Effect of Thermal Stresses on the Physiological and Productive Performance of Pregnant Doe Rabbits

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Abstract: Twenty-six New Zealand White rabbit does were used during two successive years. In the first year, 12 pregnant does were divided into two equal groups. The first group was treated with heat (HSW) and the second was kept inside rabbitry under ambient air temperature as a control group (CW). In the second year, 14 does were divided into two equal groups and were supplemented orally with vitamin C (20 mg/kg of body weight/ day) for 15 days before mating and 15 days after mating. The first group was treated with heat (HSV) and the second was kept as control group (CV) the same in first year. Treated rabbits (HSW and HSV) were exposed to summer heat (August) outside the rabbitry and under a shade for one hour between 13:00 and 14:00 on days 9 and 10 of pregnancy term. Data were collected on does on days 1, 3, 7, 9, 10, 11, 13, 15 after mating, for 2 weeks during lactation period and on kids for two weeks after parturition. Results showed that exposure of doe pregnant rabbits to thermal stress resulted in significant physiological responses, including body reactions parameters (rectal and ear lob temperatures, respiration and pulse rates), hematological parameters (hemoglobin, hematocrit, red blood cells and white blood cells) and triiodothyronine (T_3) hormone values. In addition, heat stress caused reduction in litter size and litter weight of newborn rabbit kits. The pre-weaning mortality rate of bunnies reached 17% in heat stressed-does, while it was only 9% in pregnant does consuming vitamin C during pregnancy. Milk yield in heat-stressed (525.2 g/doe) rabbit does was lower than that in control groups (597.8 g/doe), respectively. In conclusion, addition of ascorbic acid (vitamin C) at a dose of 20 mg/kg BW/day to pregnant rabbit does exposed to heat stress reduced the pronounced adverse effects of heat stress on most of the physiological parameters and productive traits. This treatment could be used as a routine treatment in rabbit commercial production farms during summer season.

Keywords: Rabbit does, heat stress, physiology, newborn, vitamin C.

INTRODUCTION

In recent years, there has been raising awareness on the importance of rabbit meat production in developing countries as an alternative means of alleviating world food shortages (FAO report, 2004). In Egypt, during hot summer, rabbit production is faced with many problems such as electricity breakdown for some time during the mid day, which may raise temperature inside rabbitry to be 32°C or above. This puts more burden and stress on rabbit does and especially, the pregnant ones and leads to high abortion rate and early embryo losses. Heat stress at critical stages of embryonic development produces developmental defects or embryonic absorption. Most embryonic developmental defects were observed in the first trimester of pregnancy in humans (Milunsky *et al.,* 1992), on gestation day (GD) 9 in rats (Webster *et al.,* 1985), and on GD 11-14 in guinea pigs (Smith *et al.,* 1992).

Marai (1997) reported that the management practices concerned in hot climate involve modification of the environment, reduction of the animal heat production, and increase of its heat loss. Ascorbic acid (vitamin C) is a water-soluble vitamin, which is a free radical scavenger (Dumitrescu *et al.,* 1993) and plays an important role in various physiological processes of the body (Head, 1998). The oral supplementation of vitamin C to rabbits in summer may protect animals from the harmful effects of heat stress. Alam (2000) reported that vitamin C is involved in the synthesis of some stress hormones such as epinephrine. These hormones control respiration rate, blood flow and pressure and maintain body temperature almost constant.

The objectives of the present study were to determine the physiological responses and productivity occurring in pregnant rabbits during summer and also after exposure to one hour of high environmental temperature, during days 9 and 10 of pregnancy. The effect of vitamin C treatment on alleviating the stressful effect of heat on pregnant rabbits was also investigated.

MATERIALS AND METHODS

Animals and Management:

The present study was carried out at the rabbitry of the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt, during the period from July to September (summer season) for two successive years (2005 and 2006). Nulperious mature female New Zealand White (NZW) rabbits were used in this experiment. Natural mating was used to achieve pregnancy and pregnancy detection was carried out by abdominal palpation at day 9 of mating. For that reason, twenty females were used for natural mating in July each year. Twelve pregnant does in the summer of year 2005 and 14 does in the year 2006 were chosen and continued for the rest of the experiments. All females were kept for a preliminary period of two weeks, and were found to be healthy and clinically free of diseases. The ages of chosen females ranged from 6-8 months with an average live body weight of 2.78 kg. Animals were individually housed in galvanized wired cages, where feed and water were provided *ad libitum.* Animals were fed on basal pellet ration contained yellow corn, soybean meal, corn gluten, minerals and vitamins premix, bone and molasses. The calculated chemical components were 20% crude protein, 2.8% fat, about 10% crude fiber and 2600 kcal digestible energy / kg diet.

In 2005, the selected twelve pregnant does were randomly divided into two equal groups, namely control and treatment (6 females in each group). Animals in the control group were kept indoors as natural air temperature throughout the experiment, while animals of the treated group were transferred outdoors and were exposed to indirect solar radiation under shade for a period of one hour (from 13:00 to 14:00 h, p.m) on days 9 and 10 of pregnancy.

In 2006, the experiment aimed to determine the effect of vitamin C supplementation in reducing heat stress on pregnant doe rabbits. Fourteen pregnant does were divided into two equal groups (treatment and control) and supplemented with Vitamin C as sodium salt of L-ascorbic. The ascorbic acid (AA) was dissolved in distilled water to yield a final concentration of 2.0 %. The used dose of AA was 20 mg / Kg body weight/doe/day (Yacout *et al.,* 2002) and was given orally to doe rabbits one time daily at morning for 15 days before mating and 15 days after mating. The treatment group was exposed to exactly the same method and time as in 2005 (the first experiment), while the control group was kept inside the rabbitry.

