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ADAPTIVE AND REPRODUCTIVE PERFORMANCE OF RABBITS 2- RESPONSE TO CONTINOUS HEAT STRESS

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SUMMARY

Twenty seven adult does of New Zealand White rabbits (NZW), aging 9 months and weighing 3.0 kg in average, were used to study the effect of constant artificial climatic condition on adaptive and reproductive performance. These does were divided into two groups [11 does under artificial heat stress (HS) 35.2 ± 2.0°C and 16 does kept under natural winter temp. (WT) 10.4°C]. These does were maintained under these conditions for three months to give two consecutive parities, in the fourth month 13 does (7 under WT and 6 in HS) were used to study the pregnant genitalia by slauhtering at 15 days post-coitum. Heat stress caused slight increase in body temp., but great increase in respiration rate. The hematological (Hb, PCV and RBCs) parameters showed clear drop due to heat stress, the same with T_3 and T_4 levels in the first and the second parities either before and during gestation and lactation stages. Heat stress had a hampering effect on the genitalia, ovaries weight, uterus weight and length, embryonic mortality, fetus length and weight, litter size, survival rate and bunny body weight gain. Also, heat stress depressed progesterone level during one week before gestation, midterm of 1st, 2nd and 3rd gestations and one week after parturition. Thus heat stress evoked efficient adaptive response by reduction in metabolism which is reflected on drop of reproductive and productive performance.

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Keywords: Rabbits, heat stress, adaptation, reproduction, hormones, genitalia anatomy

INTRODUCTION

Climatic heat stress had deleterious effect on exotic temperate breeds such as New Zealand White rabbits (NZW) more than indigenous tropical and subtropical breeds such as Egyptian Baladi Red (BR), as found by many workers (El- Maghawry et al.,1988; Abd El-Hakeam et al.,1991; Abd El-Moty et al.,1991; Tag El-Din et al.,1992 and Mahmoud,1993). Heat stress caused pronounced increase in body temperature, this increase in NZW was 1.1°C (Johnson et al.,1958); 0.5°C (Trammell et al.,1989) and 0.4°C (Abd El-Hakeam et al.,1991). Respiration rate (breath/ min) increased due to heat stress by 121 (Johnson et al.,1958); 100 (Gonzalez et al.,1971) and 101 (Mahmoud,1993). Shafie et al. (1982) concluded that the long term heat stress caused great increase about 7 % for each 1°C. On the other hand, RBCs, PCV, Hb, T_3 and T_4 were decreased greatly due to heat stress (Trammell et al.,1989; Abd El-Hakeam et al.,1991 and Mahmoud,1993). Reproductive performance drops due to heat stress as found by many workers. There were marked decline in post-coital ovulation time, ovulation rate, success of implantation, embryonic development, embryos weight and length (Marai et al.,1991). Litter size at birth and at weaning were clearly affected (Shafie et al.,1984; Trammell et al.,1989 and Abd El-Moty et al.,1991) as well as milk yield (Rafai and Pappu,1984 and Mahmoud,1993). On the other hand, mortality rate increased especially under sustained heat stress (Rafai and Pappu,1984 and Shafie et al.,1984). The impact of artificial heat stress on adaptive and reproductive performance has been studied by various authors, but usually for short periods of stress ranging from just a few hours to a few weeks.

The present work was planned as a prolonged, 4 months, trial to study the effect of sustained heat stress on rabbits performance compared to natural winter conditions to assess the feasibility of traditional managerial procedure of stopping rabbit breeding during hot summer in Egypt.

MATERIALS AND METHODS

Twenty seven adult does of New Zealand White rabbits (NZW) were used to study the effect of constant artificial climatic conditions on adaptive and reproductive performance. These does were divided into two groups, [11 does under artificial heat stress 35±2°C (HS) and 16 does kept in natural winter thermal condition (WT) with a range of 6°C to 15°C (average 10.4°C) while the relative humidity ranged between 60 to 70% (64.0%)]. These does were maintained under these conditions continuously for three months to study the adaptive response and reproductive performance in two consecutive parities. In the fourth month, 13 does of them were divided into two groups (7 does under WT and 6 does in HS) to study the pregnant genitalia. These does were mated and stayed under their particular condition till the 15±2 days of pregnancy when they were slaughtered. The does average age and body weight were 9 months and 3.0 Kg resp. The animals were maintained under normal nutritional status, ad. lib. green Berseem (Trifolium alexandrinum) and standard pelleted concentrate.

