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PERFORMANCE, BEHAVIOUR, CARCASS TRAITS AND BLOOD CONSTITUENTS OF JAPANESE QUAILS REARED UNDER HEAT STRESS

(With 6 Tables)

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الاداء الانتاجى والسلوكى وخصائص الذبيحة ومكونات الدم للسمان المربى تحت الاجهاد الحرارى

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اجريت هذه الدراسة على عدد 300 من كتاكيت السمان عند عمر يوم تم تربيتها فى بطاريات تحت الظروف البيئية الطبيعية. بدأت مرحلة التربية تحت درجة حرارة 37 ثم تم خفضها تدريجيا بمغدل ثلاث درجات اسبوعيا حتى عمر 28 يوما ثم قسمت الطيور عشوائيا الى 5 مجموعات متساوية كل منها تحتوى على 4 تكرارات وذلك لدراسة تاثير الاجهاد الحرارى على الأداء الانتاجى والسلوكى وخصائص الذبيحة وبعض مكونات الدم. تعرضت المجموعات الخمس خلال الاسبوعين الخامس والسادس لدرجات حرارة 22 و29 و34 و36 و40 على التوالى. تم تغذية الطيور خلال فترة التجربة على عليقة تحتوى على 24 % بروتين خام و 2.8 ميجاكلورى طاقة ممثلة. أثبتت النتائج ان هناك تناقص طردى فى كل من وزن الجسم وكمية الاكل ومعدل التحويل الغذائى مع زيادة درجة الحرارة. كما وجد تاثير معنوى للاجهاد الحرارى على سلوكيات تناول الاكل والسلوك الاجتماعى وسلوكيات الحركة والنقر غير العدائى. لوحظ ان نسب التصافى والكبد والقونصة انخفضت معنويا بينما ارتفعت نسبة وزن القلب مع زيادة درجة الحرارة. كما وجد ان الاجهاد الحرارى قد اثر معنويا على قياسات الدم التى تم تعيينها وقد خلصت النتائج الى ان الاجهاد الحرارى له اثر سئ على كفاءة اداء السمان وان درجة الحرارة 22 درجة مئوية هى الدرجة المثلى.

SUMMARY

Three hundred of one day old Japanese quail chicks were housed in battery cages and kept under similar environmental and managerial conditions. During raising period the temperature was set initially at 37 ºC and gradually reduced at a rate of 3 ºC/week until 28th days old was reached. At that time, birds were randomly distributed into five groups (60 chicks each) with four replicates (15 chicks each) to examine the effect of heat stress on performance, behaviour, carcass traits and some blood constituents. The five groups were reared for 15 days (5th and 6th week) at 22, 29, 34, 36 and 40 ºC respectively. Diet was formulated to contain approximately 24 % CP and 2.8 Mcal ME/Kg as recommended by NRC, (1994). The birds were fed ad-libitum on the mash diet and given free access to fresh and clean water. The results indicated that, there was a linear decrease in body weight gain, feed intake and feed conversion with increased environmental temperature. Heat stress significantly ($p<0.05$) affect the ingestive, social, locomotor and non aggressive pecking behaviour of the experimented quails. Dressing %, liver and gizzard weights were significantly ($p<0.05$) decreased, while, heart % was significantly increased with increasing the environmental temperature. The results also indicated that, the estimated blood parameters were affected significantly ($p<0.05$) by heat stress. It could be concluded that, heat stress affects the quail performance and the optimum obtained at 22 ºC.

Key words: *Quails, Performance, behaviour, blood constituents, heat stress*

INTRODUCTION

The lower tolerance of birds to heat stress in hot climate is a major limiting factor and a big problem for birds reared in tropic and subtropic regions. High ambient temperature in Egypt during summer generates a status of stress and evokes a combination of behavioral, biochemical, immunological and physiological changes (Faisal *et al.*, 2008).

