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Effect of thermal stress on fertility and egg quality of Japanese quail

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ABSTRACT

Heat stress is one of the major causes of a decreased performance of laying quail in tropical and subtropical countries. The aim of this study was to investigate the impact of temperature humidity index (THI) on fertility aspects, external and internal egg quality parameters in Japanese quail. One hundred and forty four (144) Japanese quail, 12 of weeks age, were used. Birds were divided randomly into three equal groups, control (at low THI, lower than 70), H_1 (at moderate THI, 70–75) and H_2 (at high THI, 76–80). Quail in the control and H_1 groups had significant greater fertility ($p=0.021$) and hatchability % ($p=0.037$), compared with H_2 group. Quail in the control group (at low THI) laid heavier egg weight with a higher external (egg weight ($p=0.03$), shell thickness, shell weight, eggshell ratio and eggshell density ($p=0.001$)) and internal egg quality score (albumin weight ($p=0.026$), yolk height ($p=0.003$), yolk index ($p=0.039$) and Haugh unit ($p=0.001$)). Otherwise, such quality traits were compromised in heat-stressed quail. At the high THI level, egg weight had a significant positive correlation with albumin weight ($r=0.58$, $p<0.01$), yolk weight ($r=0.22$, $p<0.05$), albumen ratio ($r=0.17$, $p<0.05$), yolk height ($r=0.14$, $p<0.05$) and yolk index ($r=0.18$, $p<0.05$), but was negatively correlated with yolk ratio ($r=-0.15$, $p<0.05$). Japanese quail exposed to heat stress (THI over 75) revealed drop in fertility indices and egg quality traits, indicating a detrimental policy of economic income.

1. Introduction

Japanese quail (Coturnix japonica) is a domestic bird of economic importance for commercial egg and meat production in Egypt. The birds are hardy, resist disease, and require lower space and equipment utility (Minvielle, 2004). Japanese quail are considered the smallest avian species raised in farms, used for research purposes (Panda and Singh, 1990) and raised for meat and egg production (Punya Kumaril et al., 2008). In European countries, they are reared mainly for meat in contrast to Asian countries that consider them dual-purpose (Minvielle, 1998).

Overall egg quality is crucial for both poultry breeders and consumers. Poor egg quality results in major economic losses to the globalized egg industry, such as losses attributed to poor eggshell quality, which calculated to be in the order of 6–8% (Baylan et al., 2011). Measurements of egg quality can be assigned into two main divisions: external and internal traits (Song et al., 2000). External qualities such as egg weight and shell condition are significant for consumer's acceptability (Wolanski et al., 2007), while the interior parameters are fundamental for the egg production industry (Song et al., 2000). The primary interior quality trait is thick albumin, considered an important criterion for egg freshness (Toussant and Latshaw, 1999). Eggs distinguished by a superior yolk index and Haugh unit are preferable (Ayorinde, 1987).

All homeothermal animals including birds maintain a constant internal body temperature. According to thermodynamic basics, animals regularly exchange heat with the surrounding environment, but this mechanism is exactly efficient at the animal's thermoneutral range of environmental temperatures (Hannas, 1999; El-Tarabany and El-Bayoumi, 2015). When environmental temperatures exceed the thermoneutral range, rectal temperature elevates, as well as respiratory rate, where panting is a mechanism used by birds to promote evaporative heat loss, thereby attempting to preserve body temperature (Silva et al., 2001). Thus, environmental temperature and humidity are substantial factors affecting egg production. Birds raised at environmental temperatures outside their thermoneutral zone may suffer severe physiological changes, including decreased feed intake, decreased feed efficiency and consequent drop in egg production and deteriorated egg quality, including light eggs, decreased yolk weight and percentage, and low specific gravity (Macari et al., 2004). To minimize these detrimental effects of thermal stress, many practical approaches have been suggested to enhance thermotolerance of birds, leading to minimize the adverse impacts on productivity (Del Vesco et al., 2014). Taking these facts into consideration, the aims of this trial were to elucidate the impact of temperature humidity index (THI) on egg quality traits in Japanese quail and

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estimate the correlations between external and internal egg quality traits.

2. Material and methods

2.1. Birds and management

All procedures included in this trial were approved in accordance with the guidelines belonging to the Committee of Animal Ethics (ANWD-206), based on Ethics and Animal Welfare Committee guidelines (ICLAS). One hundred and forty four (144) adult Japanese quail at 12 weeks of age were selected with a homogenous body weight (156.27 g ± 1.49) . The birds were identified by means of wing bands and were assigned randomly into three equal groups (48 birds in each). Each group comprised 4 replicates (12 birds in each), where the allowed floor spaces in the cage was 250 cm^2/bird. The actual measures of each flat deck cage were 60 (L) × 50 (W) × 37 (H) cm.