The studied adaptive responses were; body temperature, respiration rate, hematological traits (RBCs count, PCV, Hb) and concentration of T_3 and T_4 hormones. Body temperature and respiration rate were recorded simultaneously once daily for each doe at morning (8-9 a.m.).

The reproductive items studied in slaughtered animals included; the weights of ovaries, weight and length of uterine horns after and before releasing the embryos, number of corpora lutea, embryonic viability. Embryonic mortality is recorded as the difference between the No. of C.L. and viable embryos.

The productive capacity study was concentrated on viability of offspring (mortality rate), litter size at weaning, milk yield, growth of offspring and collective weight of bunnies per parity. Milk yield of each doe was determined three times weekly till 30 day post-partum by the weight of the litters before and after suckling. The average body weight of the offsprings was recorded by weighing the animals collectively for the litter three times a week, until 4 weeks of age.

Blood samples were collected at morning (8-9 a.m.) from each doe at three times, one week before mating, at

15 day post-coitum and one week after parturition. RBCs (10^6 x mm^3), Hb (g/100ml) and PCV (%) were determined. Progesterone (P_4), Triiodothyronine (T_3) and Thyroxine (T_4) were determined by using RIA technique (Pantex, santa Monica, U.S.A.).

Data were statistically analyzed by using SAS (1990).

RESULTS AND DISCUSSION

A- Adaptive Response

1. Body temperature

Heat stressed (HS) NZW rabbits (35°C) had higher body temperature than being under winter thermal (WT) conditions (10.4°C). The differences between the two groups were (0.1- 0.3°C) in the first and second parities, resp., either during gestation or lactation (Table 1). At any case the increase was not statistically significant. This response proves that this exotic breed has a good physiological efficiency in keeping its temperature within normal level under such sustained higher temperature. These results are in agreement with Trammell et al. (1989) and Abd El-Hakeam et al. (1991).

Table 1. Respiration rate and body temperature in NZW rabbits before gestation (BG), during two consecutive parities of gestation (G) and lactation (L) as affcted by heat stress (HS) compared to natural winter temperature (WT) (Mean±SE)

Parity	cond.	Respiration Rate			Body Temperature		
		BG	G	L	BG	G	L
1st	WT	84.8^b±2.1	90.9^b±6.5	110.6^b±7.0	38.9±0.04	38.9±0.04	39.3±0.05
	HS	177.5^a±3.2	184.9^a±5.9	209.1^a±9.0	39.2±0.05	39.1±0.03	39.4±0.04
2nd	WT	78.9^b±3.5	96.4^b±4.4	106.4^b±7.2	39.2±0.04	39.2±0.03	39.4±0.04
	HS	167.9^a±7.5	185.4^a±6.8	204.7^a±9.9	39.4±0.04	39.4±0.06	39.5±0.05
Aver.	WT	81.9	93.7	108.5	39.1	39.1	39.4
	HS	172.7	185.2	206.9	39.3	39.3	39.5
HS/WT		2.1	2.0	1.9	1.0	1.0	1.0

a,b P<0.05, ** P<0.01.

2. Respiration rate

Respiration rates (RR) of heated group were elevated significantly by heat stress through the first and second parities at one week before gestation, 4 weeks of gestation and lactation. The rate continued to increase with the advancement of gestation and reached its peak

at the 2nd week of the first and second parities. Johnson et al. (1958) reported that RR of NZW (barren animals) increased by 121 breath/min., from 69 to 190 breath/min. under 18.3°C vs 33.3°C. The increase in pregnant NZW was 32.1 breath/min., from 146.5 to 178.6 breath/min., under 16.4°C vs 33.8°C.(Abd El-Hakeam et al.,1991).

This wide discrepancy in RR may be attributed to : Technical variations, interference of other environmental conditions (light, feeding, humidity, .. etc.) and/or interaction with other physiological responses. This wide change in RR (more than 60 %) due to heat stress is the major counteraction to maintain normal body temperature through respiratory water vaporization. Gonzalez et al. (1971) showed that under normal cage conditions, approximately 35 % of body heat is dissipated by water vaporization, 60% from the respiratory system through panting and 40 % positively through the skin.

3. Hematological response

Heat stress induced clear reduction in the three studied hematological parameters, Hb, PCV and RBCs count at any physiological status of animals (Table 2). This drop is a responsive trial to reduce oxygen intake thus reducing metabolic heat production under this hot condition. This can be also explained by the findings of Seley (1960) who found that heat stress decrease the level of ACTH, which in turn decrease the values of PCV, RBCs count and Hb. This was attributed to the stimulatory effect of ACTH on erythropoiesis.