Heat stress has detrimental effects on the performance of broilers reared in the open- sided poultry houses; principally through reducing feed intake, growth rate, feed efficiency and carcass quality as well as health (Har *et al.,* 2000). In addition, prolonged periods of elevated ambient temperature increase the time to reach market weight and increase mortality (Howlider and Rose, 1989). May and Lott (1992) and Mashaly *et al.* (2004) reported that, the main consequence of heat stress is the reduction in feed intake as a trial from the bird to reduce metabolic heat production.

Heat stress not only adversely affects production performance but also inhibits immune function and causes a reduction in antibody production in young chicks (Zulkifli *et al.*, 2000). The thyroid hormones T_3 and T_4 are primarily involved in energy production by increasing the metabolic rate. This increase in energy production is to the greatest extent manifested as heat production. The importance of these iodine-containing hormones to the growth and development of organisms is most visible in deficient animals that exhibit stunted growth and lower productivity. Since the production of broilers in the poultry industry lasts only 42 days, one would expect that thyroid hormones should play a vital role during this process (Stojevic *et al.,* 2000). Heat stress is associated with low plasma T_3 concentrations (Yahav and McMurty, 2001), high H/L ratio (Altan *et al.,* 2000a and Gharib *et al.,* 2005) and release of corticosterone and catecholamines (Richards, 1997). The present work aimed to study the performance, behaviour, carcass characteristics and some blood parameters in Japanese quails reared under heat stress.

MATERIALS and METHODS

Birds, housing and feeding three hundred of one day old Japanese quail chicks were housed in battery cages and kept under similar environmental and managerial conditions. During raising period the temperature was set initially at 37 ºC and gradually reduced at a rate of 3 ºC/week until 28th days old was reached. At that time, birds were randomly distributed into five groups (60 chicks each) with four replicates (15 chicks each). The five groups were reared for 15 days (5th and 6th week) at 22, 29, 34, 36 and 40 ºC respectively.

Diet was formulated to contain approximately 24 % CP and 2.8 Mcal ME/Kg as recommended by NRC, (1994). The birds were fed ad-libitum on the mash diet and given free access to fresh and clean water. The composition and metabolizable energy value of the diet are shown in Table 1.

Chemical composition and energy value

Table 1: Composition and energy value of the experimental diet

Physical composition, %	
Yellow corn, ground	49.6
Soya bean meal	45.0
Dried fat	2.20
Lime stone,ground	1.0
Dicalcium phosphate	1.6
Common salt	0.25
Premix*	0.22
Methionine	0.13

CP %	24.08
EE %	3.47
CF %	4.24
Ca %	0.87
TP %	0.73
Methionine %	0.50
Lysine %	1.34
ME, mcal/kg	2.83

* Each Kg of premix contained vit. A 8.000.000 IU; vit. D_3 1.600.000 IU; vit. E 7 mg; vit. K_3 1.5 mg ; vit. B_1 1.0 mg ; vit. B_2 3.5 mg; vit. B_6 1.0 mg; vit. B_{12} 10.0 mg; Nicotinic acid 20.0 mg; Pantothenic acid 7.0 mg; Folic acid 1.000.000 IU; Biotin 40.000 IU; Choline chloride 350.0 mg; Mn 40.0 mg; I 0.3 mg; Co 0.75 mg; Zn 40.0 mg; Cu 3.0 mg; Fe 25.0 mg; Se 0.1 mg; Ethoxyquin 5.0 mg and Ascorbic acid 500 mg.

Quail performance:

Live body weight (g) and feed intake (g) of quails were recorded at the start and then weekly during the period of heat stress (28-42 days old). Body weight gain (g) and feed conversion ratio (g feed/ g gain) were also calculated.

