between period and copper, PFN_{ijk} = Interaction between period, feeding time and copper and e_{ijkl} = Random error.

Differences among means were tested by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Temperature –humidity index:

Temperature – humidity index values (THI) were 18.9 and 24.7 at comfort and hot periods, respectively, indicated absence of heat stress during the comfort period (less than 22.2) and exposure of animals to moderate heat stress during the hot periods (23.3-25.5) similar to that reported by Marai *et al.*(1996).

Only the main factors were reported due to that the interaction effects on all the studied traits were not significant.

Doe performance:

A- Productive and reproductive performance:

1- Period effect:

Litter size and weight at birth, 21 days and weaning, litter weight gain from birth to 21 days and from birth to weaning were significantly ($P<0.01$or 0.05) higher for kits born during the mild period than the kids born during hot period (Table 2). Such difference may be a reflection of differences in seasonal climatic conditions. Also, the drop in litter size and weight in hot conditions may be attributed to the effect of this environmental conditions on mothering ability and milk production as a result of hyperthermia. Similar trends were obtained by Abdel-Monem and Ayyat (2002) and Marai *et al.* (2006), also Abdel-Monem *et al.* (2007 and 2008) reported the similar results in litter size and weight.

Table 2. Productive and reproductive performance of NZW doe rabbits as affected by period of year, feeding time, copper supplementation and their interaction.

Items	Litter Size at			Litter weight at			Litter weight gain		Daily feed intake (gm/day)	Daily water intake (ml/day)	Water / feed ratio	Calculated milk yield (0-21 days)
	Birth	21 day	Weaning	Birth	21 day	Weaning	Birth – 21 days	Birth-weaning				
Period of year (A):												
Hot	5.2^{b}± 0.18	3.8^{b}± 0.19	3.0^{b}± 0.18	$227.6.51^{b}$± 8.0	1345.9^{b}± 74.0	1762.0^{b}± 111.2	1118.3^{b}± 19.6	1534.4^{b}± 33.4	187.9^{b}± 2.3	410.3^{a}± 0.29	2.2^{a}± 0.08	1996.96^{b}
Mild	6.9^{a}± 0.20	5.6^{a}± 0.25	4.8^{a}± 0.26	315.75^{a}± 11.1	2479.1^{a}± 114.6	2978.5^{a}± 171.3	2163.8^{a}± 24.3	2662.8^{a}± 36.2	249.1^{a}± 3.7	293.0^{b}± 10.6	1.2^{b}± 0.04	3863.20^{a}
Sig.	**	**	**	**	**	**	**	**	**	**	**	**
Feeding time (B):												
Ad libitum	5.5^{b}± 0.20	4.2^{b}± 0.21	3.4^{b}± 0.23	239.9^{b}± 9.1	1711.6^{b}± 100.0	2020.5^{b}± 146.3	1471.7^{b}± 15.9	1780.6^{b}± 41.4	217.4^{b}± 4.0	365.1^{a}± 11.9	1.7^{a}± 0.02	2628.0^{b}
Feeding only at night	6.5^{a}± 0.22	5.2^{a}± 0.27	4.5^{a}± 0.27	304.3^{a}± 11.7	2155.3^{a}± 134.3	2772.5^{a}± 172.6	1851.0^{a}± 22.1	2468.2^{a}± 39.7	241.7^{a}± 3.4	301.6^{b}± 8.5	1.2^{b}± 0.08	3305.4^{a}
Sig	*	*	*	**	**	**	*	**	**	**	*	**
Copper suppl.(C):												
0 mg/kg diet	5.3^{c}± 0.23	3.9^{b}± 0.25	2.8^{b}± 0.22	236.2^{c}± 11.4	1497.8^{c}± 112.7	1628.8^{c}± 132.4	1261.6^{c}± 17.5	1392.6^{c}± 29.3	209.3^{b}± 6.2	370.9± 15.6	1.8± 0.03	2252.9^{c}
75 mg/kg diet	6.0^{b}± 0.21	4.7^{b}± 0.30	4.1^{a}± 0.30	273.0^{b}± 11.5	1931.9^{b}± 143.2	2518.3^{b}± 189.7	1658.9^{b}± 18.9	2245.3^{b}± 26.0	$223.6^{a\ b}$± 5.8	378.3± 18.2	1.7± 0.01	2962.3^{b}
150 mg/kg diet	6.9^{a}± 0.27	5.7^{a}± 0.31	4.9^{a}± 0.33	312.3^{a}±1 6.1	2393.6^{a}± 158.9	3065.1^{a}± 218.2	2081.3^{a}± 28.1	2752.8^{a}± 38.5	239.8^{a}± 4.9	383.5± 13.7	1.6± 0.04	3716.6^{a}
Sig.	**	**	**	**	**	**	**	**	*	NS	NS	**
Interaction :												
AXB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AXBXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

a,b,c.., Means bearing different letters in the same column within each factor differ significantly ($P \leq 0.05$).
NS = Not significant, * = $P<0.05$, ** = $P<0.01$

Data in Table 2 revealed that higher performance ($P<0.01$) of milk yield in mild condition than that in hot condition. The decrease in milk production during the hot climate may be due to reduce in apatite and feed intake. These results agree with Askar (1989) who found that milk production was decreased in summer than in winter under Egyptian conditions.