Table 2. Hematological parameters in NZW rabbits at one week before gestation (BG), midterm in the 1st, 2nd & 3rd gestation (G) and one week after parturition (AP) as affected by heat stress (HS) compared to natural winter temperature (WT). (Mean ± SE)

Items	cond.	BG	1st G	2nd G	3rd G	AP
Hb	WT	$12.4^{b}\pm0.01$	$12.8^{b}\pm0.01$	12.1 ±0.03	12.5 ±0.09	12.4 ±0.09
(g/dL)	HS	$9.0^{a}\pm0.06$	$9.5^{a}\pm0.04$	10.6 ±0.40	11.0 ±0.10	11.1 ±0.17
		**				
PCV	WT	$38.9^{b}\pm0.40$	$37.8^{b}\pm0.30$	34.8 ±0.20	36.0 ±0.30	36.9 ±0.70
(%)	HS	$28.5^{a}\pm0.90$	$32.5^{a}\pm1.10$	33.0 ±0.90	34.7 ±1.10	34.0 ±0.90
		**				
RBCs	WT	$4.3^{b}\pm0.01$	$4.2^{b}\pm0.06$	3.9 ±0.01	3.9 ±0.03	4.1 ±0.03
($10^{6}/mm^{3}$)	HS	$3.2^{a}\pm0.01$	$3.6^{a}\pm0.08$	3.6 ±0.10	3.8 ±0.02	3.7 ±0.02

a,b $P<0.05$, ** $P<0.01$.

4. Thyroid activity

Heat stress hampered the activity of the thyroid gland causing reduction in concentration of both T_4 and T_3 hormones (Table 3).At any case the drop was more conspicuous in T_4 concentration. The decrease of T_3 was the greatest in the 3rd gestation. Is this due to the extended duration under stress or specific changes in uterine conditions. T_3 concentration during gestation ranged from (1.91 to 2.40 ng/ml) under WT while it ranged from (1.72 to 1.83 ng/ml) under HS (Table 3). T_4 concentrations under WT were higher by 49.2 % ($P<0.01$) at one week before gestation, 5.2 %, 11.6 % and 11.8 % at midgestation of 1st, 2nd and 3rd parities, resp. and 4.2 % at one week after parturition, than its values under HS. This reduction in T_3 and T_4 coincided with the drop in RBCs count and Hb concentration to intensify the drop in general metabolic rate with consequent decrease in production of metabolic heat under the external heat stress. This is usually a sustained reaction to help in maintenance of the normal body temperature. Thyroid index (T_4/ T_3) ng/ml was higher in rabbits under WT than its value under HS at all studied stages except at mid of the 3rd gestation, the index was the highest in does under HS. These differences were significant ($P<0.01$) in barren animals, at one week before gestation (Table 3).

Table 3. Thyroid hormones and rogesterone (P_4) and levels (ng/ml) in NZW rabbits at one week before gestation (BG), midterm in the 1st, 2nd & 3rd gestation (G) and one week after parturition (AP) as affected by heat stress (HS) compared to natural winter temperature (WT) (Means±SE)

Horm.	cond.	BG	1st G	2nd G	3rd G	AP
T_3	WT	0.86 ±0.00	1.91 ±0.10	1.81 ±0.07	2.40 ±0.07	1.80 ±0.04
	HS	0.84 ±0.00	1.72 ±0.70	1.80 ±0.08	1.83 ±0.08	1.80 ±0.05
		**				
T_4	WT	3.65^{b}±0.06	4.02 ±0.20	4.24 ±0.30	3.81 ±0.23	3.80 ±0.19
	HS	2.45^{a}±0.07	3.82 ±0.23	3.79 ±0.30	3.42 ±0.30	3.65 ±0.01
		**				
T_4/T_3	WT	4.23^{b}±0.06	2.11 ±0.04	2.34 ±0.05	1.59 ±0.07	2.11 ±0.05
	HS	2.91^{a}±0.05	2.22 ±0.05	2.07 ±0.04	1.88 ±0.02	2.03 ±0.05
			**	**		
P_4	WT	0.41 ±0.00	11.04^{b}±0.23	13.45^{b}±0.52	10.70 ±0.28	0.61 ±0.00
	HS	0.50 ±0.00	5.17^{a}±0.30	7.56^{a}±0.67	9.94 ±0.30	0.59 ±0.00
HS/WT		1.2	0.5	0.6	0.9	1.0

a,b $P<0.05$, ** $P<0.01$.