Behavioural observations:

Twenty birds from each group (5 from each replicate) were randomly selected and marked with paint. The behaviour of the marked birds was recorded using video tape recorder for three hours daily (7.00-8.00 am, 11.00-12.00 am and 3.00-4.00 pm) during the second week of heat stress. Behaviour of the experimented birds was recorded and analyzed according to the recommendations of Lee and Craig (1990) and Mahrous (1993). Behavioural observations included ingestive behaviour (feeding and drinking), social behaviour (agonistic acts and vocalization), movement activities (standing, walking and running) and non aggressive picking (trough, feather and wall picking).

Carcass characteristics

At the end of the experiment, 14 birds (7 males + 7 females) from each group were randomly taken. Birds were individually weighed and slaughtered by severing the carotid artery and jugular veins. After four minutes of bleeding, each bird was dipped in a water bath for two minutes and feathers were removed by hand. After the removal of head, carcasses were manually eviscerated to determine some carcass traits including dressing % (eviscerated carcass without head, neck and legs) and giblets % (gizzard, liver and heart). Heart, empty gizzard and liver weights were expressed as relative weight proportionate to pre-slaughter live body weight. Dressing % was calculated according to Batta (2004) as following:-

$$\text{Dressing \%} = \frac{\text{Eviscerated carcass weight + giblets (heart, empty gizzard and liver) weight}}{\text{Live body weight at slaughter}} \times 100$$

Blood parameters:

Blood samples were collected from the slaughtered birds of each treatment in heparinized test tubes to determine the hematological parameters. Moreover, other blood samples were collected in test tubes without anti coagulant, allotted to clot at ambient temperature, centrifuged for 15 minutes at 3000 rpm and then extracted. The serum samples were kept at -20 ^{0}C until biochemical parameters were measured. Blood haemoglobin (Hb %) was assayed by a colorimetric method using a commercial kit. Packed cell volume (PCV) was estimated according to the recommendations of Sahin *et al.* (2005). RBCS and WBCS counts were carried out according to Natt and Herrick (1952) using Natt and Herrick solution and methyl violet stain. Differential count of white blood cells and heterophil / lymphocyte ratio were carried out according to Gross and Siegel (1983) and Parga *et al.* (2001). Mean corpuscular hemoglobin, mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) were calculated using the formula reported by Mangrum (1975). Total serum proteins, albumin, calcium and inorganic phosphorus were estimated by Digital- VIS ultraviolet spectrophotometer using specific diagnostic kits. Serum globulin and Albumin: globulin (A/G) ratio were calculated. Serum T3, T4 and corticosterone were estimated by stat fax-2100 (Awareness technology, INC, USA) and commercial ELISA kits.

Statistical analysis:

The results were expressed as the mean ± SE. All data were analyzed using one way analysis of variances (ANOVA) followed by LSD TEST using Spss 11.0 statistical software (Spss, Inc, Chicago, IL,2001), www.Spss.com.

RESULTS

Results in tables 2-6 illustrate the effect of heat stress on quail performance, behaviour, carcass traits and some blood parameters.

DISCUSSION

Quail performance:

The results in Table 2 indicated that, there was no significant decrease in body weight with increasing environmental temperature from 22 ºC up to 36 ºC, while, there were only significant ($p<0.05$) differences between body weights of chicks kept under 22 and 40 ºC. These results are in agreement with that reported by Nadia (2003) and Faisal *et al.* (2008), who recorded no significant differences in body weight of Japanese quails that reared at (32^oC and 38^oC) and the control ones. The decrease in body weight during the high temperature may be attributed to the reduction in both feed consumption and true digestibility of protein and amino acids (Sritharet *et al.,* 2002).