Feed intake which includes feed intake by pups before weaning decreased significantly ($P<0.01$) in hot period as compared with mild period (Table 2). This means that the period was responsible for any increase in feed intake. This may be explained on the basis that rabbits required more heat requirements during cold conditions, covered by increasing feed consumption. Conversely, rabbits exposed to sever heat stress increase heat production by decreasing voluntary feed intake. This results agree with this obtained by Abdel-Monem (2000); Abdel-Monem and Ayyat (2002) and Marai *et al.*(2008), who stated feed intake was decreased significantly ($P<0.05$) in doe NZW rabbits under heat stress condition

The average water intake followed the opposite trend observed with feed intake. Water intake and water/feed ratio were significantly ($P<0.01$) higher in hot period compared with mild period (Table 2). The present results agree with Abdel-Monem *et al.*(2007 and 2008), who found that water intake was increased significantly ($P<0.01$) in doe NZW rabbits under heat stress condition.

2- Feeding system effect:

Data presented in Table 2 show that feeding the doe rabbits at night only improved significantly ($P<0.05$ or 0.01) litter size and weight at birth, 21 days and weaning, litter weight gain from birth to 21 days and from birth to weaning and milk yield. The improve in litter size and weight by using feeding system at night only may be due to the improve in feed intake and milk production. Similar trend were obtained by Mahrose (2000) and Abdel-Monem *et al.* (2007), who found that feed doe rabbits nocturnally improved significantly ($P<0.01$) litter size and weight at birth, 21 days and at weaning.

In feeding system at night only the feed intake increased significantly ($P<0.01$) with 11.18 %, but the water intake and water/feed ratio decreased significantly ($P<0.01$ or 0.05) with 17.4 and 29.4%, respectively than feeding system all day (Table 2).

3- Copper supplementation effect:

Data presented in Table 2 show that addition of copper on the diets of NZW doe rabbits significantly ($P<0.05$ or 0.01) improved all traits of productive and reproductive performance studied comparatively with those receiving unsupplemented one during all the experimental periods. The feed intake was significantly ($P<0.05$) improved, while the water intake, water/feed ratio were not significantly affected by the same factor. The present results agree with those of Marai *et al.*(2000), who found that litter size and weight at birth, 21days and at weaning were significantly ($P<0.05$ or 0.01) affected by copper supplementation.

B- Some physiological and blood biochemical changes:

1- Period effect:

Hot climatic conditions showed significantly ($P<0.05$) higher values of rectal temperature, respiration rate and respiration rate/ rectum temperature ratio than mild conditions (Table 3). These results may be due to exposure of rabbits to heat stress. These results agree with those obtained by Abdel-Monem(2000), Abdel-Monem and Ayyat (2002), Marai *et al.* (2006) and Abdel-Monem *et al.* (2007 and 2008), who found that rectal temperature and respiration rate were significantly ($P<0.05$) higher in summer than in winter under Egyptian conditions.

Results in Table 3 show that serum total protein, albumin, globulin, GOT and GPT were significantly ($P<0.05$ or 0.01) affected by period. The present results agree with Abdel-Monem (1996); Marai *et al.*(2006) and Abdel-Monem *et al.*(2007 and 2008), who found that serum total protein, albumin, globulin, GOT and GPT were significantly ($P<0.05$ or 0.01) affected by period.

2- Feeding system effect:

The rectum temperature, respiration rate and respiration rate/ rectum temperature ratio were not significantly affected by feeding system. At night feeding, albumin was increased ($P<0.05$), while the reverse occurred with globulin, where it was decreased ($P<0.05$) as presented in Table 3. Similar trends were obtained by Mahrose (2000), Barakat (2001) and Abdel-Monem *et al.* (2007). The other traits studied were not significantly affected by feeding time.

3- Copper supplementation effect:

Rectum temperature, respiration rate and respiration rate/ rectum temperature ratio were not significantly affected by the copper supplementation (Table 3).

Results in Table 3 show that dietary supplementation of doe rabbits with copper up to 150 mg increased significantly ($P<0.05$) each of total protein, albumin, GOT and GPT, while the globulin was not affected significantly by the same factor. The present results agree with Marai *et al.* (2000), who found that serum total protein and albumin were significantly ($P<0.05$) affected by copper supplementation.