Data collection

Metrological and Production data:

Ambient air temperature and relative humidity were recorded daily inside and outside the rabbitry during the experimental period by using thermometer and hygrometer, respectively. Calculations of the temperature-humidity index (THI) were determined according to following equation:

THI = db°C – {(0.31 – 0.31 RH) (db°C – 14.4)}, which was formulated by Livestock and Poultry Heat Stress Indices, Agriculture Engineering Technology Guide (LPHSI, 1990) and adapted by Marai *et al.* (2001).

Where: db°C = dry bulb temperature in degrees Celsius, and RH = relative humidity percentage /100. The obtained values are then classified as follows: less than 27.8= absence of heat stress, 27.9-28.9 = moderate heat stress, 28.9-30.0 = severe heat stress, more than 30.0 = very severe heat stress.

Feed and water were recorded daily during the experimental period. Number of kits born was recorded and kits were weighed weekly. Milk yield for each doe was estimated for two weeks at 8.00 am in the morning as the difference in the weight of pups before and after suckling. Pups were separated before suckling for 12 hour to carry out doe milk production measurements.

Body reactions:

The following parameters were recorded at days 1, 3, and 7 (pre-treatment), 9 and 10 (during treatment), 10, 11, 13, and 15 (post treatment) of pregnancy at 8.00 am for each doe. Rectal and ear temperatures were measured in animals by using clinical thermometer. Respiratory rate (RR/min) was measured by counting the movements of the chest fleece. Pulse rate (PR/min) was measured by counting pulses in the femoral vein with a finger.

Blood sampling and analysis:

About 2 ml of blood samples were collected in the early morning at 1, 3, 7, 9, 10, 11, 13 and 15 days after mating from the marginal ear vein. One drop of heparin was added in each sample to prevent blood coagulation.

Hemoglobin (Hb) was determined by the cyanomethemoglobin method (Eiters, 1967). Hematocrit value (Ht) was determined by microhematocrit tubes with a hematocrit centrifuge at 4000 rpm for 5 min to determine packed cell volume percent (PCV%). Red blood cells (RBCs) and white blood cells (WBCs) were counted on an AO bright line hemocytometer slide using a light microscope.

Blood was centrifuged at 3000 rpm for 20 min to separate plasma which was stored at -20°C until used. Triiodothyronine hormone (T_3) was estimated in plasma by using ELISA Kit purchased from DIMA Gmbh, industriestr., Goettingen, Germany.

Statistical Analysis:

Statistical analysis was carried out on data according to Snedcor and Cochran (1982). Data were analyzed by using general linear model (GLM) of statistical analysis system (SAS, 1999). The significance of differences among means was tested according to Duncan's new multiple test (Duncan, 1955).

RESULTS AND DISCUSSION

Metrological Data:

Data of ambient temperature, relative humidity and calculated THI during the experimental period are presented in Figure (1). Temperature inside the rabbitry ranged from 30 to 34°C and ranged from 37 to 41°C outside the rabbitry during the indirect solar radiation treatment in days 9 and 10 of pregnancy. The THI calculations during days of experiment (Figure 1) showed that rabbits were exposed to heat stress according to Marai *et al.* (2001) criteria. Results showed that rabbits suffered from moderate to severe heat stress inside rabbitry during days of experiment. On the other hand, rabbits transferred outside the rabbitry during days 9 and 10 suffered from very severe heat stress (more than 30 THI).

Effect of Heat Stress on the Physiological Reaction of Pregnant Rabbits:

Physiological body reaction were significantly ($P<0.05$ and 0.01) affected by exposure of pregnant rabbits to heat stress and vitamin C supplementation. Figure (2) shows the marked effect of indirect solar radiation on rectal temperature (RT), ear lobe (EL) temperature, respiration rate (RR) and pulse rate (PR). However, statistical analysis showed insignificant effects of heat stress, vitamin C treatment and between days of pregnancy on rectal and ear lobe temperatures. When the treated rabbits were exposed to ambient temperature ranged from 37- 41°C outside the rabbitry on days 9 and 10 of pregnancy either alone or with vitamin C supplementation, rectal temperature was elevated to 41.0 and 41.2°C in HSW and was 39.8 and 41.0°C in HSV on days 9 and 10, respectively. However, rectal temperature of the control animals (CW and CV) inside rabbitry ranged from 39.1 to 39.3°C. This agrees with Gonzalez *et al.* (1971) who reported that the normal RT in rabbits ranged from 39.1 to 40.5 °C during summer.

Heat treated rabbits (HSW and HSV) without or with vitamin C showed elevations in EL temperatures (40°C) than those observed in control ones (38.6–38.8°C.as in Figure 1). However, no significance differences were noted between treatments, vitamin C addition, and days of pregnancy or their interactions. Gonzalez *et al.* (1971) and Gad (1996) reported that the normal range of EL temperature in rabbits was 37.0 – 37.2°C.during summer season. It is known that rabbits use general body position, respiration and peripheral temperature (ear temperature) to increase heat loss. When ambient temperature reaches above 25-30°C, rabbits stretch out and erect their ears to loose heat (Lebas *et al.*, 1986).