The results claimed non significant ($p<0.05$) differences between birds reared at 22 and 29 ºC in both weeks of the experiment, while there was significant reduction in body weight gain in birds exposed to 34, 36 and 40 ºC as compared with those kept under 22 ºC. These results are in accordance with those of Sahin *et al.* (2006 b) who stated that, exposure to 34 ºC significantly decreased body weight and weight gain. The data of feed intake showed significant ($p<0.05$) differences among birds reared at 22, 34, 36 and 40 ºC during the 5^{th} week, while, during the 6^{th} week, the results showed non significant decrease in feed intake between birds kept under 22, 29, 34 and 36 ºC. However, only birds that reared at 40 ºC showed significant ($p<0.05$) lower feed intake. This may be explained by the finding of Leeson *et al.* (1992) who stated that, increased environmental temperature stimulates the peripheral thermal receptors to transmit suppressive nerve impulse to the appetite center in the hypothalamus causing a decrease in feed consumption. This result was consistent with the general trend observed in heat stressed broilers and quails by Nadia (2003), Garriga *et al.* (2005) and Sahin *et al.* (2006 a). Decreased feed intake can be explained by in high environmental temperature, energy consumption declines and consequently heat production reduced. Concerning feed conversion efficiency, the data indicated a non significant decline in feed conversion ratio with increasing environmental temperature. Similar results were obtained by Nadia (2003).

Behaviour

The data represented in Table 3 indicated that, birds reared at 34, 36 and 40^0C displayed significantly ($p<0.05$) less feeding frequencies than those reared at 22^0C.This result was consistent with the general trend observed in heat stressed birds by Nadia (2003) and Soleimani *et al.* (2008). Regarding to drinking behaviour, the data illustrated in Table 3 showed significant ($p<0.05$) increase in drinking frequency in quails exposed to 40^0C than those exposed to 22^0C. Similar results were obtained by Pereira *et al.* (2007 a) who mentioned that, when temperature increased, the birds remained longer at the drinker. The present findings indicated a significantly ($p<0.05$) higher agonistic frequency in quails reared at 34, 36 and 40^0C however, no significant differences were found between those reared at 34 and 36^0C. This finding may be related to increased secretion of corticosterone upon stress with a subsequent inhibiting effect on aggression as recorded by Leshner (1978) and Pereira *et al.* (2007 a).

Significant ($p<0.05$) increase in vocalization was observed in quails reared under 40^0C than 22^0C. Similar results were obtained by Moura *et al.* (2008) who found that, birds exposed to thermal comfort had a tendency to vocalize less. Significant decreased locomotor activities (Standing, walking and running frequencies) was also recorded as illustrated in Table 3, a result which is in line with the finding of Saiful *et al.* (2002). These results may be attributed to increase of resting behaviour of the birds to reduce heat generated by activities (Pereira *et al.,* 2007 a). The data in Table 3 also revealed that, heat stress had no effect on trough pecking and non edible objects pecking. This result was consistant with the general trend observed by Sihe and Jun (2008) who concluded that, heat stress had no effect on non edible object pecking. However, it was accompanied with a significant ($p<0.05$) increase in feather pecking frequency. Feather pecking was positively correlated with the plasma concentration of corticosterone (Pereira 2007 a).

Carcass traits

Sahin *et al.* (2001 b) found that, rearing Japanese quails under heat stress had no effect on carcass characteristics. A significant ($p<0.05$) decrease in dressing % was observed in birds reared at 34, 36 and 40^0C as shown in Table 4. These results are in accordance with those of Sahin *et al.* (2005 and 2006 b) who reported that, heat exposure decreased carcass yield %. The result can be attributed to elevated concentrations of glucocorticoids that exerts catabolic effect, decreases the rate of protein synthesis and thus resulted in muscle wasting and retardation in growth (Hayash *et al.,* 1994). Growth retardation is probably due to decreased muscle protein synthesis and elevated proteolysis in muscle. Also, the reduction in dressing % in the results could be attributed to the significant decrease in edible giblet %. The data also showed that, birds kept under heat stress had a significant ($p<0.05$) lower liver weight % than those reared at 22^0C. These results are in agreement with the work of (Abd El-Gawad *et al.,* 2008) who recorded that, heat exposure decreased the relative weight of liver. This can be explained as cardiovascular adjustement in response to heat include vasodilatation in the cutaneous vascular bed and vasoconstriction in hepato-splanchnic vascular area (Richardson *et al.,* 1991) leading to fatty and parenchymatus degeneration of the hepatocyte manifested by shrinkage in the liver size (Sritharet *et al.,* 2002). Regarding the heart weight of birds, the results indicated non significant increase with increasing the environmental temperature, while, there was only significant ($p<0.05$) increase in heart weight of birds kept under 40^0C. These results are in accordance with those of Abasiekong (1987) and Yahav *et al.* (1997) who reported linear relationship between haematocrit and heart weight under constant temperature. The results also indicated that, the gizzard weight % was significantly ($p<0.05$) lower at heat stress as compared with the control, however non significant differences were observed among groups reared under 34, 36 and 40^0C. These results are in agreement with the findings of Abd El-Gawad *et al.* (2008) who observed a non significant decreases in gizzard weight of heat stressed birds. On the contrary, Abasiekong (1987) showed that, birds reared at 35^0C had higher gizzard weight than those reared at 23^0C.