Table 3. Some physiological parameters and Blood biochemical of NZW doe rabbits as affected by period of year, feeding time, copper supplementation and their interaction

Items	Physiological parameters			Blood biochemical				
	Rectum temperature (R.T.)	Respiration rate (R.R.)	(R.R.)/ (R.T.) ratio	Total protein g/dl	Albumin g/dl	Globulin g/dl	GOT	GPT
Period of year (A):								
Hot	39.8a±0.57	138.7a±5.5	3.5a±0.11	$5.8^{b}\pm0.07$	$2.9^{b}\pm0.02$	$2.4^{b}\pm0.02$	$23.9^{b}\pm1.3$	$40.2^{b}\pm2.1$
Mild	39.3b±0.41	112.5b±4.9	2.9b±0.09	$7.3^{a}\pm0.06$	$4.1^{a}\pm0.03$	$3.2^{a}\pm0.03$	$25.6^{a}\pm1.1$	$43.8^{a}\pm1.9$
Sig.	*	*	*	*	**	*	*	**
Feeding time (B):								
Ad libitum	39.5±0.29	141.1±6.1	3.6±0.14	5.9±0.04	$3.1^{b}\pm0.03$	$2.8^{a}\pm0.03$	26.5±0.8	41.1±1.7
Feeding only at night	39.3±0.33	135.7±5.0	3.5±0.12	6.2±0.05	$3.5^{a}\pm0.03$	$2.7^{b}\pm0.02$	26.9±0.9	40.9±2.3
Sig	NS	NS	NS	NS	*	*	NS	NS
Copper supplementation (C):								
0 mg/kg diet	39.6±0.37	142.0±4.8	3.6±0.14	$5.1^{b}\pm0.03$	$3.0^{b}\pm0.03$	2.1±0.02	$25.7^{b}\pm0.89$	$39.4^{c}\pm1.6$
75 mg/kg diet	39.4±0.40	137.6±3.6	3.5±0.12	$5.7^{a}\pm0.06$	$3.6^{a}\pm0.03$	2.1±0.02	$29.4^{a}\pm1.1$	$41.7^{b}\pm1.9$
150 mg/kg diet	39.4±0.26	131.9±4.5	3.3±0.12	$5.9^{a}\pm0.04$	$3.7^{a}\pm0.04$	2.2±0.02	$30.1^{a}\pm1.3$	$42.5^{a}\pm2.0$
Sig.	NS	NS	NS	*	*	NS	*	*
Interaction :								
AXB	NS	NS	NS	NS	NS	NS	NS	NS
AXC	NS	NS	NS	NS	NS	NS	NS	NS
BXC	NS	NS	NS	NS	NS	NS	NS	NS
AXBXC	NS	NS	NS	NS	NS	NS	NS	NS

a,b,c.. Means bearing different letters in the same column within each factor differ significantly ($P\leq0.05$).
NS = Not significant, * = $P<0.05$ and ** = $P<0.01$,

Buck performance:

A-Semen characteristics:

1- Period effect

Data in Table 4 show that ejaculate volume, mass motility, and sperm concentration were decreased significantly (P<0.01 and 0.05) with 40.4 , 42.2 and 28.8 % respectively, while the reaction time, abnormalities sperm and dead sperm were increased significantly (P<0.01) with 256.3, 77.0 and 60.3 % respectively, in hot period when compared with the mild period. Similar results were obtained by Tharwat *et al.* (1994), Abdel-Monem (2000) and Abdel-Monem and Ayyat (2002) and Marai *et al.*(2008). El-Sherry *et al.* (1980) confirmed that summer stress retarded spermatogenesis in rabbits. Farag *et al.*(1983) attributed the lowest motility in summer to the decrease in sperm cell calcium concentration. Braun (1975) also, reported that calcium concentration with other divalent metal ions occurring in semen has a significant regulation of perm metabolism and motility. The decrease in sperm concentration may be due to the degeneration of germinal epithelium and partial atrophy in the somniferous tubules (Chou *et al.*, 1974 and El-Sherry *et al.*, 1980). The increase in percentage of dead spermatozoa after exposure to high temperature may be due to the effect of heat stress on the epididymis function which is under the control of testosterone (Davis *et al.*, 1970; Damber *et al.*, 1980 and Chap and Bedrak, 1983).

2- Feeding system effect:

During sever heat stress feeding the male rabbits at night only was improved significantly (P<0.01 or 0.05) the ejaculate volume, reaction time, mass motility, and sperm concentration, but the other semen traits were not affected by feeding time. (Table 4). Similar trends were obtained by Zaki *et al.* (2000); Daader *et al.* (2002) and Marai *et al.*(2008).

3- Copper supplementation effect:

Table 4 show that treatment of buck rabbits with copper as supplementation increased significantly (P<0.05) ejaculate volume and sperm concentration, also the dead sperm percentage and reaction time were improved, significantly (P<0.05), but the other semen traits were not affected by supplementation the buck diets with copper.