Respiration rate (RR) in control groups without or with vitamin C, was within the normal range between 130 -152.85 res/min during the experiment. These values were very close to the normal range of 125.2 to 190 during summer season (Jonson *et al.*, 1970). Statistical analysis showed significant ($P<0.01$) effects of heat treatment, vitamin C addition, days of pregnancy and all their possible interactions on RR. Respiration rate of rabbits exposed to solar radiation (HSW and HSV) on days 9 and 10 of pregnancy was elevated to 171.16 and 175.48 in HSW and decreased to 170 and 173.57 res/min in HSV on days 9 and 10, respectively. Addition of vitamin C to heat treated rabbits (HSV) reduced the increase in RR and alleviated the effect of thermal stress on pregnant rabbits. On the other hand, control groups showed no elevation in RR during experiment.

Pulse rate (PR) in pregnant doe rabbits ranged between 81 to 85.6 pulse/min during days 1-7 of pregnancy (pre-treatment) in all groups. Heat exposure to rabbits (HSW, HSV) outside the rabbitry caused significant ($P<0.001$) elevation in their PR and reached to 91.0 and 87.0 pulse/min on day 9 and were 99.0 and 86.42 on day 10 of pregnancy, respectively. Vitamin C significantly ($P<0.001$) reduced the elevation in PR in both heat treated animals and in control group. Addition of vitamin C to treated rabbits (HSV) alleviated the effect of thermal stress on pregnant rabbits. Furthermore, pulse rate in control groups (CW and CV) ranged between 83 and 71 pulse/min during the experimental period. On the hand, the PR in heat stressed rabbits (HSW and HSV) ranged from 95 to 86 pulse/min during heat treatment.

It was reported that the comfort zone temperature for rabbits is around 21°C (Marai *et al.*, 2002). Many authors found that the highest rabbit's rectal temperature during summer and the lowest value during winter season (Mesherky and Abbas 2000). EL-Sobhy (2000) reported that rabbits exposed to heat increased their RT (39.65 in treated *vs.* 38.42°C in control). In the present study, although the heat treatment elevated RT in HSW group compared to CW group (41.1 *vs.* 39.49), the overall mean effect of heat stress on rabbits RT was not statistically significant probably due to using physiological means to sustain animals' heat balance as shown in RR and PR data. It was reported that hyperthermia in animals induces several physiological changes such as increases in heart rate, and increase in cardiac output, oxygen demand, cutaneous vasodilatation (Shapiro and Seidman, 1990), respiration (Gautier, 2000) and respiratory alkalosis in rabbits (Daghir, 1995). In addition, rabbits use general body position such as respiration and peripheral temperature (ear temperature) to increase heat loss.

The beneficial effect of vitamin C in alleviating heat stress was reported by Alam (2000) and Marai *et al.* (2002). Alam (2000) stated that vitamin C is involved in the synthesis of some stress hormones such as epinephrine. These hormones control respiration rate, blood flow and pressure and maintain body temperature almost constant during heat stress.

The present study showed that rabbits suffered from moderate to severe heat stress inside rabbitry during the experiment, and to very severe heat stress when transferred outside the rabbitry during days 9 and 10 of pregnancy. Addition of vitamin C to animals slightly reduced the above mentioned physiological parameters. The effect of vitamin C on RT and on ear temperature was insignificant. In heat-stressed animals (T-H index above 32), slight changes were noted in ear temperature during experiment because of the continuous loss of heat through ears as indicated by Lebas *et al.* (1986). They stated that respiration and ears in rabbits are the most important heat dissipation pathways. The ear lobe plays an important role in rabbit thermoregulation, because it functions like a car radiator. In addition, Wolfenson and Blum (1988) stated that when ambient temperature exceeds 30°C the rabbit looses heat as much as possible by radiation, convection and ear temperature increases significantly.

Responses of Hematological Parameters

Effect of summer heat on some hematological parameters (Hb, Ht, RBCs and WBCs) is presented in Figure (3). Significant ($P<0.01$) variations were found in RBCs and WBCs values between rabbit groups due to heat stress and vitamin C addition. On the other hand, insignificant effects were found due to heat stress and vitamin C addition in hemoglobin concentration and hematocrit value. Addition of vitamin C to treated rabbits (HSV) reduced the increase of Hb and Ht and quietly alleviated the effect of high thermal stress on pregnant doe rabbits. On the other hand, control groups showed no elevation in Hb and Ht levels during experiment and it ranged from 11.1-12.6 gm/dl. In addition heat-treatment caused an elevation in Ht value (39.5%) in rabbits without vitamin C supplementation (HSW) compared to (37.4%) in rabbits supplemented with vitamin C (HSV) on days 9 and 10 of pregnancy.

Effect of heat stress exposure on RBCs and WBCs counts in pregnant rabbits is presented in Figure (3). It indicated that RBCs of pregnant doe rabbits ranged between 4.9 – 5.9 x $10^6/mm^3$ during days 1-7 of pregnancy in all groups. When rabbits were exposed to ambient heat (HSW and HSV), the values ranged from 6.2 to 6.7 x 10^6/mm³ in HSW group, and from 5.1 to reach 5.2 10^6/mm³ in HSV group on days 9 and 10, respectively. The elevated level of red blood cells was probably due to dehydration effect during heat stress exposure of doe rabbits. Addition of vitamin C to solar radiation treated rabbits (HSV) maintained the level of WBCs at the normal value and significantly alleviated the effect of thermal stress on pregnant rabbits.