The groups were managed in experimental units provided with devices regulated to meet the required temperature and humidity for each experimental group, control [low temperature humidity index (THI), lower than 70; at 23.8 ± 0.7 °C and 58.5 ± 5.7% RH], H_1 (moderate THI, ranged 70–75; at 32.8 ± 0.8 °C and 57.7 ± 4.6% RH) and H_2 (high THI, ranged 76–80; at 35.8 ± 0.6 °C and 59.2 ± 4.5% RH). Each unit measures 2.5 × 3.5 × 2.5 m, provided with an electrical air heater (power of 2000 W), and an air humidifier (4.5 L capacity). The THI was calculated according to formula reported by Zulovich and DeShazer (1990) and modified by Bayhan et al. (2013). THI = 0.6 T_{db} + 0.4 T_{wb}, where T_{db} = dry-bulb temperature, °C; T_{wb} = wet-bulb temperature, °C. The temperature and relative humidity were adjusted using automated thermo-hygrometers. Throughout the period of experiment (6 weeks), birds in the H_1 and H_2 groups were exposed to controlled temperature and humidity for 8 h daily, beginning at 8 a.m. A standard layers mash (20.0% crude protein, 11,937 KJ/kg ME) was provided (Table 1). The lighting schedule was 15 h light: 9 h dark for the whole experimental period. One male: two females mating ratio was applied to ensure fertility aspects. Initial and end of the experiment body weights were determined using a standardized electronic balance (1202 MP, Sartorius, Germany). To record egg quality traits, random egg samples (n = 160/group; N = 480) were collected over 4 consecutive weeks. Carefully, eggs were labeled immediately after collection and the studied traits of egg quality were taken within 10 h of collection.

Table 1
Diet composition in the laying period.

	% diet
Ingredients	
Yellow corn	64.50
Soybean meal (44%)	20.50
Concentrate (52%)	10.00
Di- calcium phosphate	2.31
Limestone	0.96
DL- methionine	0.09
Lysine	0.08
Vitamin and trace mineral	0.30
Premix	1.06
Coccidostate	0.10
Antioxidant	0.10
Calculated analysis	
ME (KJ/kg)	11,937
Crude protein (cp %)	20.00
Calcium%	2.33
Available phosphorus%	0.66
Lysine %	1.04
Methionine %	0.52

2.2. Fertility indices

Eggs were labeled per experimental group and incubated in automatic incubator, with controlled humidity (60%) and temperature (37.6 °C) parameters. On the 15th day, incubated eggs were transferred to a hatching sector and after two days the hatched chicks were transferred to the rearing area. Unhatched eggs were opened to determine fertility and hatchability percentages. Fertility and hatchability indices over the experimental period (repeated in the form of four sequent batches at 15–18 weeks of age) were calculated. Fertility percentage was computed as the of number of fertile eggs divided by total number of eggs incubated. Hatchability percentage was calculated as the number of chicks hatched divided by total number of eggs incubated.

2.3. External egg quality traits

Egg weight was measured using an electronic balance (1202 MP, Sartorius, Germany) with accuracy ± 0.01 g. Egg width and egg length (mm) were calibrated using an electronic digital device with accuracy ± 0.001 mm. Egg shape index was computed as 100 × (egg width/egg length) according to Das et al. (2010). Eggshell thickness (mm) was calibrated via a standardized electronic digital device once the eggshell was dried at room temperature, taken as the average of estimates from both ends and the equator of the examined eggs (Das et al., 2010). Eggshell weight (g) was determined using a standardized Sartorius 1202 MP balance after the shell had been dried at room temperature. Eggshell ratio was computed as 100 × (shell weight/egg weight). The area of egg surface (cm^2) was estimated as $3.9782W^{0.7056}$, where W equal to egg weight (Sezer, 2007). Egg shell density was computed as shell weight (mg)/egg surface area (cm^2) (Vits et al., 2005).

2.4. Internal egg quality traits

After recording the external parameters, the estimates of internal quality components were recorded. Gently, breaking the egg was performed using a sharp scalpel and emptying the contents onto a glass surface. The albumin was gently separated from the yolk to weigh the yolk mass. The albumin mass was computed via subtracting the weights of shell plus yolk from the total egg weight. Regarding weighing process, the glass surface was washed and dried after each weighing. The yolk and albumin dimensions (mm) were estimated using an electronic device (Reddy et al., 1979). The following traits of the internal egg quality were achieved according to Romanoff and Romanoff (1949). Yolk index value was calculated as 100 × [Yolk height (cm)/Yolk diameter (cm)]. Yolk ratio was calculated as Yolk weight (g)/Egg weight (g) × 100. Albumin ratio was computed as 100 × [Albumin weight (g)/Egg weight (g)], and Haugh units (HU) were determined according to previous formula reported by Haugh (1937). HU equal 100 log $(H + 7.57 - 1.7W^{0.37})$, H: Albumin height (mm), W: Egg weight (g).

2.5. Statistical analysis

All statistical methods were applied using SAS statistical system Package V9.2 (SAS, 2002). After testing normality using Kolmogorov-Smirnov procedure, data were analyzed by means of one-way analysis of variance (*ANOVA*) through the applied general linear models (GLM) procedure. The MIXED model included the fixed effects of the treated groups (3 levels) and the random effects of replicates. The Duncan's multiple range test was performed to