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BEHAVIOURAL RESPONSES OF TWO JAPANESE QUAIL LINES DIFFERING IN BODY WEIGHT TO HEAT STRESS

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SUMMARY

The objectives of this experiment were to study the effects of different environmental temperatures during the rearing phase on the heat tolerance and behavioral responses of two Japanese quail lines to heat stress. A total of 192 chicks from two lines were randomly distributed between eight brooding cages. Each line was divided into 4 treatments. Each treatment was different in experimental period of exposure to 35°C heat (2, 3, 4 and 5 weeks after that the temperature was reduced to 25°C). The behavioral traits were determined during the first 5 weeks of age. Also, temperature preference test was done and rectal and leg temperatures and latency until panting were determined after 10 weeks from the starting of the experiment.

Results indicated that birds under heat stress changed their behavior significantly. They tended to spend more time sitting and less time standing, walking and feeding. Increase of environmental temperature during the rearing phase leads to an increase in the heat tolerance in Japanese quail. The light quail line was more active and tolerated heat better than the heavy quail line under heat stress.

The results obtained could contribute new aspects to a better understanding of thermo-regulative process in Japanese quail. It can allow for developing of new housing and production systems that are more suitable for a specific climatic condition.

Keywords: Japanese quail, heat stress, behavioural traits, heat tolerance

INTRODUCTION

The environment includes all external factors (temperature, population density, light, humidity, etc.) as well as internal factors (pathogenic organisms, parasites, or any other foreign substance). Any change in the environment will cause both specific and non-specific responses reactions that are directed at re-establishing a state of homeostasis in the bird. To maximize meat or egg production, poultry producers must do every thing possible to minimize the number and intensity of stressors within the poultry house. One stressor, which is common to poultry, especially in summer months and in tropical areas, is heat (Siegel, 1980; Ali *et al*., 1980; Richard *et al*., 1998; Khalil, 2004, Khalil *et al*., 2006, 2007and 2008).

The negative effects of heat stress on poultry are widely known since a long time. High housing temperature (35°C) had negative effects on body weight, feed efficiency, carcass yield and survivability of the Japanese quail (Michael *et al*., 1996; Khalil, 2004; Khalil *et al*., 2006, 2007 and 2008). Furthermore, heat stress caused a series of physiological and metabolic changes in avian species such as elevated body temperature, panting and respiratory alkalosis (Deyhim and Teeter, 1991 and Khalil, 2004) and reduced thyroid activity (Bowen and Washburn, 1985).

This experiment was conducted to compare the reactions to heat stress of two Japanese quail lines differing in body size. The experiment was also designed to detect whether the environmental temperature during the rearing phase could influence the heat tolerance and behavior in either of these lines.

MATERIALS AND METHODS

Birds and husbandry:

This experiment took place at the Poultry Farm, Institute of Animal Breeding and Genetics, University of Goettingen, Germany. One hundred and two unsexed one-day-old Japanese quail chicks from light and heavy body weight lines were randomly distributed between eight brooding cages (20-30 chicks / cage). Each brooding cage (100 x 50 x 40 cm) had two heaters (white light, 250 Watt) set in the ceiling. The temperature of the heaters was controlled by a dimmer switch. The floors consisted of a mesh made from strips of green plastic. At the end of each cage, there was a wooden box (50 x 30 x 5 cm), divided into two sections, one for sand (dust bathing) and the other for straw (egg laying). At the front of each cage, there was a feeder and water. Feed, water, sand and straw were available *ad libitum*.

Sex differentiation was done at three weeks of age. All chicks were wing banded to register their pedigree. At five weeks of age, all the birds were transferred from the brooding cages into eight floor pens (80 x 130 x 70 cm). The ceiling of the pens was made of polyvinyl netting (mesh size four cm^2). Woodshavings were used as a litter. In each pen contained a feeder, two automatic cups and two wooden boxes with straw. Feed, water and straw were available *ad libitum*. The average body weight of the light and heavy quail lines at 6 weeks of age were 100 and 290 g respectively.

The poultry farm had a closed side housing system so that the room temperature and light period could be artificially controlled. A fluorescent tube (58 Watt) was suspended from the ceiling to light the room. The light came on at 0600h to 2200h, with a 15 min twilight phase at the start and the end of the light period. The light intensity in both the brooding cages and pens ranged from 35 - 40 Lux in the front to 8 - 10 Lux at the back. The birds were subjected to 23L to 1D for the first day post-hatching and 20L to 4D on day 2 until the end of the first week. At the beginning of the second week, the light was changed to give 16L - 8D. This regime was maintained until the end of the experiment.