Blood parameters

A significant ($p<0.05$) decrease in RBCs and WBCs count, as well as PCV% is shown in Table 5. These results are in agreement with the finding of Nadia (2003). The decrease in RBCs count may be due to the inhibition effect of heat stress on the life span of the present RBCs as well as on the production of new RBCs from the bone marrow. However, the decrease in WBCs count may be related to the atrophy of the lymphoid organs as their weights were reduced by heat stress. This may be due to the reduction of feed intake and thereby, providing less nutrients for proper development of these organs (Smith 1993) and an increase in plasma corticosterone which subsequently depress the activities of the lymphoid organs and total leukocytic counts as proved by Gross *et al.,* 1980. The reduction in haematocrit (PCV%) in heat stressed birds can be attributed to haemodilution (Deyhim and Teeter 1991). The data also illustrated that, there was indirect relation between the degree of temperature and the decrease in Hb concentration, MCH and MCHC of heat stressed quails, however, only MCV had significant ($p<0.05$) increase in birds reared at 40^0C. This result was agreed with that of Nadia (2003) who reported that, heat stress leads to a decrease in Hb concentration, MCH and MCHC of the blood. The data demonstrated in Table (5) showed a significant ($p<0.05$) increase in heterophil % and a significant decrease in lymphocyte % in the blood of heat stressed birds. These results are in accordance with those of Faisal *et al.* (2008) and Nadia (2003) for heterophil and lymphocyte %, respectively. The obtained results showed a significant ($p<0.05$) increase in esinophil, monocyte and basophil percentages in birds exposed to heat stress. These results are in agreement with that reported by the same authors.

The results in Table 6 indicated a significant ($p<0.05$) decrease in serum calcium and phosphorus levels in birds exposed to 29 ^{0}C, 34 ^{0}C, 36 ^{0}C and 40 ^{0}C in comparison with birds exposed to 22 ^{0}C. Similar results were obtained by Nadia (2003) and Ozcelik and Ozbey (2004) as they reported that, serum calcium and phosphorus in Japanese quail chicks exposed to high temperature (35 ^{0}C) were significantly reduced. On the contrary, (Mujabid *et al.*, 2009) mentioned that, no significant differences were observed in blood calcium levels. The obtained results can be explained by the consequence of the significant decrease in feed intake (calcium and phosphorus intake), in birds reared under 25^{0}C and 34^{0}C (Rama Rae *et al.*, 2002). Moreover, Belay and teeter (1996) indicated that, heat stress exposure elevated urinary calcium and phosphorus as a result of increased urinary flow rate and osmolar excretion.