The rise in RBCs and WBCs counts during the hot summer season agree with a previous report on sheep (Sodhi, 1983). This was attributed to the hemoconcentration effect of thermal stress of summer heat causing a great mobilization of red blood cells from spleen, lungs and liver (El-Nouty *et al.*, 1989). In addition, the observed increase in WBCs count in treated rabbits (HSW) could be also attributed to the stressful condition of rabbits on days 9 and 10 of pregnancy which increased blood viscosity and which may lead to allergic effects that induce WBCs production (Lee *et al.*, 1976).

Triiodothyronine (T_3) in Pregnant Rabbit Does:

Results of the present study (Figure 4) showed significant (P<0.001) effects of vitamin C addition and insignificant effects due to heat stress, days of pregnancy and their interactions. The effect of vitamin C on T_3 hormone concentrations was pronounced on days 11 and 15 in HSV group and on days 10, 11 and 15 of pregnancy in CV group, respectively.

Heat stressed rabbits (HSW and HSV) which were exposed to one hour of ambient heat (ranged 37- 41°C) at days 9 and 10 of pregnancy, showed that T_3 concentrations decreased from 1.95- 2.16 ng/ml (during days 1-7 of pregnancy) to reach 1.85 - 1.93 ng/ml in HSW and 1.65 - 1.81 ng/ml in HSV on days 9 and 10, respectively. Addition of vitamin C to rabbits exposed to heat stress (HSV) maintained the level of T_3 to be at normal levels and alleviated significantly the effect of thermal stress on pregnant rabbit does. On the other hand, control group (CW) showed stable levels of T_3 during the experiment. However, addition of vitamin C to control group (CV) elevated T_3 concentrations from 1.28 in day 1 to 10 ng/ml in day 15 of the experiment. Furthermore, treated rabbits (HSV) showed an increase in T_3 concentrations and reached to 6.15 and 7.75 ng/ml on days 11 and 15 of pregnancy, respectively.

In adult animals, the thyroid gland is considered to play an important role in the adaptive phenomena associated with changes in environmental temperatures (Bobek *et al.*, 1996). A marked decrease in serum thyroxin (T_4) and thyroid stimulating hormone in heat stressed rats were observed by Tal and Sulman (1975). Sahin *et al.* (2002) reported that supplementing vitamins C and E either separately or in a combination increased serum T_3 and T_4 concentrations, whereas decreased serum ACTH concentration in laying hens. Therefore, in the present study the observed increase in T_3 levels in rabbit does consumed vitamin C for two weeks, before and after mating (Figure 4) is mainly due the effect of vitamin C on thyroid gland functions. On the other hand, many authors reported the beneficial effects of vitamin C in detoxification of different toxic materials, in enhancing the immune system (Head, 1998) and in prevention of cellular free radical damage (Dumitrescu *et al.*, 1993). Thus, the oral supplementation of vitamin C, which is a free radical scavenger, may protect the animals from the harmful effects of environment such as severe heat stress.

Effect of Heat Stress on Doe and Offspring Productive Traits:

Litter Size and Litter Weight Traits:

Results in Figure (5) showed the effect of heat stress exposure on litter size and litter weight during the first two weeks of lactation period. Results showed that rabbits which were not supplemented with vitamin C gave slightly higher litter size than those supplemented with vitamin C. However, vitamin C addition to rabbit does groups HSV and CV yielded heavier litter weights in offspring than those in groups HSW and CW in the first week of age (Figure 5). Moreover, at the end of second week, rabbit kits in HSV and CV groups gave higher growth rate (120 % and 96% respectively) than those in HSW and CW groups (37% and 35% respectively).

Many authors reported a significant effect of season of kindling on litter weight and litter size at birth (Ayyat and Marai 1998). They found that litter weight and litter size at birth were higher during winter than in summer season. Also they reported a production of 5.8 kits in summer and 6.6 kits in winter season, i.e. a reduction of 14% in the summer season of the NZW White breed. The number of kits born alive was also found to be the lowest during May and August (McNitt and Moody, 1990; Bassuny, 1999).

Doe Milk Yield:

Table (1) showed the effect of heat stress exposure on milk yield/doe during the first two weeks of lactation period. Results showed that rabbits (HSW) which were exposed to heat and were not supplemented with vitamin C yielded lower (P<0.01) milk than control groups (CW, CV) and than HSV which were exposed to solar radiation and supplemented with vitamin C. Vitamin C addition to rabbit groups HSV and CV yielded higher litter weights than those in groups HSW and CW in the first week (Figure 4), indicating of higher milk production.

Does milk yield was found to be significantly lower in summer season than in the other seasons of kindling (Habeeb *et al.*, 1999). An effect which is mainly due to increases of ambient temperature. Thus, Szendro *et al.* (1998) found that milk yield was significantly lower at 30°C than at 5°C ambient temperature after the first 2 weeks of lactation. Rafai and Papp (1984) found that the daily milk yield of the rabbit does decreased by 7.7 gm for each degree increase in ambient temperature beyond the 20°C. Muertens and De-Groote (1990) stated that high ambient temperature caused significant decrease in milk yield (-9%) and the decrease was most pronounced when ambient temperature was greater than 30°C during day time and more than 24°C at day night. The present results agree with the previous findings as shown in Table (1). The amount of milk yield decreased in heat-stressed does in HSW and HSV groups and ranged from

12-15% than that yield in CW and CV groups. However, the effect of vitamin C addition in improving milk production in rabbit does was not significant until two weeks.

