EFFECTS OF HEAT STRESS AND ITS AMELIORATION ON REPRODUCTION PERFORMANCE OF NEW ZEALAND WHITE ADULT FEMALE AND MALE RABBITS, UNDER EGYPTIAN CONDITIONS

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Abstract - The temperature-humidity index values were 58.9 (no stress) during winter and 84.3 (severe heat stress) during summer experimental periods when calculated according to Livestock and Poultry Heat Stress Indices, Agriculture Engineering Technology Guide, Clemson University, USA. In summer, litter size, litter weight and pups gain weight were, in general, lower, while pre-weaning mortality, gestation period were higher than in winter. In males, the depression was significant (P<0.05) in ejaculate volume, mass motility and advanced motility, and not significant in sperm concentration in summer than in winter. In both females and males, feed intake decreased, while water intake, rectal temperature and respiration increased in summer than in winter. Treatment of heat-stressed rabbits with cooling by drinking cool water l0-l5□CARSPECIAUX 176 \f "Times New Roman Euro"C improved litter size and weight, pups gain weight at weaning and pre-weaning mortality rate as traits of the female, mass motility (P< 0.05), ejaculate volume, sperm concentration and dead spermatozoa in males, and feed intake, water intake, rectum temperature and respiration rate in both females and males. Conception rate decreased with 76.8% in summer than in winter. Treatment of heat stressed bucks with cooling by drinking cool water increased conception rate with 108.4% than in the summer control group, but that value was less than that of the winter with 51.7%. The results showed that the bucks were more affected than the does by the summer heat stress, in Egypt.

INTRODUCTION

In Egypt, the breeding season of rabbits normally begins at October and ends at May each year, due to the negative effects of summer conditions on production and reproduction. The studies on the effects of hot summer of Egypt and its amelioration on the Californian (Cal) and New Zealand White (NZW) growing male and female rabbits have been curried out by MARAI *et al.* (1994a and b, and 1995). However, the studies on the adult females and males of the same breeds, are still lacking.

The present work aimed to study the effects of Egyptian summer climate and its amelioration on reproductive traits of NZW rabbits, in a trail to extend its breeding season to include all the year round.

MATERIAL AND METHODS

The present study was carried out on NZW rabbits breed at the Rabbitry of the Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig, Egypt, during the period from November, 1992, to March, 1993 (mild weather and is nearly equal to the traditional breeding season), and from June to October, 1993 (hot climate and is nearly equal to the summer breeding pause in Egypt).

The number of 44 of adult females and 21 adult males of 6 months of age, were used in the present study. The adult females were divided to four groups. One of the groups (of 14 animals) was kept in winter without treatment. The other three groups (10 animals in each) were kept during summer of which Group 1 was kept without any treatment as control and each of the other two were treated for amelioration heat stress. Diet of the first group was supplemented with 5% taphla (desert clay and its composition is shown in Table 1) to improve digestion efficiency through slowing the rate of passage of the digesta in the intestines and to act as a mineral supplement. The second group was cooled by drinking cool water (10-15°C). Such two amelioration methods were tried as low cost natural ones with the aim to choose the best one of them to be used in the following male experiment. The adult males were divided into three groups of 9 animals in the first group and 6 animals in each of the other two groups. The first group was raised during winter. The other two groups were kept during summer of which the first group was kept without treatment as control and the another one was treated with drinking cool water for amelioration heat stress.

Table 1 : Taphla macroelements

Items	Mean	Items	Mean
Soluble cations and anions (meq/100 g soil):	Available nutrients (mg/ 100g soil):		
Ca++	0.75	P	5.00
Mg++	0.25	K	1.20
Na+	0.05	Fe ppm	0.55
K+	0.10	Mn	2.40
Cl-	0.55	Zn	0.74
SO4	0.30	Cu	0.30
HCO3	0.75		
Excangeable cations (meq/100 g soil)	2.65		

The animals were fed on pelleted ration and watered *ad libitum.* The ration consisted of 30.0% alfalfa hay, 24.0% corn, 13.0% soybean meal, 28.0% wheat bran, 3.0% molasses, 1.4% limestone, 0.3% sodium chloride salt, 0.3% vitamin and mineral premix. The winter and summer control rations contained 16.3% crude protein (CP), 13.2% crude fibre (CF) and 2668 Kcal digestible energy (DE), while the diet supplemented with 5% taphla contained 15.5% CP, 12.6% CF and 2541 Kcal DE.