Treatments:

Two Japanese quail lines differing in body size and two different brooding environmental temperatures (25°C and 35°C) were used in this experiment. Each line was divided into 4 groups according to the period of brooding under 35°C. The 1st, 2nd, 3rd, and 4th groups were kept under 35°C for 2, 3, 4 and 5 weeks from hatching, respectively. Subsequently, the ambient temperature for all the groups was reduced to 25°C.

Traits Studied:

Behavior:

The behavioral traits of all the groups were determined during the first five weeks of life using a video camera in each brooding cage. The behavioral traits were recorded one day a week during the period of light from 0600 to 2200h (every 20 minutes) as follows:

a- Basic activities (percentage of birds standing, sitting or walking),

b- Additional activities (percentage of birds feeding, drinking or preening).

Temperature Preference Test:

This test was done at 10 weeks of age. The aim of this test was to see whether the rearing treatment had an influence on the temperature preference of adult quail for either 25°C or 35°C. This test also measures the ability of adult quail to freely choose the optimal ambient temperature for quail which is 25°C.

Equipment:

The equipment consisted of two brooding cages joined together with a small opening (diameter 15 cm) in the middle, so that the birds could move easily between the two compartments (Figure 1). Each cage was equipped with two heaters and a video camera.

Methods:

All birds were randomly divided into 24 groups according to treatment and line [(12 groups/line) and/or (three groups/treatment)]. Each group consisted of 2-5 birds from the same line. Every group was kept in the test situation during the period of light from 06:00 to 22:00h.

Each group was kept in the test situation for two successive days. Every bird was tested only once during the period of light from 06:00 to 22:00h. On day one, the birds were put in Unit 1 randomly either in the compartment for 25°C or for 35°C. On day two, the birds were put in Unit 2 in the same side (left or right) as on day 1, but this time the compartment had the other ambient temperature (Figure 1). The behavior of the birds was recorded every 10 minutes using the two video cameras in each double-caged unit as follows:

a- Distribution of birds (%) in the two compartments (preferred temperature 25 or 35°C).

b- Basic activities (percentage of birds in each cage standing, sitting or walking).

c- Additional activities (percentage of birds in each cage: feeding, drinking or preening).

Room temperature and relative humidity:

Room and cage temperatures and relative humidity were recorded every two min during the whole experiment using a digital thermo-hydrometer. The average temperature and relative humidity in heat stress and control groups were (35.25±1.15°C, 17.56±7.25 RH and 25.23±1.26°C, 30.62±8.7 RH, respectively).

Short-term heat stress test:

Aim:

The aim of this test was to evaluate the bird's adaptive reactions towards short-term heat stress (30 minutes at 35°C). Leg temperature was used in this test. It was chosen as indirect measures for core body temperature by infrared thermography equipment was used in this test (The Thermovision (R) 900 system; AGEMA, 1992).

Method:

A total of 40 birds were used in this test according to treatment and line (each treatment group consisted of five birds). The birds were chosen randomly and each was subjected individually to 35°C for 30 minutes in the testing cage. Thirty-one pictures were taken for every bird during the test (one picture / minute). Each bird was tested only once at 10 weeks of age.

Traits studied under heat stress:

1- Leg temperature (°C). 2- Time to start of panting (minutes) when subjected to heat stress. 3- Rectal temperature (°C) before and after the test.

Statistical analyses:

Values are presented as means ± SE. Data were analyzed using the General Linear Model (GLM) procedure of SAS (SAS Institute Inc., 1998), and the significant differences between means were detected according to Duncan's multiple range test (Duncan, 1955). A probability value (P) of less than 0.05 was considered to be significant.

RESULTS

Behaviour:

Basic behavioural activities:

The Basic behavioural activities (standing, sitting and walking) of quail were significantly influenced by treatments. Light weight birds spent more time standing in the control and 3-weeks heat stress groups compared with the other heated groups. The lowest percentage of sitting and the highest percent of walking were obtained in control group. On the other hand, in the heavy weight line, percentage of standing decreased, but percentage of sitting and walking increased with increasing length of rearing under 35°C (Table 1).