Pre-weaning Mortality Rate:

Pre-weaning mortality rate during two weeks period is shown in Table (2). Results showed high mortality rates in HSW and HSV (17 and 9 %) as compared to those in CW and CV (4.7 and 4.8%). The effect of heat exposure to pregnant rabbits during days 9 and 10 of pregnancy caused high mortality percent after two weeks. Addition of vitamin C to rabbits (HSV and CV) reduced pre-weaning mortality rate in heat stressed rabbits by 45 %.

Pre-weaning mortality percentage was found to be affected significantly by season of kindling (Farghaly *et al.,* 1994; Radwan, 1998). The highest values were recorded in summer (Marai *et al.,* 2001 and Bassuny, 1999), while the lowest values were recorded in winter (Habeeb *et al.,* 1999), spring (Farghaly *et al.,* 1994) and autumn (Radwan, 1998). Habeeb *et al.* (1999) reported that mortality rate from birth up to weaning increased significantly with the increase in ambient temperature from 19.5°C in January to 34.8°C in July. This might be attributed to the direct effect of heat stress on the sensitive offspring, in addition to reduction of doe's milk production (Ayyat *et al.,* 1995) or due to the general depression of metabolic activity in summer season (Shafie *et al.,* 1984). Coates (1984) stated that the growth and promoting effect of ascorbic acid (vitamin C) may be associated with the alleviation of retardation in thyroid gland function during summer.

In the present study, the effect of vitamin C on milk production seems to be indirect through affecting thyroid gland functions, growth rate, feed intake, reducing stress. Verde and Piquer (1986) found that in rabbits exposed to stress, the plasma ascorbic acid is significantly reduced. The metabolic need for ascorbic acid is increased at certain conditions and so, the growth-promoting effect of ascorbic acid may be associated with the alleviation of retarded functions in the thyroid gland (Coates, 1984).

In conclusion, in under Egyptian summer conditions, rabbit production is faced by elevation in ambient temperature and humidity inside rabbitries, which cause severe heat stress, and put more burden on rabbit does and especially the pregnant ones. Supplementation of doe rabbits with ascorbic acid (vitamin C) as 20 mg/Kg body weight reduced the pronounced adversely effects of heat on animals productivity.

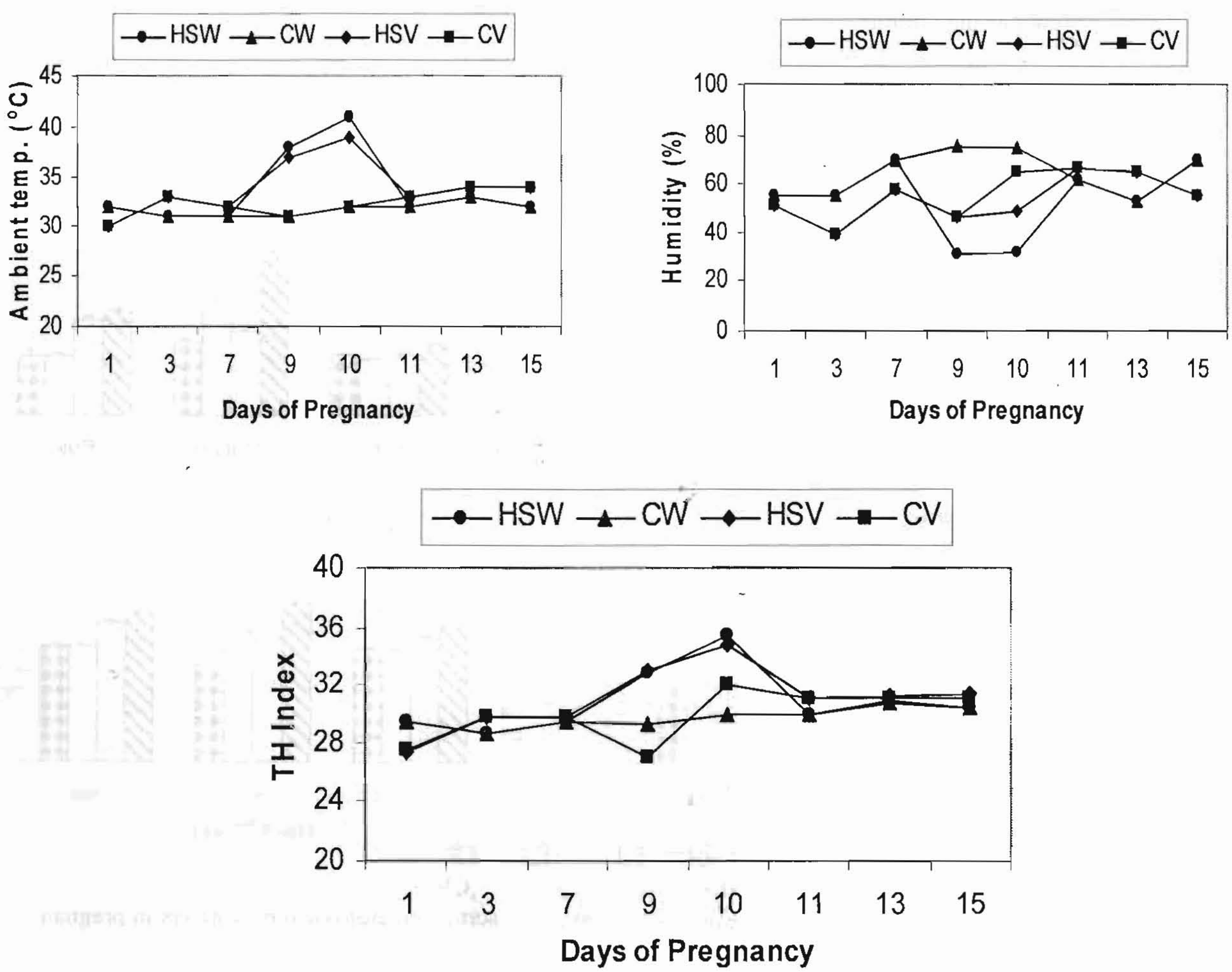

Figure (1): Ambient temperature (T), humidity (H) and TH index during the experiment.