B- Reproductive Performance

1. Anatomy and activity of genitalia

Continuous heat stress (HS) caused reduction in weights of ovary, uterus and embryos (Table 4). The number of viable embryos were the highest in the control group (under winter condition) compared with the HS group (Table 4), however this HS did not affect number of corpora lutea (Table 5). This means that the rate of embryonic regression was higher in does under HS (35°C) than in WT group. The intrauterine development of the foetuses up to this 15 days of pregnancy was stunted by heat stress as evidenced from the average weight and lenght (C.R.L.) (Table 5). Hafez and Rajakoski (1964) found that the weight and length of live embryos at 15 days post-coitus were reduced due to heat stress. Bruce and Abdul-Karim (1973) reported that the different magnitude in myometrial weight was 38.7, 49.1, 41.8 and 46.8 gm at 16, 20, 24 and 28 days of gestation in crosses of NZW and Chinchilla rabbits. Argente et al. (1992) reported that in rabbit does the numbers of implants, regressed embryos and live embryos were 12.37, 0.2 and 12.17. The total rabbits born, prenatal survival, foetal survival, embryos survival, implantion survival and implantion ratio were 9.75, 0.66, 0.76, 0.87, 0.98 and 0.88, resp.

Table 4. Weight of ovary (mg) and uterus (g) and length of uterus (cm) at midterm in the 3rd gestation in NZW as affected by heat stress (HS) compared to winter natural temperature (WT), (Means±SE)

Side	cond.	Weight		Length
		Ovary	Uterus	Uterus
Right	WT	615.6 ±8.0	23.2b±1.8	23.7 ±1.7
	HS	583.3 ±4.8	17.8a±1.1	20.8 ±2.3
Left	WT	580.0 ±4.7	21.7 ±2.7	22.4b±1.2
	HS	570.0 ±3.7	17.9 ±2.9	16.8a±1.2
Aver.	WT	597.8	22.5	23.1
	HS	576.7	17.9	18.8
HS/WT		1.0	0.8	0.8

Table 5. Average number per doe of corpora lutea (C.L), viable embryos (V.emb.) and weight and crown rump length (C.R.L) of embryos at midterm of gestation in NZW under winter natural temperature (WT) and heat stress (HS), (Means±SE)

Side	cond.	Number		Weight(g)		C.R.L
		C.Ls	V.emb.	all emb.	one emb.	(cm)
Right	WT	5.3 ±0.8	5.2 ±0.9	4.4^{b}±1.0	0.87^{b}±0.4	1.6 ±0.2
	HS	5.5 ±0.9	4.8 ±0.9	3.5^{a}±1.0	0.72^{a}±0.4	1.4 ±0.2
Left	WT	5.3 ±0.9	5.3^{b}±1.1	4.5^{b}±1.1	0.84^{b}±0.4 **	1.5 ±0.2
	HS	5.3 ±1.0	4.2^{a}±1.2	2.8^{a}±1.2	0.68^{a}±0.5	1.3 ±0.2
Aver.	WT	5.3	5.3	4.5	0.86	1.6
	HS	5.4	4.5	3.2	0.70	1.4
HS/WT		1.0	0.8	0.7	0.8	0.9

a,b $P<0.05$, ** $P<0.01$.

2. Progesterone level

Continuous heat stress caused reduction in progesterone concentration (P_4) ng/ml in does serum (Table 3). The differences due to the two thermal conditions were significant only within the first and second gestation, about half concentration under HS. The insignificant decrease (only 7%) in the third gestation suggests some sort of adaptation. Khalil and El-Sharabassy (1987) found that progesterone concentration averaged 0.38 ± 0.1 ng/ml on the day of mating. This value increased to 1.68 ± 0.3 ng/ml on day 5 and 6.3 ± 1.0 ng/ml on day 8, this last concentration was almost maintained until day 15 of pregnancy, thereafter it started to decline slowly and then rapidly on day 30 to reach a value of 1.02 ± 0.3 ng/ml.