Birds exposed to 34^{0}C, 36^{0}C and 40^{0}C recorded significant decrease in serum total protein while, there was non significant increase in total protein of the birds reared at 29^{0}C compared to the control. This result was consistent with the general trend in Japanese quails by Nadia (2003), Ferit *et al.* (2004) and Ozcelik and Ozbey (2004). The reduction in total protein during the heat stress may be due to reduced protein synthesis (Hamoud *et al.*, 1993). Serum albumen, globulin and Alb/Glob ratio were significantly decreased in birds reared at 29, 34, 36 and 40^{0}C in comparison with those reared at 22^{0}C. Similar results were obtained in Japanese quails exposed to 34 and 35^{0}C by Nadia (2003) and Faisal *et al.* (2008) they suggested that, the result could be due to reducing the amount of protein consumed and consequently deficiency of essential amino acids as a result of the decreased amount of feed consumed by the experimental chicks.

Table 6 illustrated a significant decrease ($p<0.05$) in serum triiodothyronine (T_3) and Thyroxine (T_4) in birds exposed to 29, 34, 36 and 40^{0}C in comparison with those reared at 22^{0}C. These results are in agreement with those of Nadia (2003), Garriga *et al.* (2005) who mentioned that, heat stress induces significant reduction in circulating T_3 concentration, as heat stress stimulates the hypothalamus to lower the level of thyroid releasing hormone (Sturkei, 1986). The results in Table 6 also showed a significant increase ($p<0.05$) in serum corticosterone level in birds exposed to 29, 34, 36 and 40^0C in comparison with birds exposed to 22^0C. A corresponding results were obtained by Nadia (2003) and Sahin *et al.* (2001 b) who reported that, heat stress tended to elevate corticosterone concentration in Japanese quails.

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Table 2: Effect of heat stress on performance characteristics of quail

Item	body weight at the end of 4th week	body weight at the end of 5th week	Body weight at the end of 6th week	Body weight gain of the 5th week	Body weight gain of the 6th week	Feed intake of the 5th week g /bird / week	Feed intake of the 6th week g/bird /week	Feed conversion of the 5th week	Feed conversion of the 6th week
22ºC	107.96 ± 3.252	151.57[a] ± 3.593	187.78[a] ± 4.415	43.61[a] ± 0.629	36.21[a] ± 1.413	143.98[a] ± 7.160	157.76[a] ± 10.779	3.31 ± 0.189	4.38 ± 0.349
29 ºC	106.62 ± 2.266	148.48[ab] ± 2.586	181.67[ab] ± 2.715	41.86[a] ± 0.801	33.20[a] ± 1.043	141.65[a] ± 4.362	149.03[a] ± 6.768	3.39 ± 0.146	4.55 ± 0.412
34 ºC	109.98 ± 1.957	144.26[ab] ± 2.542	174.10[b] ± 2.700	34.27[b] ± 0.901	29.84[b] ± 1.085	126.71[b] ± 3.511	143.81[ab] ± 8.817	3.72 ± 0.214	4.83 ± 0.265
36 ºC	110.59 ± 3.016	143.82[ab] ± 3.291	172.24[bc] ± 3.511	33.23[b] ± 0.927	28.42[b] ± 1.268	124.16[b] ± 2.977	139.68[ab] ± 4.179	3.75 ± 0.173	4.95 ± 0.205
40 ºC	111.45 ± 3.026	140.95[b] ± 2.293	164.64[c] ± 2.648	29.50[c] ± 0.909	23.69[c] ± 1.137	114.17[b] ± 1.59	123.33[b] ± 2.575	3.88 ± 0.122	5.27 ± 0.369

Means within the same column with different superscripts are significantly different ($P < 0.05$).