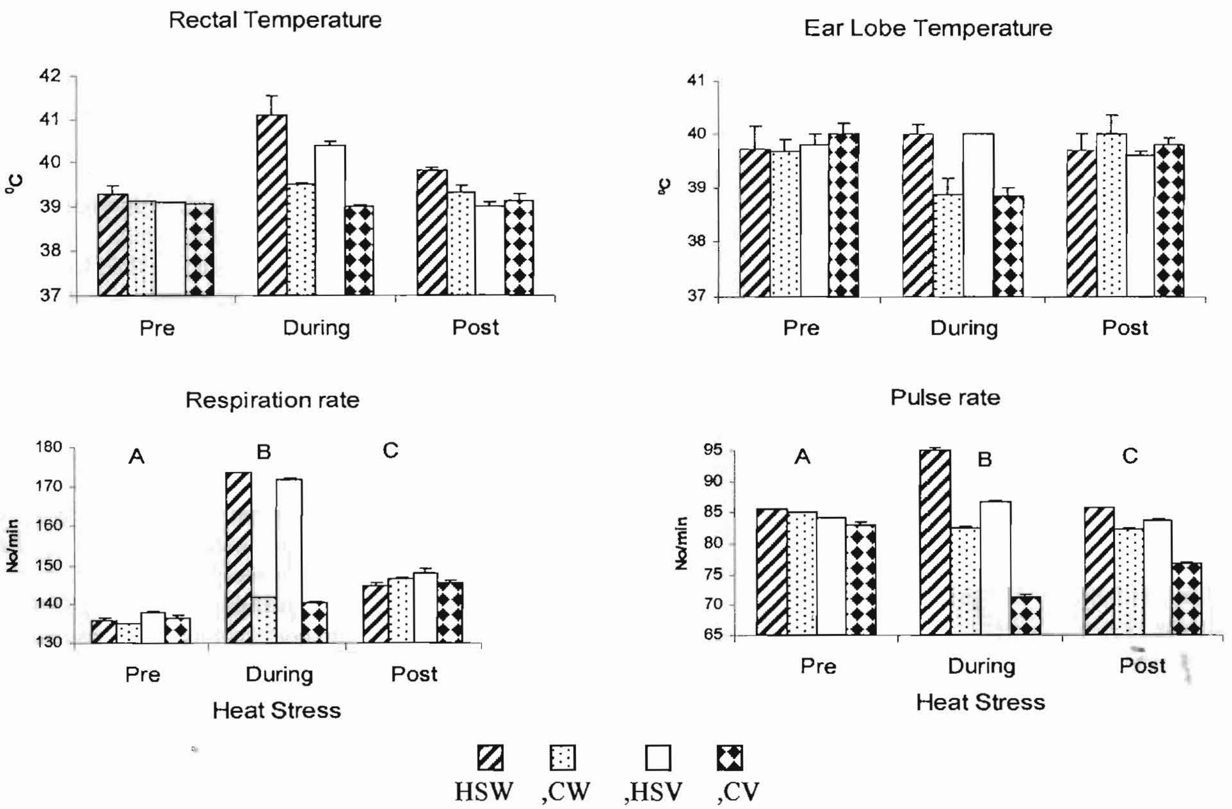

Figure (2): Effect of heat stress and vitamin C supplementation on physiological body reaction parameters in pregnant New Zealand rabbits.
[A,B,C] Denotes differences between experimental stages at P<0.01.