B-Feed and water intake:

1- Period effect:

Feed intake decreased significantly (P<0.05) in hot period as compared with mild period (Table 4). This means that the period was responsible for any increase in feed intake. This may be explained on the basis that rabbits required more heat requirements during cold conditions, covered by increasing feed

Table 4 .Semen characteristics, feed intake, water intake and water /feed ratio of New Zealand White male rabbits as affected by period of year, feeding time, copper supplementation and their interaction.

Items	Semen characteristics							Daily feed intake (g /day)	Daily water intake (ml /day)	Water : feed ratio
	Volume (ml)	pH	Reaction time	Mass motility (u)	Abnormalities spermatozoa (%)	Dead spermatozoa (%)	Sperm concentration (10^{6} x ml)			
Period of year (A):										
Hot period	$0.56^{b}\pm0.02$	7.4±0.1	$44.9^{b}\pm2.1$	$35.0^{b}\pm2.1$	$17.7^{a}\pm0.61$	$25.0^{a}\pm1.5$	$265.3^{b}\pm13.6$	113.6b±2.7	187.4a±5.2	1.6±0.03
Mild period	$0.94^{a}\pm0.03$	7.5±0.02	$160.0^{a}\pm1$	$60.6^{a}\pm2.3$	$10^{b}\pm0.58$	$15.6^{b}\pm0.82$	$372.7^{a}\pm9.5$	129.2a±1.6	131.1b±6.1	1.0±0.02
Sig.	**	NS	**	*	**	**	**	*	**	*
Feeding time (B):										
Ad libitum	$0.64^{b}\pm0.3$	7.5±0.1	$37.8^{a}\pm3.2$	$38.2^{b}\pm2.6$	15.0±0.72	21.0±1.5	$262.4^{b}\pm13.3$	117.8b±2.1	189.7a±4.3	1.4±0.02
Feeding only at night	$0.86^{a}\pm0.04$	7.3±0.03	$23.1^{b}\pm2.1$	$57.4^{a}\pm2.7$	13.0±0.60	19.8±0.75	$375.6^{a}\pm9.0$	133.1a±2.9	138.0b±7.0	1.0±0.01
Sig.	**	NS	*	**	NS	NS	**	*	*	NS
Copper supplementation (C):										
0 mg/kg diet	$0.68^{b}\pm0.05$	7.6±0.5	$35.9^{a}\pm4.1$	43.8±3.6	15.8±0.93	$24.0^{a}\pm2.1$	$281.8^{b}\pm17.7$	105.7b±3.0	150.1±5.9	1.4±0.03
75 mg/kg diet	$0.75^{ab}\pm0.04$	7.4±0.1	$30.1^{ab}\pm3.5$	46.1±3.9	14.0±0.83	$19.9^{ab}\pm1.6$	$320.0^{ab}\pm18.4$	119.5a±1.9	142.0±4.8	1.2±0.03
150 mg/kg diet	$0.82^{a}\pm0.04$	7.4±0.4	$25.3^{b}\pm2.9$	52.1±4.1	13.9±0.82	$17.0^{b}\pm1.1$	$355.2^{a}\pm15.3$	122.9a±2.3	140.3±6.0	1.1±0.01
Sig.	*	NS	*	NS	NS	*	*	*	NS	NS
Interaction :										
AXB	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AXBXC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

a,b,c.. Means bearing different letters in the same column within each factor differ significantly ($P\leq0.05$).
NS = Not significant, * = $P<0.05$ and ** = $P<0.01$,

consumption. Conversely, rabbits exposed to sever heat stress increases heat production while decreasing voluntary feed intake. This results agree with those obtained by Abdel-Monem (2000), Abdel-Monem and Ayyat (2002) and Marai *et al.*(2008), who stated that feed intake was decreased significantly (P<0.05) in buck NZW rabbits under heat stress condition

The average water intake followed the opposite trend observed with feed intake. Water intake and water / feed ratio were significantly (P<0.01or 0.05) higher in hot period compared with mild period (Table 4). The present results agree with Abdel-Monem (1996) and Marai *et al.* (2008), who found that water intake was increased significantly (P <0.01) in buck NZW rabbits under heat stress condition.

2- Feeding system effect:

In feeding system at night only, the feed intake increased significantly (P<0.05) with 13.0 %, while, the water intake decreased significantly (P<0.05) with 27.3 than feeding system all day (Table 4).The water/feed ratio was not affected by feeding time. Similar trends were obtained by Marai *et al.*(2008).

3- Copper supplementation effect:

The feed intake was significantly (P<0.05) improved, while the water intake and water / feed ratio were not significantly affected by supplementation the buck diets with copper (Table 5).