3. Litter size and mortality rate

Continuous heat stress caused clear reduction in litter size at birth (10 %) and significant loss by mortality rate, from birth to weaning (23 %) during the first parity. In the second parity the loss in litter size was equal to that of first parity. However the loss by mortality was lower in the 2nd parity (Table 6), most probably due to almost no drop effect by HS in dam's milk production (Table 6) plus expected gaining

efficient mothering ability. Shafie et al. (1984) found that the highest value for mortality percentage until weaning (31.8 %) was recorded in the sustained heat stress (35°C) group and the lowest value (17.2 %) was found in the control group under normal winter condition in Egypt. Rafai and Pappu (1984) reported mortality rates of 2.9, 8.6, 22.9 and 66.0 % during the experiment at 20, 25, 30 and 35°C, resp., he attributed this to deficient doe's milk supply as a result of hyperthermia.

Table 6. Litter size (LS), birth weight (BW g), weaning wight (WW g), mortality rate (MR%), No of weaned bunnies/ litter (NW) and meat yield/ litter at weaning (MY) in NZW as affected by heat stress (HS) compared to natural winter temperature (WT) during two consecutive parities (Means±SE)

Parity	cond.	LS	BW	WW	MR%	NW	MY
					**		
1st	WT	7.2 ±1.3	67.2 ±2.6	442.8 ±5.8	27.0^{b}±2.7	5.3	2347
	HS	6.5 ±0.9	61.1 ±2.1	380.6 ±9.0	36.0^{a}±1.9	4.2	1599
2nd	WT	7.0 ±0.5	73.0 ±3.0	451.1 ±8.8	20.2 ±1.5	5.6	2526
	HS	6.0 ±1.1	64.0 ±3.1	341.7 ±7.1	24.2 ±0.9	4.5	1538
Aver.	WT	7.1	70.1	447.0	23.6	5.4	2414
	HS	6.3	62.6	361.2	30.0	4.4	1589
HS/WT		0.9	1.0	0.8	1.3	0.8	0.66

a,b $P<0.05$, ** $P<0.01$.

4. Daily Milk Production

Daily milk production (DMP) declined due to HS significantly ($P<0.01$) by 26.1 % in the 3rd week of lactation in the first and second parities and at ($P<0.05$) in the 2nd and 4th weeks of both parities (Table 7). Rafai and Pappu (1984) reported that above 20°C daily milk yield falls by 7.7 g for every 1°C increase in air temperature. This expected decrease in milk yield especially in the 3rd week, when it reach its peak, may be attributed to the effect of high temperature as stressor on the hypothalamus and in turn on the pituitary gland and on the appetite of does minimizing the amount of food intake. Hafez (1970) support this conclusion that milk production of does depend upon diet, parity, number of suckling young and genetic difference.

Table 7. Daily milk production (DMP g/wk), bunny body weight gain (BWG g/wk) and total yield (TY) in NZW as affected by heat stress (HS) compared to natural winter temperature (WT) during two consecutive parities (Means±SE)

Parity	cond.	1st	2nd	3rd	4th	TY
				**		
1st	WT	93.1 ±2.7	127.3 ±5.5	151.6^{b}±3.3	107.0^{b}±2.5	479.0
	HS	93.1 ±3.1	112.2 ±3.8	112.1^{a}±4.3	88.4^{a}±5.3	405.8
DMP						
				**		
2nd	WT	99.2 ±3.4	134.5^{b}±5.5	162.7^{b}±6.9	112.2 ±3.5	508.6
	HS	89.8 ±2.2	116.8^{a}±3.8	127.6^{a}±5.6	106.0 ±5.6	440.2
Aver.	WT	96.2	130.1	157.2	109.6	493.1
	HS	91.5	114.5	119.9	97.2	423.1
% Depression by HS		4.9	12.0	23.7	11.3	14.2
1st	WT	75.6 ±5.4	94.9 ±7.8	106.3^{b}±8.2	98.8^{b}±7.5	375.6
	HS	68.4 ±3.7	87.7 ±5.7	84.9^{a}±8.5	78.5^{a}±8.7	319.5
BWG						
2nd	WT	80.9 ±3.6	99.5 ±4.3	104.1 ±6.0	96.1 ±4.9	380.6
	HS	78.0 ±3.8	93.2 ±4.7	94.2 ±6.2	84.3 ±4.2	349.7
Aver.	WT	78.3	97.2	105.2	97.5	378.2
	HS	73.2	90.5	89.6	81.4	334.7
% Depression by HS		6.5	6.8	14.8	16.5	11,5

a,b $P<0.05$, ** $P<0.01$.