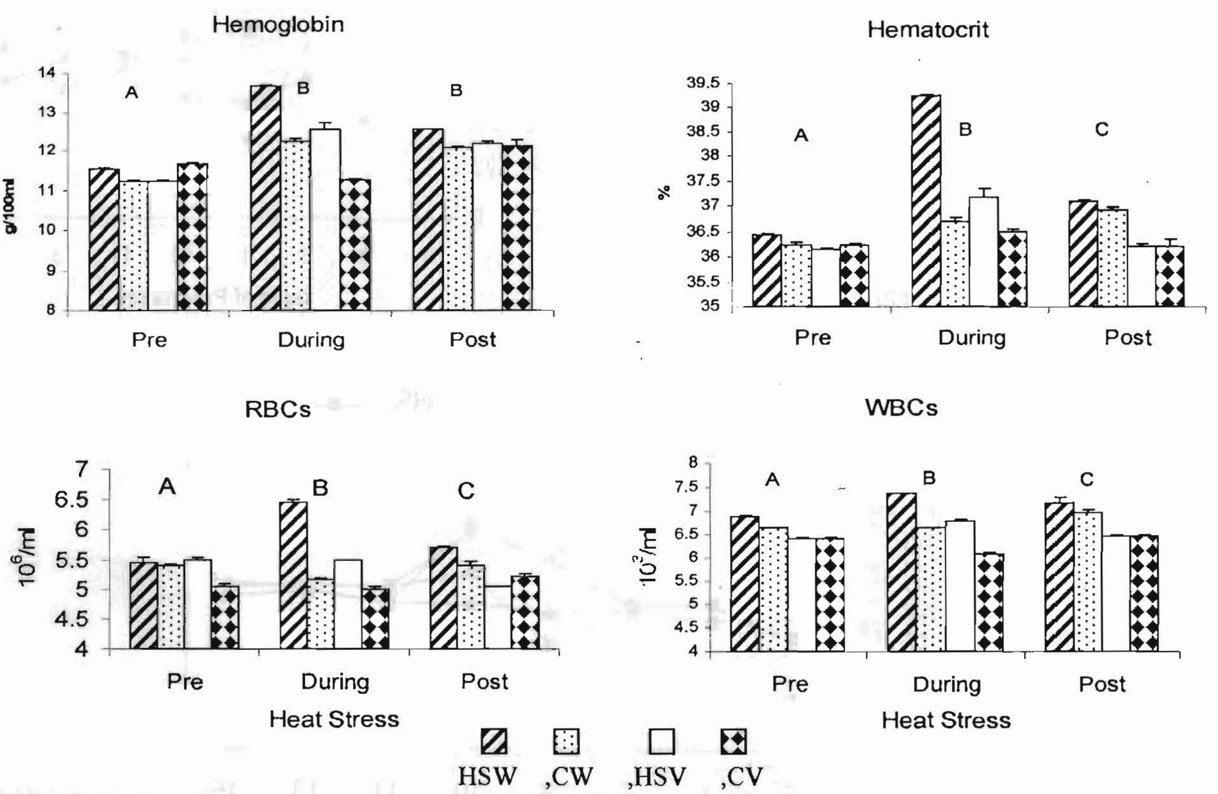

Figure (3): Effect of heat stress and vitamin C supplementation on some hematological parameters in pregnant New Zealand rabbits.
[A,B,C] Denotes differences between experimental stages at P<0.01.

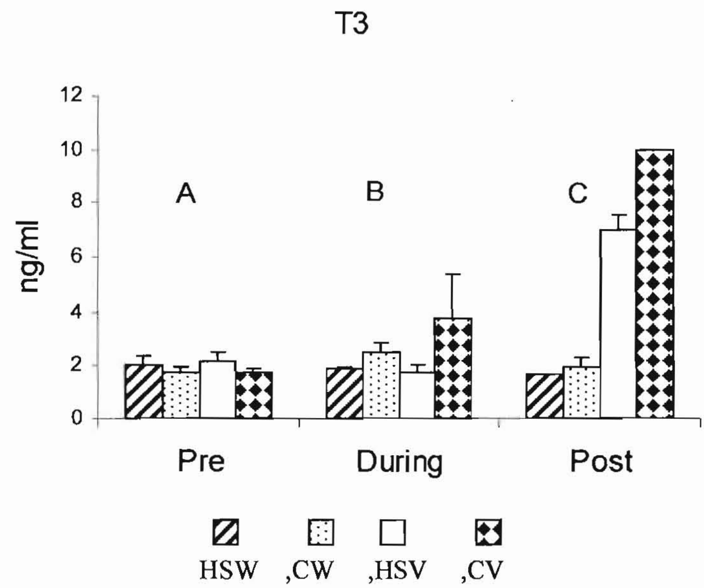

Figure (4): Effect of heat stress and vitamin C supplementation on triiodothyronine (T_3) concentration (ng/ml).
[A,B,C] Denotes differences between experimental stages at P<0.01.

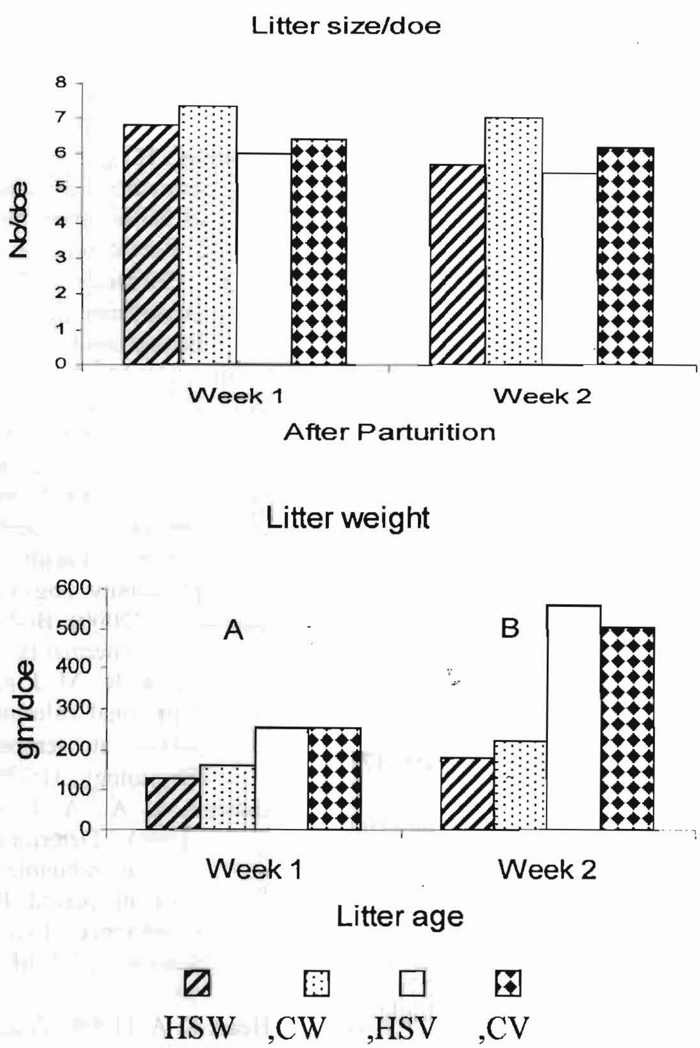

Figure (5): Effect of heat stress and vitamin C supplementation on litter size and litter weight of newborn after parturition in New Zealand rabbits.
[A,B,C] Denotes differences between experimental stages at P<0.01.