C- Some physiological and blood biochemical changes:

1- Period effect

Hot climatic conditions showed significantly (P<0.05) higher values of rectal temperature and respiration rate/ rectum temperature ratio (Table 5) than mild conditions. While, the respiration rate was not affected by the same factor. These results may be due to exposure of rabbits to heat stress. Our results agree with those obtained by Abdel-Monem (1996), Abdel-Monem and Ayyat (2002) and Marai *et al.*(2008), who found that rectal temperature and respiration rate were significantly (P<0.05) higher in summer than in winter, under Egyptian conditions.

Results in Table 5 showed that serum total protein, albumin, globulin, GOT and GPT were significantly (P <0.05) affected by period, while serum globulin, and GPT were not affected. The present results agree with Abdel-Monem (1996) and Marai *et al.*(2008), who found that serum total protein, albumin, globulin, GOT and GPT were significantly (P<0.05 or 0.01) affected by period.

2- Feeding system effect:

The rectum temperature, respiration rate and respiration rate/ rectum temperature ratio were not significantly affected by feeding time. At night

Table 5. Some physiological parameters and Blood biochemical of NZW buck rabbits as affected by period of year, feeding time, copper supplementation and their interaction

Items	Physiological parameters			Blood biochemical				
	Rectum temperature (R.T.)	Respiration rate (R.R.)	(R.R.)/ (R.T.) ratio	Total protein g/dl	Albumin g/dl	Globulin g/dl	GOT	GPT
Period of year (A):								
Hot	39.6a±0.43	146.0±3.9	3.7a±0.14	6.1b±0.05	3.2b±0.02	2.9b±0.03	27.2b±1.0	39.6±1.8
Mild	38.1b±0.34	109.0±2.6	2.9b±0.12	6.4a±0.04	3.5a±0.03	3.2a±0.03	28.8a±1.4	40.0±1.6
Sig.	*	NS	*	*	*	NS	*	NS
Feeding time (B):								
Ad libitum	39.3±0.21	131.0±3.1	3.3±0.16	6.4±0.03	3.3b±0.03	3.1a±0.02	30.9±0.7	40.3±1.9
Feeding only at night	39.1±0.50	122.0±4.1	3.1±0.11	6.5±0.05	3.9a±0.03	2.6b±0.02	31.0±1.1	40.5+1.6
Sig	NS	NS	NS	NS	*	*	NS	NS
Copper supplementation (C):								
0 mg/kg diet	39.4±0.29	136.30±3.5	3.5±0.15	6.0±0.03	2.9±0.01	3.1±0.03	22.6c±0.6	40.0+1.3
75 mg/kg diet	39.5±0.32	129.0±3.8	3.3±0.13	6.1±0.03	3.4+0.02	2.7±0.04	24.8b±0.9	40.2±1.5
150 mg/kg diet	39.4±0.38	125.0±2.9	3.2±0.14	6.2±0.05	3.2±0.02	3.0±0.03	27.1a±1.0	40.4±1.1
Sig.	NS	NS	NS	NS	*	*	*	NS
Interaction :								
AXB	NS	NS	NS	NS	NS	NS	NS	NS
AXC	NS	NS	NS	NS	NS	NS	NS	NS
BXC	NS	NS	NS	NS	NS	NS	NS	NS
AXBXC	NS	NS	NS	NS	NS	NS	NS	NS

a,b,c.. Means bearing different letters in the same column within each factor differ significantly ($P \leq 0.05$).
NS = Not significant, * = $P<0.05$ and ** = $P<0.01$,

feeding albumin, globulin and GOT were affected (P<0.05), while the other blood serum constants were not affected by feeding time as presented in Table 5. Similar trends were obtained by Marai *et al.*(2008).

3- Copper sulphate supplementation effect:

Rectum temperature, respiration rate and respiration rate/ rectum temperature ratio were not significantly affected by supplementation the buck diets with copper (Table 5).

Results in Table 5 show that dietary supplementation of buck rabbits with copper up to 150 mg affected significantly (P<0. 05) each of albumin, globulin and GOT, while the total protein and GPT were not affected significantly by the same factor.

Conclusively, it could be concluded that, feeding NZW adult female and male rabbits at night only and supplementation their diets with copper up to 150 mg /kg diet improve its performance during hot period in Egypt.

REFERENCES

Abdel-Monem, U. M. (1996). Heat stress effects and their amelioration on some traits of rabbits under Egyptian summer conditions in Egypt. M. Sc. Thesis, Zagazig University, Egypt.

Abdel-Monem, U. M (2000). Dietary supplementation with ascorbic acid and its effects on productive and reproductive performance of New Zealand white rabbits, under the summer condition of Egypt. *2nd International Conference On Animal Production and Health in Semi-Arid Areas*, Al-Arish, South Sinai, Egypt.