The heavy quail line spent significantly more time sitting than the light quail line (51.70 vs. 48.52 %, respectively). Contrary to that, light birds walked significantly more than the heavy quail (16.13 vs. 11.50 %, respectively), irrespective of the different rearing temperatures (Table 1).

Additional behaviour activities:

The traits studied (preening and feeding) were significantly influenced by the rearing temperatures, line and their interactions. Light birds spent more time preening and feeding in the control and 3-weeks high brooding temperature groups compared with the other heated groups. However, in the heavy birds the control and 4 weeks high brooding temperature groups spent more time preening than the other heated groups. The lowest percentage of feeding was obtained in 5 weeks high brooding temperature groups, while the highest percentage was obtained in the control group (Table 2).

Also, significant differences ($P \leq 0.05$) among the two lines in additional behaviour activities percentage were found. The heavy birds spent significantly more time feeding and drinking than the light birds (10.22 vs. 8.81 & 3.57 vs. 2.4%, respectively). Conversely, higher percentage of preening was obtained in the light birds than in the heavy birds (13.27 vs. 10.22%, respectively), irrespective of the different rearing temperatures.

Preference test:

Preferred ambient temperatures of the two quail lines as affected by different rearing temperatures at 10 weeks of age are presented in Table (3).

There were significant differences ($P \leq 0.05$) between the two ambient temperatures used in the preference test (25°C as control & 35°C as heat stress) on choosing temperatures. Higher percentage of the birds preferred a 25°C compared to the 35°C irrespective of rearing temperatures, lines and length of brooding temperature at 35°C (76.48 vs. 23.57%, respectively). Also there are significant differences between lines and the ambient temperatures used in the preference test (25°C & 35°C). The light weight birds spent more time under high ambient temperatures compared with the heavy weight birds (30.62 vs. 16.56 %, respectively).

Short term heat stress test:

Rectal temperatures:

Data in Table (4) show Least Square Means of the rectal temperatures (°C) in the light and heavy quail lines in relation to a short-term heat stress (across 30 min) as affected by rearing temperatures.

Analysis of variance revealed significant differences ($P \leq 0.05$) between rearing temperatures and lines on rectal temperatures before (RTB) and after heat stresses (RTA), but the interactions were not significant. Before heat stress, the highest values were obtained in the control and the five weeks heat stress group. However, after heat stress, the control groups had the highest values compared with the heated groups. The differences between RTA and RTB between rearing temperatures and lines were not significant.

Heavy birds had significantly higher rectal temperatures than light quail before and after heat stress (42.28 vs. 41.83°C RTB and 42.96 vs. 42.48°C RTA, respectively). These results indicate that, small quail had more heat tolerance than the heavy quail. In addition, exposing birds to longer periods of high temperature (35°C) during the rearing phase helped to improve the heat tolerance in adult quail.

Leg temperatures by infrared thermography:

Significant effects were found for rearing treatments and the interaction between treatments and lines in leg temperatures. Light females had the lowest values in the 2 and 3 weeks of high heat brooding groups. While the heavy weight quail line had the lowest value in the 5 weeks heated group compared with the other groups. Heavy line had higher leg temperature than the light birds (37.43 vs. 37.18°C, respectively) irrespective of rearing temperatures (Table 5).

It is concluded that increasing environmental temperature during early age will result in thermal conditioning which can lead to increasing heat tolerance in heat stressed groups.

Latency until panting:

The effect of different rearing temperatures on latency until panting (min) in the light and heavy quail lines in relation to short-term heat stress are presented in Table (6).

Latency is defined as the time interval (min) from the exposure to heat stress (35°C) until the start of panting. Control birds started panting significantly earlier than other heat stressed groups in both lines. Significant differences ($P \leq 0.05$) were also found between the two lines, the heavy quail line starts panting earlier than the light females (5.28 vs. 8.39 min, respectively).

DISCUSSION

The results of this experiment showed that, behavioral thermoregulation is one of the most important responses of birds to heat stress. Behaviour of quail birds was changed significantly by rearing temperatures (short and long rearing periods at 35°C). Birds reared at 35°C tended to spent more time sitting and less time standing and walking as compared with the 25°C group.