Table (1): Mean ± S.E. of weekly milk yield for two weeks after kindling (gm /doe).

Week		Without vitamin C		With vitamin C		Overall mean
		HSW	CW	HSV	CV	
Lactation period	1	496.3± 18.4^{c}	560± 19.6^{b}	513.8± 13.7^{c}	624.4± 11.9^{a}	548.6±28.5^{B}
	2	554.1± 85.2^{c}	625.6± 2.1^{a}	587.3±15.26^{b}	653.8± 14.5^{a}	607.6±22.7^{A}
Overall mean		525.2± 28.9^{c}	597.8± 37.8^{b}	550.5± 36.7^{c}	639.1± 14.7^{a}	
Overall mean		561.5±33.3^{b}		594.8±25.7^{a}		

HSW = Heat Stressed rabbits without vit.C CW = Control without vit. C
HSV = Heat Stressed rabbits with vit.C CV = Control with vit.C
^{a,b} Means in a row with no common superscript are significantly different (P≤0.05).
^{A,B} Means within column no common superscript are significantly different (P< 0.05).

Table (2): Number of kids born /group and mortality % at two weeks of age.

Item	HSW	CW	HSV	CV
Kids born (No)	41	42	33	41
Kids dead (No)	7	2	3	2
Mortality (%)	17	4.7	9	4.8

HSW = Heat Stressed rabbits without vit.C CW = Control without vit. C
HSV = Heat Stressed rabbits with vit.C CV = Control with vit.C

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تأثير الإجهاد الحراري على الأداء الفسيولوجي والإنتاجي لأمهات الأرانب الحامل

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إستهدفت هذه الدراسة تحديد تأثيرات الإشعاع الحراري غير المباشر على الأداء الفسيولوجي و الإنتاجي للأرانب الحوامل وكذلك دور فيتامين ج في تخفيف هذه التأثيرات. تم إستخدم ستة و عشرون أنثي ارنب نيوزيلاندى أبيض خلال فترة الدراسة لعامين متتالين. إستخدم في العام الأول ١٢ أرنبة حامل حيث قسمت إلى مجموعتين متساويتين. عوملت المجموعة الأولى بالحرارة (HSW) و المجموعة الثانية بقيت داخل العنبر في حرارة الجو الطبيعية و سميت كنترول (CW). إستخدم في العام الثاني ١٤ أرنبة قسمت إلى مجموعتين متساويتين وزودت عن طريق الفم بفيتامين ج (٢٠ مللجم/كجم من وزن الجسم/يوم) لمدة ١٥ يوم قبل الحمل و ١٥ يوم بعد الحمل. تعرضت المجموعة الأولى للحرارة (HSV) و المجموعة الثانية سميت كنترول (CV) بنفس الطريقة كما في العام الأول. بقيت كل الأرانب داخل العنبر خلال التجربة. الأرانب المعاملة (HSW، HSV) عرضت لحرارة الصيف (أغسطس) خارج العنبر تحت مظلة لمدة ساعة بين الواحدة و الثانية ظهرا فى اليوم التاسع و العاشر من الحمل. تم تجميع البيانات على الأرانب في أيام ١ ، ٣ ، ٧ ، ٩ ، ١٠، ١١ ، ١٣، ١٥ بعد الحمل ، لمدة أسبوعين خلال الرضاعة و على المواليد لمدة أسبوعين بعد الولادة. أظهرت النتائج أن تعرض الأرانب لدرجات من الإجهاد الحراري أدت إلى حدوث أستجابات فسيولوجية معنوية. كما أوضحت الدراسة التأثيرات المعنوية للإجهاد الحراري على معايير تفاعلات الجسم الفسيولوجية للأرانب الحوامل،مستويات بعض معايير الدم وهرمون التراي أيودوثيرونين (T_3) في الأرانب الحوامل. هذا بالأضافة إلى أن الإجهاد الحراري سبب إنخفاض في حجم ووزن الخلفة للمواليد. كما وصل معدل النفوق للمواليد قبل الفطام إلى ١٧% في مجموعة الأمهات المعرضة للإجهاد الحراري بينما كانت ٩% فقط فى مجموعة الأمهات التى أستهلكت فيتامين ج خلال الحمل. كما أظهرت النتائج إنخفاض إنتاج اللبن للأمهات المعرضة للإجهاد الحراري (525.2 جم/الأم) عن الأرانب الكنترول (٥٩٧,٨ جم /الأم) على الترتيب.

نستنتج من هذه الدراسة أن إضافة فيتامين ج إلى الأرانب الحوامل خفضت التأثيرات السيئة للإجهاد الحراري على معظم المعايير الفسيولوجية و الملامح الإنتاجية. إضافة فيتامين ج بمستوى ٢٠ مللجم/كجم من وزن الجسم/يوم يمكن أن تكون معاملة روتينية في مزارع الأرانب التجارية خلال فصل الصيف.