Abdel-Monem, U. M.; Abdel-Ghany, B. and Mahrose, Kh. M. (2007). Effects of feeding times on performance of New Zealand White rabbit does. *The 5th International Conference on Rabbit Production in Hot Climate*. Hurghada, Egypt, 4 – 7 December, pp 485 – 493.

Abdel–Monem, U.M. and Ayyat, M.S. (2002). Effect of dietary protein level on growing and mature rabbits performance, under summer conditions of Egypt. *3rd Scientific Conference On Rabbit Production in Hot Climates*, Hurghada, Egypt, 8-10 Oct: 481-494.

Abdel-Monem. U. M.; Mahrose, Kh. M. and Darwish, M.S. (2008). Responses of New Zealand and Californian rabbit does to different dietary protein levels under Egyptian conditions. *Animal Production Research Advances*, **4**(1): 19 – 25.

Askar, A. A. S. (1989): Studies on reproduction of female rabbits. M. Sc. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Barakat, A. E. (2001). A study of some factors affecting on doe and reproductive traits in meat rabbits. Ph. D. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Braun, T. (1975). The effect of divalentctions on bovine spermatozoa! Adenylate cyclase activity. *Journal Cyc. Nucl. Research*, **1**:271.

Chap, Z. and Bedrak, E. (1983). Interrelationship between pituitary- testicular axis activity and raised environmental temperature in the rat. *Journal of Endocrinology*, **97:** 193-197.

Chou, J. P.; Chuan, L. Y. and Chen-Chao, C. (1974). Effect of heating on rabbits spermatogenesis. *Chinese Medical Journal*, **6:** 365-378.

Cowie, A.T. (1969). Variation in the yield and composition of the milk during lactation in the rabbit and the glactopaietic effect of prolactin. *Journal of Endocrinlogy* , **44:** 437-450.

Daader, A.H.; Nasr-Alla, M.M.; Azazi, I.A.; Attia, S.A.M. and Seleem, T.S.T (2002). Amelioration of heat stressed Buscat rabbits by feeding diurnally or nocturnally diets containing Nigella sativa L or fenugreek. *3rd Scientific Conference On Rabbit Production in Hot Climates*, Hurghada, Egypt, 8-10 Oct: 287-300.

Damber, J.E.; Bergh, A. and Janson, P.O. (1980). Leydig cell function and morphology in the rate testis after exposure to heat . *Andrologia*, **12:** 12-16.

Davis, J.R.; Langford, G. A. and Kirby, P.J. (1970). *The testicular capsule in the testis*. Academic press, New York, Pp 307.

Duncan, A. B. (1955). Multiple range and multiple F test. *Biometrics*, **11:** 1-42.

El- Sherry, M.I.; Nassar, S.M. and El-Naggar, S.M. (1980). Experimental study of summer stress in rabbits. 1. The description and qualification of the spermatogenic cell cycle in normal Baladi rabbit. *Assiut Veterinary Medical Journal*, **7**: 2-11.

Farag, R.S.; El-Assar, S.T.; El-Okash, H. and Mohamed, A. A. (1983). Mineral changes in ram spermatozoa as affected by freezing and various extenders. *Egyptian Journal of Animal Production*, **23:** 151-158.

Hammond, J.; Bowman, J.C. and Robinson, J.J. (1983). *Hammond's Farm Animals*. 5th Edition, Buther and Tanner Ltd, Great Britain. I.N.R.A. (1984).

Mahrose, Kh. M. A. (2000). Environmental studies on growth and reproduction traits in rabbits. M. Sci. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt

Marai, I.F.M.; Abd El-Monem, U.M. and Mahrose, Kh.M.A. (2008). Exotic male rabbit semen traits as affected by feeding systems and dietary supplementation with *Nigella Sativa* seeds under Egyptian conditions. *Egyptian Poultry Science Journal*, **28** (III): 833 – 847.

Marai, I.F.M.; Askar, A.A. and Bahgat, L.B. (2006). Tolerance of New Zealand and Californian doe rabbits at first parity to the sub–tropical environment of Egypt. *Livestock Production Science*, **104:** 165-172.

Marai, I.F.M.; Ayyat, M.S. and Abdel – Monem, U.M. (2000). Young doe rabbit performance traits as affected by dietary Zinc, Copper, Calcium or Magnesium, under winter and summer conditions of Egypt. *7^{th} World Rabbit Conference*, Spain, **8**: 313 – 320.

Marai, I.F.M.; Ayyat, M.S.; Gabr, H.A. and Abdel–Monem, U. M. (1996). Effect of summer heat stress and its amelioration on production performance of New Zealand White adult female and male rabbits, under Egyptian conditions. *6^{th} World Rabbits Congress*, Toulouse, France, 2: 197-208.