All rabbits were kept under similar managerial and hygienic conditions, during the experimental period. The adult females were housed in individual cages of commercial type (59 X 55 X 39 cm). The cages were provided with feeders, automatic nipple drinkers and nest boxes (40 X 32 X 29 cm). The adult males were housed in individual cages as those of the females, but without nest boxes. The building was naturally ventilated and provided with sided electric fans.

In females, the characters recorded (some were calculated) were gestation period, litter size and weight at birth, 21 days and at weaning (35 days) and pups gain. The adult males were trained for collection of semen by the use of artificial vagina. A doe was used for this purpose. One successful ejaculate was collected every week from each male between 8.00 and 10.00 h. Each ejaculate was kept separate for examination. All equipments of artificial collection of semen were washed thoroughly and sterilized before every collection of semen to avoid any contamination that may affect semen characteristics. Washing of equipments was carried out with tap water and soap and stored in an incubation oven at 65°C for 24 hours. All glass equipments were also washed with tap water and dipped in a bath of ethyl alcohol 75%.

In both females and males, rectal temperature and respiration rate were recorded each two weeks and each of feed and water intake was recorded weekly, during the experimental period.

At the end of the experimental period during summer, a fertilizing capacity trail for the two groups of the males bucks was carried out by mating them with does aged 6 months of those exposed to normal climatic conditions inside the Rabbitry building. Detection of conception was carried by palpation at 10 days after mating.

The ambient averages of temperature and humidity values were 29.74°C and 84.1% during the mild period, and 14.98°C and 60.0%, respectively, during the hot climate period.

The data of rectum temperature, respiration rate and semen characteristics were analyzed by a completely random design, with the following model according to SNEDECOR and COCHRAN (1982):

$$Xij = \mu + T_i + _{eij},$$

where, μ= general mean, T_i = effect of treatments and $_{eij}$ = random error

Significant differences were determined by Duncan's Multiple Range (DUNCAN, 1955).

RESULTS AND DISCUSSION

Temperature-humidity index:

The temperature humidity index values calculated according to Livestock and Poultry Heat Stress Indices, Agriculture Engineering Technology Guide, Clemson University, SC 29634, USA, were 58.9 and 84.3 during the traditional breeding season (November-March) and is considered as winter period and summer breeding pause (June to October), respectively, indicating absence of heat stress during the breeding season (less than 82) and exposure of the animals to severe heat stress (between 84 to 86) during the summer season, in Egypt.

Adult female traits

Litter size, litter weight, pups gain weight, feed intake and water feed ratio were, in general, lower, while pre-weaning mortality, gestation period, water intake, rectal temperature and respiration rate were higher in summer than in winter (Table 2 and Figures 1, 2 and 3). However, statistically the differences due to the season other traits were not significant (Table 3), except litter weight at weaning and respiration rate (P<0.05). Similar results were obtained in litter size and weight at birth and weaning and pups gain by ASKAR (1989) and AHMED *et al.* (1991) in NZW rabbits. ABD-EL-MOTY *et al.* (1991) also reported similar results in litter size and weight at birth and mortality rate, but not in gestation period which showed contrary trend. FINZI *et al.* (1992) found similar results to that reported in feed intake. Such phenomena may be due to that the high environmental temperature stimulates the thermal receptors centre in the hypothalamus causing the decrease in feed intake (HABEEB *et al.*, 1992). The recorded high values for mortality rate may be attributed to the direct effect of heat stress on the sensitive young offsprings, in addition to reduction of dams milk production (AYYAT *et al.*, 1995) due to the general depression of metabolic activity in such conditions (SHAFIE *et al.*, 1984). The increase in rectal temperature and respiration rate may be due to failure of the physiological mechanisms to maintain the thermal balance of animals (MARAI *et al.*, 1994 b).

Treatment of heat stressed doe rabbits with internal cooling by drinking cool water (10-15°C) improved litter size and weight and pups gain weight at weaning, pre-weaning mortality rate, feed intake, rectal temperature and respiration rate, than in summer control and most of the other groups (Table 1 and Figures 1, 2 and 3). The taphla treatment showed a lower effect. The differences due to treatment effect were not significant, except between taphla treatment and winter group in litter weight at 21 days and at weaning (P<0.05). The low results of taphla supplementation may be due to that the levels used are high that suggest to carry out further studies with lower levels. The increase in feed intake by internal cooling may be due to the increase in the appetite of the animals. Internal cooling by drinking cool water acts through dissipation of heat load as a result to the difference between the cool drinking water and warm excreted urine temperature. This is together with the effect of the high specific heat of water and body water retention that help in minimizing the rise in body temperature.