Table 3: Effect of heat stress on the behavioural patterns (no/hour) of quails

Item	Feeding intake frequency	Water intake frequency	Agonistic behaviour frequency	Vocalization frequency	Standing frequency	Walking frequency	running frequency	Trough pecking	Feather pecking	Wall and ground pecking
22ºC	10.27^{a} ± 0.728	4.69^{b} ± 0.271	1.31^{a} ± 0.223	1.79^{c} ± 0.181	6.88^{a} ± 0.24	21.66^{a} ± 0.93	4.06^{a} ± 0.24	0.84 ± 0.092	1.60^{c} ± 0.145	2.37^{ab} ± 0.133
29 ºC	8.53^{ab} ± 0.650	4.80^{b} ± 0.210	1.27^{a} ± 0.226	1.97^{bc} ± 0.219	5.89^{b} ± 0.23	18.87^{ab} ± 0.67	3.09^{ab} ± 0.19	0.85 ± 0.116	2.05^{bc} ± 0.163	2.34^{a} ± 0.159
34 ºC	7.16^{b} ± 0.590	5.06^{ab} ± 0.324	0.52^{b} ± 0.128	2.29^{bc} ± 0.322	4.88^{c} ± 0.20	18.09^{ab} ± 0.71	2.81^{abc} ± 0.18	1.04 ± 0.158	2.30^{b} ± 0.191	2.62^{ab} ± 0.139
36 ºC	6.71^{b} ± 0.673	5.94^{ab} ± 0.381	0.42^{b} ± 0.137	2.42^{c} ± 0.334	4.31^{cd} ± 0.33	15.78^{ab} ± 0.66	2.37^{bc} ± 0.14	1.00 ± 0.072	2.39^{b} ± 0.199	2.05^{ab} ± 0.144
40 ºC	6.39^{b} ± 0.525	6.38^{a} ± 0.255	0.19^{c} ± 0.101	3.09^{a} ± 0.299	3.83^{d} ± 0.26	12.67^{b} ± 0.52	1.61^{c} ± 0.13	1.02 ± 0.098	3.25^{a} ± 0.177	1.90^{b} ± 0.172

Means within the same column with different superscripts are significantly different ($P < 0.05$).

Table 4: Effect of heat stress on carcass characteristics of quails

Item	Live body weight (gm)	Eviscerated carcass weight %	Dressing %	Liver %	Heart %	Gizzard %
22ºC	194.90[a] ± 6.213	68.42 ± 0.598	74.84[a] ± 0.621	3.04[a] ± 0.111	0.90[b] ± 0.034	2.48[a] ± 0.104
29 ºC	184.66[ab] ± 6.085	67.47 ± 0.785	73.12[ab] ± 0.799	2.54[b] ± 0.157	0.91[b] ± 0.029	2.20[b] ± 0.110
34 ºC	183.20[ab] ± 7.082	66.92 ± 0.813	71.74[b] ± 0.796	1.97[c] ± 0.075	0.96[b] ± 0.033	1.89[c] ± 0.089
36 ºC	182.65[ab] ± 4.318	66.18 ± 1.751	70.70[b] ± 1.782	1.71[c] ± 0.127	1.03[ab] ± 0.036	1.78[c] ± 0.089
40 ºC	178.62[b] ± 3.769	66.62 ± 0.725	71.16[b] ± 0.746	1.77[c] ± 0.090	1.06[a] ± 0.028	1.72[c] ± 0.086

Means within the same column with different superscripts are significantly different ($P < 0.05$).