Also, birds reared at 35°C for along period reduced the amount of feed they consumed compared with the control (25°C) birds. Feed intake was significantly reduced when exposing the birds to high environmental temperature, because the thermostatic mechanism of feed intake regulation results in an inverse relationship between environmental temperature and the intake of feed and energy (Payne, 1975). During periods of heat stress birds have to make major thermo-regulatory-adaptations in order to prevent death from heat exhaustion. Birds rest more during periods of heat stress and lay sprawled on the litter and spent more time near walls or waterers (May *et al*., 1997 and Gary and Richard, 1996).

Also, the results indicated that, the light quail line had more heat tolerance than the heavy quail line. Also, the heavy quail line spent significantly more time sitting than the light quail line. A significantly higher walking percentage was observed in the light quail line compared with the heavy quail line. In the preference test, the light quail line spent significantly more time under the high ambient temperatures than the heavy quail line. Also, with regard to latency until panting (min), the heavy quail line started panting significantly earlier than the light quail line. Wilson *et al.* (1975); Washburn *et al,* (1980) reported that different quail lines differed in heat tolerance due to differences in body weight and size. The small birds exhibited more heat tolerance. Because small birds have a greater surface area to body mass ratio, they should be able to dissipate heat more efficiently than the heavy quail line.

The results also showed that, the increase in environmental temperature during the rearing phase leads to an increase in the heat tolerance in Japanese quail. The heat tolerance was clearly shown in latency until panting (min) of quail birds (across 15 or 30 min at 35°C heat stress). The increase in respiration rate showed the importance of the role of respiration in losing heat stress. Panting is the most important means of thermoregulation for birds, panting ceased when abdominal temperature was below about 41°C (Zhou *et al.,* 1996).

In the present study control birds reared under 25°C started panting significantly earlier than the other heated groups. These results indicated that groups heated during the rearing phase had more heat tolerance than the control group. Many workers have demonstrated that the domestic fowl can be protected from the effects of acute heat stress.

Increasing the environmental temperature can lead to increased heat tolerance (such as early age thermal conditioning), lowering the environmental temperature can reduce the bird's ability to tolerance heat stress (Sykes and Fataftah, 1986b; Sykes and Silah, 1986; Arjona *et al.,* 1988; Zhou *et al.,* 1997; Yahav *et al.,* 1997 and Basilio *et al.,* 2001). Chickens could be acclimated to a hot, humid environment by 24 daily 4-h exposures to elevated temperatures. The increase in heat tolerance resulting from acclimatization is due to a decrease in body temperature, decreased insensible heat loss, decreased oxygen consumption, and increased panting rates (Sykes and Fataftah, 1986a).

The mechanisms associated with the induction of thermotolerance by early-age temperature conditioning involve: 1) modulation of heat production through reducing in plasma triiodothyronine (T3) concentration; 2) hemodynamic changes (decrease in heart weight and hematocrit); 3) increase in sensible heat loss; and 4) pronounced ability to control the body water economy during thermal challenge (Yahav and Plavnik, 1999). Also, from the result of experiment 4 and 5 indicated that, the optimum period of exposure to heat during rearing period to induce heat tolerance in quail lies between 4 to 5 weeks of age.

The temperatures of the leg increased gradually with time to reach a maximum after (5-7 min) from the test. After that they remained relatively constant. This result indicate that, increase unfeathered skin temperatures during heat stress, may be increase of skin blood flow in order to increase in heat loss by skin and dissipation the stored heat from unfeathered skin is very important (Zhou *et al.,* 1996).

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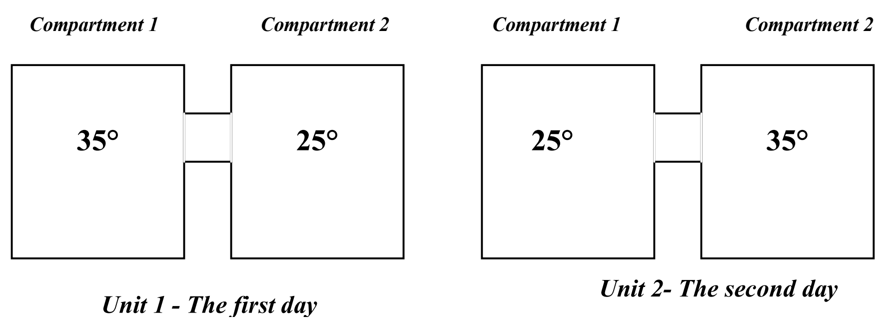

Figure 1. The two double-caged systems used for the temperature preference test.