5. Growth of offspring

The average body weight gain of suckling litters increased with the advancement of age from the 1st week until the 3rd week under WT, while it was increased only till the 2nd week in HS group during first and second parities (Table 7). The gain dropped thereafter till weaning coincident with drop in the dams milk production (Table 7). Ghany et al. (1961) found that milk yield of does was correlated with 21 days litter body weight. Abd El-Moty et al. (1991) stated that under high air temperature (33.8°C) there was a significant decrease in body weight gain. The present results cleared out that body weight of young rabbits were doubled by the end of the first week and tripled at the end of the second week (Table 7), then their growth was slower after that to reach a weaning weight of 400 g in WT group versus 344 g in HS group. These results agree with McNelly and Friesen (1978) and Nagy and Frawley (1990). Dickson (1984) stated that exposure of does to high temperature, and high relative humidity decrease thyroid hormones level, which influence, virtually, every organ in the body through change in metabolic rate and protein

synthesis of cells. He postulated that this drop in thyroid activity affect the quantity and quality of milk production, with subsequent decrease in body weight of litters.

It could be concluded from the present study that New Zealand White rabbits have efficient physiological capacity to tolerate heat stress. This is achieved by reduction of metabolic heat through readjustments of hematological agents and thyroid hormones, alongside increase of heat dissipation through respiratory water vaporization. However, this drop in metabolism induce reduction in reproductive performance by drop in litter size at birth and at weaning, about one individual per doe each parity than under winter cold condition. The productive efficiency is also damped by an average drop in milk yield of 70 g in total lactation and a decrease of 60 - 110 g in the bunny weight at weaning. This ends, generally, by a decrease of 825 g in the crop/doe/parity (meat yield per doe at weaning) (Table 6).

Economic inferences can evaluate the extent of economic loss in cases of heat stress and the feasibility of ameliorating the performance by different techniqual approaches, proper feeding, housing, treatments, good management. For example, Hassanien et al.(1994) found that supplementation by vit.E abolished the effect of heat stress on rabbits performance.

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كفاءة التأقلم والتناسل فى الأرانب ٢-الإستجابة للإجهاد الحرارى المستمر

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شملت هذه التجربة سبعة وعشرين من إناث الأرانب النيوزيلندى الأبيض بمتوسط عمر ٩ شهور ومتوسط وزن ٣كجم .وكان الهدف من هذه التجربة هو دراسة تأثير الظروف المناخية الإصطناعية المستمرة على كفاءة التأقلم والتناسل فى الأرانب النيوزيلندى . وقسمت هذه الأمهات الى مجموعتين الأولى ١١ أنثى تحت الإجهاد الحرارى الإصطناعى (٣٥,٢م) والمجموعة الثانية١٦ أنثى تحت ظروف الشتاء الطبيعية (١٠,٤م) (الكنترول). وأبقيت هذه الإناث تحت ظروف المعاملة لمدة ثلاث شهور لتعطى بطنين متتاليتين وفى خلال الشهر الرابع تم ذبح ١٣ أنثى (٦ من المجموعة الاولى و٧ من المجموعة الثانية) من هذه الأمهات فى اليوم الخامس عشر بعد التلقيح (منتصف الحمل).وكانت أهم النتائج التى توصلت اليها التجربةهى:-
أدى الإجهاد الحرارى الى زياده طفيفة فى درجة حرارة الجسم وزيادة كبيرة وواضحة فى معدل التنفس .إنخفضت مقاييس الدم (نسبة الهيموجلوبين ، الهيماتوكريت،عدد كرات الدم الحمراء) نتيجة الإجهاد الحرارى .وحدث نفس الإنخفاض فى مستويات هرمونات الدرقية(T_3, T_4) فى البطنين الأولى والثانية سواء قبل الحمل وأثناء الحمل و الرضاعة. كان للإجهاد تأثير معوق للجهاز التناسلى سواء فى وزن المبايض ،وزن وطول الرحم ،النفوق الجنينى، وزن وطول الاجنة ،عدد الخلفة ونسبة الخلفة الحية من الميلاد حتى الفطام ومتوسط الزيادة فى وزن الصغار. أيضا أدى الإجهاد الحرارى الى إنخفاض مستوى هرمون البروجيستيرون أثناء الأسبوع السابق للحمل ومنتصف الثلاث بطون المتتالية وكذلك فى الاسبوع التالى للولادة .إتضح من هذه الدراسة أن الاجهاد الحرارى أحدث إستجابة فسيولوجية للتأقلم عن طريق خفض التمثيل الذى إنعكس بدوره على الإنخفاض فى الكفاءة التناسلية و الإنتاجية للأرانب.