Figure 1 : Litter size of NZW does as affected with heat stress and its amelioration when considering the winter group values as 100%

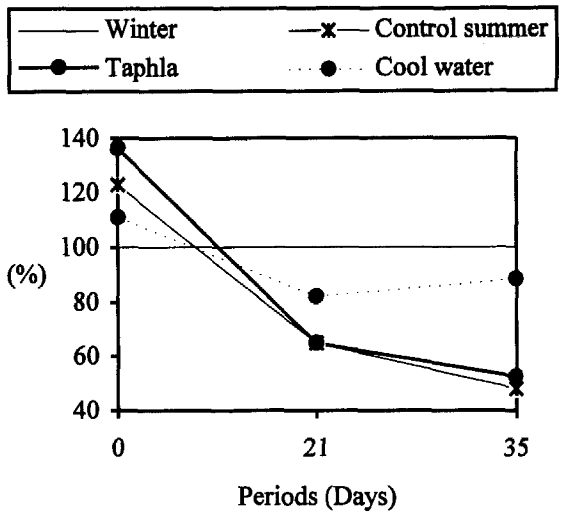


Figure 2 : Litter weight of NZW does as affected with heat stress and its amelioration when considering the winter group values as 100%.

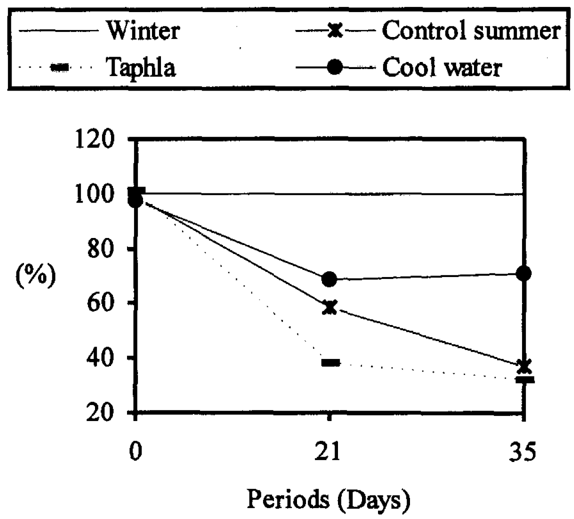
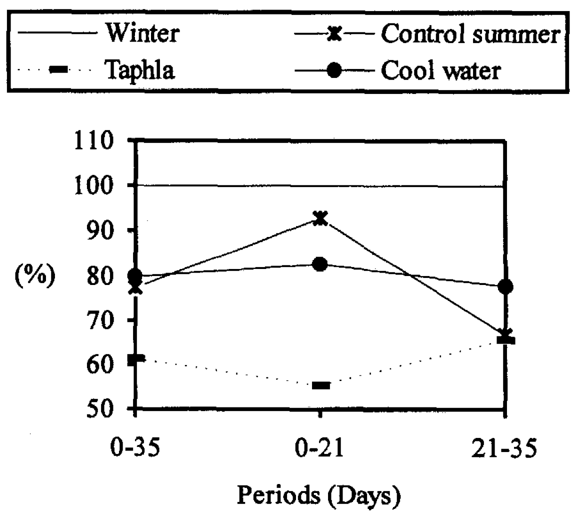


Figure 3 : NZW pups gain weight as affected with heat stress and its amelioration when considering the winter group values as 100%.



The high mortality rates occurred in both the summer control and taphla treated groups caused the decrease in the numbers of the animals presented and, accordingly, the high values of standard errors calculated for the two groups and shown in Table 2.

The water to feed ratio was higher with 0.31% in the summer group than in winter group. Similar trend was obtained by MARAI *et al.* (1994 b). Treatment of heat-stressed does with palm oil, taphla and cool water decreased water to feed ratio with 0.30, 0.27 and 0.02%, respectively, than in winter group.