Table 1. Basic behavioral activities (%) in the brooding cage in birds from both quail lines during the rearing phase with respect to rearing temperature (across 5 weeks, means ± SE)

Line	Activity	Brooding period (weeks) at 35°C			
		(Control) 2	3	4	5
Light	Standing	40.6±1.59[a]	40.3±1.67[a]	29.4±1.43[b]	30.4±1.30[b]
	Sitting	39.1±1.97[c]	45.5±1.99[b]	54.7±1.91[a]	54.8±1.48[a]
	Walking	20.3±1.36[a]	14.2±1.05[b]	15.9±1.43[b]	14.8±1.13[b]
Heavy	Standing	43.6±2.21[a]	36.5±1.71[b]	37.9±1.54[b]	28.9±1.52[c]
	Sitting	41.7±2.34[c]	50.5±2.11[b]	51.0±1.85[b]	63.8±1.34[a]
	Walking	14.7±1.26[a]	13.0±1.24[ab]	11.1±0.94[b]	7.3± 0.61[c]

[a,b,c] Means in a row with no common superscript differ significantly ($P \leq 0.05$).

Table 2. Additional behavioral activities (%) in the brooding cage in birds from both quail lines during the rearing period at different rearing temperature (across 5 weeks, means ± SE)

Line	Activity	Brooding period (weeks) at 35°C			
		(Control) 2	3	4	5
Light	Preening	17.5±1.12^{a}	14.5±1.14^{b}	10.4±0.71^{c}	10.7±0.61^{c}
	Feeding	10.6±0.71^{a}	11.8±0.86^{a}	6.7±0.61^{b}	6.1±0.46^{b}
	Drinking	2.2±0.33	2.9±0.34	2.1±0.28	2.4±0.23
Heavy	Preening	11.7±1.21^{a}	8.9±0.84^{b}	10.7±0.86^{a}	8.9±0.66^{b}
	Feeding	13.5±1.13^{a}	10.8±1.21^{b}	10.4±0.73^{b}	6.2±0.46^{c}
	Drinking	3.6±0.46	3.2±0.47	3.9±0.42	3.6±0.42

^{a,b,c} Means in a row with no common superscript differ significantly ($P \leq 0.05$).

Table 3. Preferred ambient temperature (%) in the two quail lines with respect to rearing temperature at 10 weeks of age (means ± SE)

Line	Preferred ambient temp.	Brooding period (weeks) at 35°C			
		(Control) 2	3	4	5
Light	25°C	64.3±0.04^{b}	65.7±0.03^{b}	62.7±0.04^{b}	84.3±0.05^{a}
	35°C	35.7±0.04^{a}	34.4±0.01^{a}	37.3±0.03^{a}	15.7±0.03^{b}
Heavy	25°C	78.0±0.08	82.3±0.03	89.3±0.02	89.7±0.01
	35°C	22.0±0.08	17.7±0.03	10.7±0.02	10.3±0.01

^{a,b,c} Means in a row with no common superscript differ significantly ($P \leq 0.05$).

Table 4. Rectal temperatures (°C) of female quail from the light and heavy lines in relation to short-term heat stress (across 30 minutes) at 18 weeks of age as affected by rearing temperatures (means ± SE)

Traits	Line	Brooding period (weeks) at 35°C				Overall
		(Control) 2	3	4	5	
RTB [1]	Light	42.00±0.06^{ab}	41.61±0.05^{bc}	41.46±0.03^{c}	42.23±0.04^{a}	41.83±0.05^{B}
	Heavy	42.80±0.03^{a}	41.77±0.03^{b}	42.00±0.03^{ab}	42.37±0.04^{a}	42.28±0.03^{A}
	Overall	42.40±0.06^{a}	41.69±0.04^{b}	41.83±0.04^{b}	42.31±0.04^{a}	
RTA [2]	Light	42.70±0.03^{a}	42.46±0.04^{ab}	42.15±0.04^{b}	42.62±0.04^{a}	42.48±0.04^{B}
	Heavy	43.60±0.03^{a}	42.44±0.04^{c}	42.80±0.03^{bc}	43.00±0.05^{ab}	42.96±0.04^{A}
	Overall	43.15±0.04^{a}	42.45±0.04^{b}	42.47±0.04^{b}	42.81±0.03^{ab}	
RTD [3]	Light	0.70±0.04^{ab}	0.85±0.05^{a}	0.69±0.05^{ab}	0.38±0.04^{b}	0.66±0.04
	Heavy	0.80±0.03	0.66±0.04	0.60±0.03	0.63±0.04	0.67±0.03
	Overall	0.75±0.03	0.76±0.03	0.65±0.05	0.51±0.03	

[1]Rectal temperatures before heat stress. [2] Rectal temperatures after heat stress. [3] Differences between RTA and RTB.
$^{a, b}$ Means in a row with no common superscript differ significantly ($P \leq 0.05$). ^{A,B} Means between lines within trait with no common superscript differ significantly ($P \leq 0.05$).