Marai, I. F. M.; Ayyat, M. S.; Gabr, H. A. and Abdel–Monem, U. M. (1999). Growth performance, some blood metabolites and carcass traits of New Zealand White broiler male rabbits as affected by heat stress and its alleviation, under Egyptian conditions. *Cahiers Options Mediterraneenne*, **8:** 35-42.

Marai, I.F.M.; El-Masry, K.A. and Nasr, A.S. (1994). Heat stress and its amelioration with nutritional, buffering, hormonal and physical techniques for New Zealand White rabbits maintained under hot summer conditions of Egypt. *Cahiers Options Mediterraneenne*, **8** (Supplement): 475-487.

Marai, I. F. M. and Habeeb, A. A. M. (1998). Adaptation of Bos Taurus cattle under hot climate conditions. *Annual Arid Zone*, **37** (3): 253 – 281.

Marai, I.F.M.; Habeeb, A.A.M. and Gad, A.E. (2001). Rabbits productive, reproductive and physiological performance traits as affected by heat stress: a review. *Livestock Production Science*, **78**: 71-90.

Nalbandov, A.V. (1970). *Reproductive Physiology*. 2^{nd} Edition. Taraporovala Sons and Company Private Ltd., Bombay, India.

NRC (1977). National Research Council. *Nutrient Requirements of Rabbits*. The 2 nd Edition. National Academy of Science. Washington, D.C. USA.

Okab, A.B. (2007). Semen characteristics and plasma testosterone of New Zealand male rabbits ad affected by environmental temperatures. *Slovakian Journal of Animal Science*, **40**(4): 161 – 167.

Okab, A.B.; El-Banna, S.G. and Koriem, A.A. (2008). Influence of environmental temperature on some physiological and biochemical parameters of New Zealand rabbit males. *Slovakian Journal of Animal Science*, **41**(1): 12 – 19.

Partridge, G.G. and Allan, S.J. (1982). The effect of different intakes of crude protein on nitrogen utilization in the prégnant and lactating rabbit. *Journal of Animal Production*, **35:** 145-155.

Patton, N.M.; Harris, D.J.; Grobner, M.A.; Swich, R.A. and Cheeke, P.R. (1982). The effect of dietary copper sulfate on enteritis in fryer rabbits. *Journal of Applied Rabbit Research,* **5:** 78-82.

Rafai, P.; Papp, Z. and Szechy, K. (1972). Tenyesz es ujszulott hybrid nyulak oxygen fogyasztasanak vizsgalata. *Baromfiipar,* **19**(9): 392-399.

Salisbury, G.W.; Van Demark, N.L. and Ladge, J.R.(1978). *Physiology of Reproduction and Artificial Insemination of Cattle.* W.H. Freeman and Company, San Frnciso, U.S.A.

Schurch, A. (1956). The effect of high copper doses upon the weight gain of pigs. *Mitt. Gebiete Lebensm*, U Hyg., **47**: 458-463.

Snedecor , G.W. and W.G. Cochran (1982). *Statistical Methods.* 6th Edition. lowa State University Press, Ames, U.S.A.

Soliman, M. M.; Bassuny, S. M.; Yamani, K. A. and El-Aaser, M. A. (2007). Effect of seasons and dietary contents of protein and energy on semen characteristics and fertility rate of New-Zealand White rabbit bucks under Egyptian conditions. *Zagazig Journal of Agricultural Research*, Vol. **34**(1): 117 – 132.

Stephan, E. (1980). The influence of environmental temperatures on meat rabbits of different breeds. *Proceeding World Rabbit Congress*, **2:** 399 – 409.

Stefan, E.; Schlolaut, W. and Lange, K. (1979). Schurleistung, Futter und Wasseraufnahme bel manallchem angrorakaninchen unter verschiedner Temperature bedungungen. III. *Arbeiten Tag. Veterinary Gesllschaft Cellular.*

Tharwat, E.E.; Khadr, A.F.; Amin, S.0.; Miukawy, M.Y. and Kotby, E.A. (1994). Effect of hot environment on the reproduction performance of New Zealand White rabbits. *1st International Conference on Rabbit Production in Hot Climate,* Egypt, **2:** 613-618.

Theau-Clement, M. (2000). Advances in biostimulation methods applied to rabbit reproduction.*7th World Rabbit Congress Reproduction and Reproductive Physiology*, 4-7 July 2000, Valencia SPAIN, A- Volume: 61.

Zaki, T.G.; Zeidan, A.E.B. and Seleem, T.S.T.(2000). Some physiological and reproductive aspects of Baladi Red rabbits fed *fenugreek* or *Nigella sativa*, under hot climate. *Proceeding of Conference of Social and Agricultural Development of Sinia,* Al-Arish, North Sinai, pp89-99.