Table 2 : Performance of NZW doe rabbits as affected with summer heat stress and its amelioration

Items	Winter	Summer Control	Summer Taphla 5%	Summer Cool water
Gestation period (Days)	31.7±0.5	32.7±0.6	32.2±0.5	32.1±0.5
Litter size at:				
Birth	5.29±0.68	6.50±1.38	7.22±0.55	5.88±0.40
21 days	4.12±0.58	2.67±1.33	2.67±1.07	3.38±1.13
Weaning	3.82±0.56	1.83±1.22	2.00±1.04	3.38±1.13
Pre weaning mortality (%)	27.8	71.9	72.3	42.5
Litter weight (g) at:				
Birth	330±41	325.8±60.3	332.78±26.2	320.63±20.9
21 days	1338±177	785±351	511±193	918±279
Weaning	2712±385	1009±675	887±447	1930±594
Pups gain (g/day):				
0-21 days	12.50	11.61	9.61	10.33
21-35 days	27.51	18.36	18.01	21.38
0-35 days	18.50	14.31	11.35	14.75
Physiological parameters:				
Rectum temperature (°C)	39.79±0.06	39.95±0.06	39.89±0.05	39.85±0.06
Respiration rate	92.9±1.1	109.5±1.48	108.7±0.98	106.6±0.8
Feed intake (g/day)	226.3	201.6	192.9	213.3
Water intake (g/day)	722.2	946.0	529.4	707.0
Water/feed ratio	3.19	4.69	2.74	3.31

Table 3 : Test of significance for the effects of heat stress and its amelioration on doe traits of NZW rabbits

SOV	df	Means squares: Litter size at Birth	Litter size at 21 days	Litter size at 35 days	Litter weight at Birth	Litter weight at 21 days	Litter weight at 35 days	Gestation Period	Temperature	Respiration
Between treatments	3	7.84	5.60	9.93	239.4	1473324*	8402772*	0.4	0.06	843.8***
Error	36	5.93	8.31	7.81	17503.4	533304	2448598	2.8	0.05	16.4

*** P<0.001 and * P<0.05.

Adult male traits

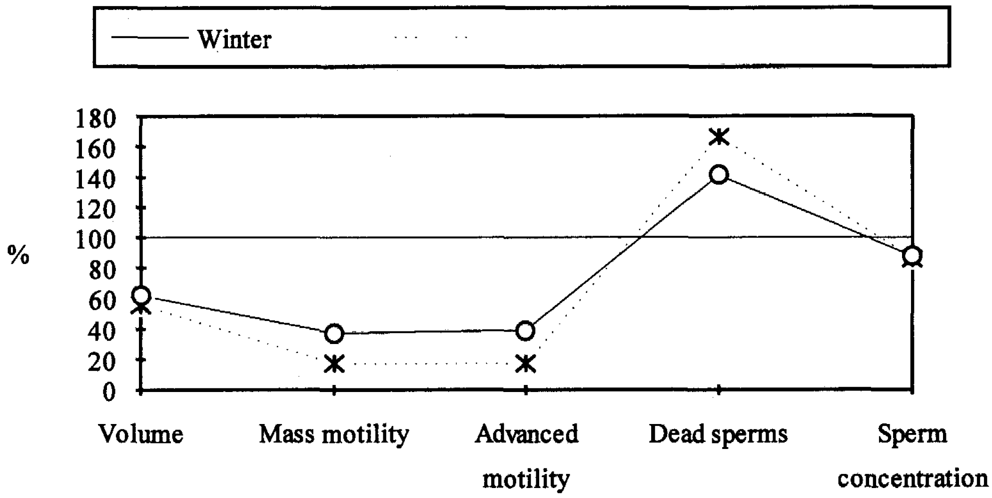
In summer, the depression was significant (P<0.05) in ejaculate volume, mass motility and advanced motility, and not significant in sperm concentration when compared to the values of the same traits in winter (Table 4 and Figure 4). The average feed intake also decreased in summer, while dead spermatozoa increased (P<0.05) and water intake, rectum temperature (P<0.05) and respiration rate (P<0.05) increased in summer than in winter. These results agree with those of FINZI *et al.* (1992) who found that exposure of bucks to heat stress decreased feed intake, and those of KASA and THWAITES (1992) and THARWAT *et al.* (1994) in rectum temperature and respiration rate. This may be due to the failure of the physiological mechanisms to maintain the thermal balance of the animals (MARAI *et al.*, 1994 b). Similar results to those of semen traits were obtained EL-SHERBINY (1987) and THARWAT *et al.* (1994). The low ejaculate volume in summer may be due to hypoactivity of the accessory sexual glands and testes as a reaction to the high ambient temperature, since the accessory glands and spermatogenesis are controlled by testosterone concentration (BONE, 1979 and HAMMOND *et al.*, 1983), which was shown to be lower in summer than in other seasons of the year (WHITEHEAD and McEWAN, 1973 and KATONGOLE *et al.*, 1974). FARAG *et al.* (1983) attributed the low motility in summer to the decrease in sperm-cell calcium concentration, since calcium connection with other divalent metal ions occurring in semen significantly regulate sperm metabolism and motility (BRAUN, 1975).