Table 5. Leg temperatures (°C) in females from light and heavy quail lines in relation to short-term heat stress (across 30 minutes) at 18 weeks of age as affected by rearing temperatures (means ± SE)

Line	Brooding period (weeks) at 35°C				Overall
	(Control) 2	3	4	5	
Light	36.89±0.05^{b}	36.95±0.04^{b}	37.58±0.03^{a}	37.32±0.03^{ab}	37.18±0.04
Heavy	37.40±0.03^{a}	37.82±0.03^{a}	37.82±0.02^{a}	36.78±0.04^{b}	37.43±0.04
Overall	37.14±0.04^{b}	37.38±0.05^{ab}	37.65±0.02^{a}	37.05±0.04^{b}	

$^{a, b}$ Means in a row with no common superscript differ significantly ($P \leq 0.05$).

Table 6. Latency until panting (min) in females from the light and heavy quail lines with respect to short-term heat stress (across 30 minutes) at 18 weeks of age as affected by rearing temperatures (means ± SE)

Line	Brooding period (weeks) at 35°C				Overall
	(Control) 2	3	4	5	
Light	6.49±0.02[b]	10.25±0.01[a]	8.01±0.01[a]	9.21±0.01[a]	8.39±0.02[A]
Heavy	4.08±0.02[b]	4.09±0.01[b]	5.11±0.01[ab]	8.23±0.01[a]	5.28±0.01[B]
Overall	5.48±0.02[b]	7.11±0.02[ab]	6.36±0.01[b]	8.41±0.01[a]	

[a, b] Means in a row with no common superscript differ significantly ($P \leq 0.05$).
[A,B] Means in a column with no common superscript differ significantly ($P \leq 0.05$).

الإستجابة السلوكية لخطين من السمان اليابانى مختلفين فى وزن الجسم للإجهاد الحرارى

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أستهدفت هذه التجربة دراسة تأثير درجات الحرارة المختلفة خلال فترة الحضانة على مدى التحمل الحرارى وكذلك الإستجابة السلوكية لخطين من السمان اليابانى مختلفين فى وزن الجسم للإجهاد الحرارى. استخدم فى هذه التجربة ١٩٢ كتكوت عمر يوم من كل من خطى السمان اليابانى, حيث وزعت عشوائيا على ثمانى مجاميع تجريبية. كل خط قسم إلى أربعة مجاميع تجريبية وفقا إلى مدة التعرض للحرارة العالية (٢ أو ٣ أو ٤ أو٥ أسبوع من الفقس على درجة حرارة ٣٥°م ثم ٢٥°م بعد ذلك).

ويمكن تلخيص أهم النتائج فيما يلى:

١ـ أظهرت النتائج أن للإجهاد الحراري تأثيراً معنويا على سلوك الطيور خلال الأسابيع الأولى من العمر حيث زادت نسبة الطيور الراقدة وقلت نسبة الطيور الواقفة والمتحركة وكذلك معدل استهلاك الغذاء.

٢ـ أوضحت النتائج أن معاملة الكتاكيت حراريا خلال فترة الحضانة أدت إلى زيادة معدل التحمل الحراري لدى الطيور فى أعمار متأخرة.

٣ـ أظهرت النتائج أن السلالة خفيفة الوزن تميزت بنشاط وبقدرة تحمل حرارى أعلى من السلالة ثقيلة الوزن عند التعرض للإجهاد الحرارى.

نتائج هذه الدراسة تساهم بمفاهيم جديدة و هامه لفهم جيد لعمليات التنظيم الحرارى فى طيور السمان اليابانى مما يساعد فى تطوير أنظمة الإسكان والإنتاج فى المساكن الحديثة والتى تتلائم مع الظروف المناخية التى تؤدى إلى الإجهاد الحرارى فى الطيور كما هو الحال فى مصر.