Table 5: Effect of heat stress on blood haematological parameters of quails

Item	RBCS X 10^6	WBCS X 10^3	PCV %	Hb conc. (g / dl)	MCH (pg)	MCV (mm)	MCHC (%)	Heterophil %	Lymphocyte %	H /L ratio	Esinophil %	Monocyte %	Basiophil %
22ºC	3.60^{a} ± 0.120	22.88^{a} ± 0.174	48.90^{a} ± 0.900	16.02^{a} ± 0.58	44.48^{a} ± 0.69	136.71^{b} ± 4.04	32.81^{a} ± 1.13	19.69^{c} ± 0.55	73.81^{a} ± 1.49	0.27^{d} ± 0.009	4.44^{d} ± 0.32	1.42^{c} ± 0.15	0.69^{c} ± 0.12
29 ºC	3.29^{a} ± 0.171	20.65^{b} ± 0.361	45.70^{b} ± 0.423	13.72^{b} ± 0.63	41.92^{ab} ± 0.96	140.16^{ab} ± 5.23	30.20^{ab} ± 1.061	27.69^{b} ± 0.62	59.69^{b} ± 1.72	0.47^{c} ± 0.014	7.63^{c} ± 0.38	2.75^{b} ± 0.31	1.75^{b} ± 0.23
34 ºC	3.21^{b} ± 0.130	20.53^{b} ± 0.283	45.20^{b} ± 0.680	13.14^{bc} ± 0.44	41.18^{bc} ± 1.04	142.66^{ab} ± 5.23	29.05^{b} ± 0.783	28.81^{b} ± 0.52	57.88^{c} ± 1.52	0.50^{c} ± 0.010	9.19^{b} ± 0.49	2.27^{b} ± 0.14	1.81^{b} ± 0.21
36 ºC	3.19^{b} ± 0.107	19.38^{b} ± 0.445	45.30^{b} ± 0.597	12.47^{bc} ± 0.52	39.08^{c} ± 0.82	147.47^{ab} ± 3.73	26.65^{bc} ± 0.830	33.69^{a} ± 0.87	53.38^{d} ± 1.66	0.63^{b} ± 0.023	8.50^{bc} ± 0.54	2.75^{b} ± 0.22	1.56^{b} ± 0.20
40 ºC	3.04^{b} ± 0.121	17.46^{c} ± 0.849	46.70^{b} ± 0.817	12.01^{c} ± 0.49	39.30^{bc} ± 1.18	151.85^{a} ± 4.87	26.25^{c} ± 0.931	33.94^{a} ± 0.68	46.13^{e} ± 1.74	0.74^{a} ± 0.022	10.56^{a} ± 0.57	6.07^{a} ± 0.38	2.69^{a} ± 0.25

Means within the same column with different superscripts are significantly different ($P < 0.05$).

Table 6: Effect of heat stress on blood biochemical parameters of quails

Item	Total proteins (g / dl)	Total Albumin (g / dl)	Total globulin (g / dl)	A /G ratio	Calcium (mg / dl)	Phosphorus (mg / dl)	Ca / ph ratio	T_3 (nmol / l)	T_4 (nmol / l)	Corticosterone (ng / ml)
22ºC	3.93[a] ± 0.164	2.12[a] ± 0.100	1.81[a] ± 0.078	1.18[b] ± 0.048	11.59[a] ± 0.16	7.84[a] ± 0.14	1.49[a] ± 0.044	1.93[a] ± 0.051	23.44[a] ± 0.621	10.61[d] ± 0.124
29 ºC	3.63[ab] ± 0.184	2.07[a] ± 0.130	1.56[b] ± 0.085	1.36[ab] ± 0.097	10.05[b] ± 0.27	6.91[b] ± 0.19	1.44[ab] ± 0.049	1.83[b] ± 0.031	23.88[a] ± 0.683	12.32[d] ± 0.191
34 ºC	3.37[bc] ± 0.151	1.97[ab] ± 0.095	1.39[bc] ± 0.061	1.42[a] ± 0.039	8.91[c] ± 0.25	6.40[c] ± 0.16	1.41[ab] ± 0.055	1.48[c] ± 0.041	20.69[b] ± 0.514	15.41[c] ± 0.371
36 ºC	3.10[cd] ± 0.143	1.70[bc] ± 0.094	1.39[bc] ± 0.065	1.24[ab] ± 0.074	7.82[d] ± 0.17	5.88[d] ± 0.13	1.34[b] ± 0.050	1.16[d] ± 0.026	19.94[b] ± 0.576	17.20[b] ± 0.304
40 ºC	2.81[d] ± 0.162	1.56[c] ± 0.107	1.25[c] ± 0.059	1.23[b] ± 0.055	7.30[d] ± 0.17	5.64[d] ± 0.16	1.31[b] ± 0.053	1.22[d] ± 0.020	16.81[c] ± 0.463	23.39[a] ± 1.290

Means within the same column with different superscripts are significantly different ($P < 0.05$).