Table 4 : Semen characteristics and physiological parameters of NZW bucks as affected with heat stress and its amelioration with drinking cool water

Items	Winter	Summer	
		Control	Drinking cool water 10-15°C
Semen characteristics:			
Volume (ml)	0.68±0.04[b]	0.38±0.05[b]	0.42±0.04[b]
Mass motility (U)	3.00±0.17[a]	0.52±0.13[b]	1.12±0.16[c]
Advanced motility (%)	53.37±3.02[a]	9.20±2.23[b]	20.95±2.55[c]
Dead spermatozoa (%)	17.13±1.40[a]	28.56±3.44[b]	24.19±2.01[b]
Sperm concentration (10^6 x ml)	486.75±37.04[a]	419.60±49.07[a]	425.00±27.18[a]
Physiological parameters:			
Rectum temperature (°C)	39.42±0.14[a]	39.82±0.09[b]	39.65±0.11[ab]
Respiration rate (n/min.)	97.67±3.75[a]	108.50±1.36[b]	96.50±1.52[a]
Feed intake (g/day)	152.15	102.35	114.08
Water intake (g/day)	390.48	616.60	473.57
Water feed ratio	2.57	6.02	4.15
Conception rate (%)	72.0	16.7	34.8

Means bearing different letters within the same classification, differ significantly at P<0.05.

Figure 4 : Semen characteristics as affected with heat stress and its amelioration with drinking cool water when considering winter values as 100%



The decrease in sperm concentration may be due to degeneration of germinal epithelium and partial atrophy in the seminiferous 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) that is affected negatively by heat stress as shown above.

The heat-stressed bucks were treated with cool water due to its favourable effects in the does than in the other treatments as shown above. Treatment of heat-stressed bucks with cooling by drinking cool water (10-15°C) increased significantly (P<0.05) mass motility and advanced motility and insignificantly ejaculate volume and sperm concentration. Feed intake also decreased with the same treatment. At the same time, dead spermatozoa, water intake, rectum temperature and respiration rate (P<0.05) decreased, when compared to summer control group (Figure 4).

The increase in feed intake by internal cooling may be due to the increase in the appetite of the animals. The decrease in water intake may be due to the effect of drinking cool water in reduction of the heat load.

The water to feed ratio was higher with 0.58% in the summer than in winter group. Similar results were obtained by MARAI *et al.* (1994 b). Treatment of heat-stressed bucks with cool water decreased water feed ratio with 0.37% than in summer group. The comparison of heat-stressed animals treated with drinking cool water with winter group showed that water feed ratio was lower in the latter group with 0.21%.

In summer, the conception rate decreased with 76.8% than in winter group due to the effect of heat stress on bucks. Treatment of heat-stressed bucks with cooling by drinking cool water increased the conception rate with 108.4% than in summer control group. However, the comparison of the heat-stressed group treated with drinking cool water with the winter group showed that the conception rate in the former group was lower with 51.7%.

In conclusion, heat stress seemed to affect reproductive efficiency and fertility of the bucks more than that of the does , under Egyptian summer conditions. The cooling by drinking cool water technique (10-15°C) also seemed to be more effective in amelioration of the does, but not the bucks. This may suggest to use frozen semen collected during autumn and winter for insemination of the does during summer of Egypt, and at the same time, further investigations on more efficient methods for amelioration of the bucks under such conditions, are needed.

Table 5 : Test of significance for the effects of heat stress and its amelioration with drinking cool water on semen characteristics of NZW bucks

		Means squares							
	df	Volume	Mass motility	Advanced motility	Dead spermatozoa	Concen-tration	Rectum temperature	Respiration rate
Between treatments	2	1.5***	84.9***	26194.0***	1548.9***	755590.8	0.29+	276.1*
Error	147	0.1	1.7	517.0	185.7	81989.9	0.11	63.2

*** P<0.001, * P<0.05 and + P<0.10. df for error of rectum temperature and respiration rate were 18.

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