Zanaty, G.A. (2005). Effects of dietary copper on performance, carcass traits and some blood components of growing California rabbits. *The 4th International Conference on Rabbit Production in Hot Climates,* Sharm El-Sheikh, Egypt, 249-258.

تأثيرات نظام التغذية وإضافة كبريتات النحاس للعلف وكذلك الظروف المناخية على أداء إناث وذكور الأرانب النيوزيلندى الأبيض البالغة

أسامة محمد عبد المنعم

قسم الإنتاج الحيواني، كلية الزراعة، جامعة الزقازيق، الزقازيق، مصر.

تم استخدام ١٢٠ أنثي أرانب نيوزيلندي أبيض بالغة و٣٠ ذكر عند عمر ٦ شهور لدراسة تأثيرات العبئ الحراري ونظام التغذية وإضافة كبريتات النحاس على العلف (بمستويات ٠,٠، ٧٥، ١٥٠ ملجم / كجم علف) وكذلك التداخل بينهم تحت الظروف المصرية.

أظهرت البيانات أن قيم دليل الحرارة والرطوبة المقدرة كانت ١٨,٩ في الشتاء (الفترة المعتدلة)، ٢٧,٤ في فترة (الفترة الحارة)، مبينة غياب التعرض للعبئ الحراري في الشتاء (أقل من ٢٢,٢) والتعرض الشديد للعبئ الحراري في الصيف (٢٣,٣ – ٢٥,٥).

أداء الأنثي: بينت النتائج أن حجم ووزن البطن عند الميلاد، ٢١ يوم والفطام والزيادة الوزنية في الخلفة من الميلاد وحتى عمر ٢١ يوم ومن الميلاد حتى الفطام وكذلك كمية اللبن المحسوبة كانت أعلي معنوياً (٠,٠٥ أو ٠,٠١) في الفترة المعتدلة عن الفترة الحارة. تغذية إناث الأرانب ليلاً فقط حسنت معنوياً (٠,٠٥ أو ٠,٠١) من حجم ووزن البطن عند الميلاد، ٢١ يوم والفطام والزيادة الوزنية فى الخلفة من الميلاد وحتى عمر ٢١ يوم ومن الميلاد حتى الفطام وكذلك كمية اللبن المحسوبة واستهلاك العلف ومحتوي سيرم الدم من الألبومين. انخفض معنوياً (٠,٠٥ أو ٠,٠١) استهلاك المياه ومعدل استهلاك العلف إلى المياه وكذلك محتوي سيرم الدم من الجلوبيولين عند تغذية الأمهات ليلاً فقط بالمقارنة بنظام التغذية طوال اليوم. أدت إضافة كبريتات النحاس إلى عليقة الأمهات إلى تحسن معنوي (٠,٠٥ أو ٠,٠١) في كل الصفات الإنتاجية والتناسلية مقارنة بتلك التي لم يضاف إليها كبريتات نحاس. وقد أدت إضافة كبريتات النحاس إلى علائق إناث الأرانب بمستوي ١٥٠ ملجم / كجم علف إلى زيادة معنوية (٠,٠٥) في محتوي سيرم الدم من البروتينات الكلية والألبيومين وكذلك *GOT* و*GPT*.

أداء الذكور: أظهرت البيانات أن كل من استهلاك العلف وحجم القذفة والحركة الجماعية وتركيز الحيوانات المنوية قد انخفض معنوياً (٠,٠٥ أو ٠,٠١)، بينما وقت الرغبة الجنسية ونسبة الحيوانات المنوية الشاذة والحيوانات المنوية الميتة قد زادت معنوياً (٠,٠١) في الفترة الحارة بالمقارنة بالفترة المعتدلة. انخفض معنوياً (٠,٠٥ أو ٠,٠١) استهلاك المياه ومعدل استهلاك العلف إلى المياه ودرجة حرارة المستقيم ونسبة معدل التنفس إلى درجة حرارة المستقيم في الفترة الحارة عن الفترة المعتدلة. أدى تغذية ذكور الأرانب ليلاً خلال فترة العبئ الحرارى إلى تحسن معنوي (٠,٠٥ أو ٠,٠١) في كل من استهلاك العلف وحجم القذفة ووقت الرغبة الجنسية والحركة الجماعية وتركيز الحيوانات المنوية عن نظام التغذية طوال اليوم. أدت إضافة كبريتات النحاس إلى علائق ذكور الأرانب بمستوي ١٥٠ ملجم / كجم علف إلى تحسن معنوي (٠,٠٥) في استهلاك العلف وحجم القذفة ووقت الرغبة الجنسية ونسبة الحيوانات الميتة.

التوصية : يعتبر تغذية الأرانب ليلاً خلال فصل الصيف مع إضافة كبريتات النحاس بمستوى ١٥٠ ملجم / كجم عليقة تعتبر عامل مؤثرة جداً على أداء وتناسل الأرانب تحت الظروف المصرية.