Thermal Comfort Zones for Starter Meat-Type Quails

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ABSTRACT

The objective of this study was to determine thermal comfort ranges, as evaluated by air temperature and black-glove temperature and humidity index (BGTHI), for starter meat-type quails. Nine hundred quails were randomly distributed into five environmental chambers. Each chamber was programmed to provide different temperatures weekly. The following thermal environments were provided: SC – severe cold, MC – moderate cold, TC – recommended comfort environment, MH – moderate heat, and SH – severe heat. The best live performance was obtained when quails were submitted to temperatures of 36-39 °C and BGTHI of 87.1 ± 0.4 and 91.4 ± 0.6 during the first week of rearing. Temperatures of 27-30 °C and BGTHI of 75.8 ± 0.4 and 79.9 ± 0.6, during the second week, and temperature of 24 °C and BGTHI of 70.8 ± 0.5 during the third week of rearing.

INTRODUCTION

Brazil quail production increased 19.8% between 2010 and 2011, with 15,567 million birds. In Brazil, the quail flock in the mid-western region increased 34.4%, 19.6% in the southeastern region, and 9.2% in the northern region. On the other hand, the flock was reduced in 5.1% in the southern region, and in 2.2% in the northeastern region. The southeastern region houses 65.5% of the national flock, and the state of São Paulo 46.4%, recording an increase of 24% in 2011 relative to 2010 (IBGE, 2012).

Quails are susceptible to changes in environmental temperature. Poultry in general have a thermoregulatory center in the central nervous system. The hypothalamus works as a physiological thermostat, controlling heat production and dissipation through several mechanisms, such as changing skin blood flow, as well as heart and respiratory rates (Moro, 1995).

Brazil has relatively high annual average temperatures of around 25 °C. In some regions, maximum temperatures may reach 40 °C, which may be detrimental to quail production. In addition, almost all quail production houses do not have the required environmental conditions, and quails are negatively affected by cold, particularly in the winter, and hot temperatures. The growth of quail production in Brazil, therefore, requires better knowledge on the effects of environmental temperatures on the performance of quails, as there are few studies on the thermal environment of these birds in the country.

The objective of this study was to determine thermal comfort ranges, as evaluated by air temperature and black-globe temperature and humidity index (BGTHI), for meat-type quails (*Coturnix coturnix coturnix*) during the starter rearing phase (1-21 days of age).

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MATERIALS AND METHODS

The experiment was carried out in five environmental chambers, measuring 2.5 x 3.5 x 2.5 m, located in the Environment and Engineering of Agricultural System Research Center (Núcleo de Pesquisa em Ambiência e Engenharia de Sistemas Agroindustriais, AMBIAGRO) of Universidade Federal de Viçosa. Data were collected between January and February of 2012, totaling three experimental weeks (21 days).

Each environmental chamber was equipped with an electrical air heater (power of 2000 Watts), a hot/cold split air conditioner (1200 BTU/h), and an air humidifier (4.5 L capacity and average fog volume of 300 mL/h). An electronic temperature and humidity controller was used to control the heater and the humidifier.

In total, 900 one-day-old meat-type quails (*Coturnix coturnix coturnix)* of both sexes, with uniform body weight, and derived from the same breeder farm, were used. Quails were randomly distributed into the five environmental chambers, totaling 180 birds per treatment. Birds were distributed into five treatments, consisting of each environmental chamber providing different thermal environments, with six replicates (cages) of 30 birds each. Cages were 1.0-m wide x 0.5-m deep x 0.5-m high (0.5 m²) with a capacity of 166.6 cm²/bird.

Studies have demonstrated that the thermal requirements of domestic poultry change as they grow, and based on this assumption, five different thermal condition ranges were defined for the three first week of life of the quails. One of these ranges was the thermal comfort range, as suggested by Albino & Neme (1998), and the other four ranges were divided in two cold stress (moderate and severe) and two heat stress (moderate and severe) environments. Table 1 shows the different temperatures applied in each of these environments.

Table 1 – Thermal environments (treatments) applied during the three first rearing weeks.

Treatments	Temperature °C week 1	Temperature °C week 2	Temperature °C week 3
Severe cold (SC)	30	27	24
Moderate cold (MC)	33	30	27
Thermal comfort (TC)	36	33	30
Moderate heat (MH)	39	36	33
Severe heat (SH)	42	39	36

Air relative humidity was maintained at 55% (± 5%) during the entire experimental period in all treatments, as recommended by Tinôco (2004) and Medeiros (2005). Temperature and relative humidity values were maintained constant during the entire experimental period, i.e., 24 h daily.

Birds were fed a starter diet, as recommended by Silva & Costa (2009). Feed composition and feedstuff nutritional values used for feed formulation were determined according to Rostagno *et al*. (2011). All birds received the same feed supplied *ad libitum*. Feed was supplied at 08:00 and 16:00 h in order to maintain feeders full.

A continuous lighting program was adopted, of one hour of dark and 23 hours of light, during the entire experimental period, according to the standard applied in commercial farms.

In order to determine live performance, weight gain (WG) in g, feed intake (FI) in g, and feed efficiency (calculated as FE = weight gain in g / feed intake in g), and livability (number of live birds divided by the total number of birds divided by 100, expressed as %) were weekly recorded.

Temperature and air relative humidity inside each environmental chamber were controlled using humidifiers, heaters, air-conditioning, and exhaustion fans. Data loggers with 0.1°C resolution were used to record temperature and air relative humidity. Environmental parameters were recorded every five minutes.

Based on the recorded values, black-globe temperature and humidity index (BGTHI) was calculated for each thermal environment according to the equation of Buffington *et al*. (1981).

Air renovation of the environmental chambers was carried out using two automatically activated axial exhaustion fans, allowing four air renovations per hour during the entire experimental period to maintain good air quality.

The obtained data were submitted to analysis of variance and means were compared by the test of Dunnett at 5% probability level. The thermal control environment (TC) was considered as the control treatment. Data were analyzed using the statistical package SAEG (Program Analysis for System Statistics and Genetics), developed by the Federal University of Viçosa (1999).

RESULTS AND DISCUSSION

The parameters temperature, air relative humidity, and black-globe temperature and humidity index were

evaluated to determine the internal environment of the chambers.

Average temperature and air relative humidity, and respective BGTHI values obtained in each chamber during the experimental period are presented in Table 2.

Table 2 – Means and standard deviations of air temperature (Ta), relative humidity (RH), and black-globe temperature and humidity index (BGTHI) obtained weekly during the first three weeks of life of the studied quails.

Thermal environment	Ta (°C)	RH (%)	BGTHI
Week 1 (1-7 days)			
Severe cold (SC)	30.1 ± 0.6	56.9 ± 5.1	79.3 ± 0.6
Moderate cold (MC)	33.0 ± 0.8	56.9 ± 4.8	83.3 ± 0.7
Thermal comfort (TC)	36 ± 0.6	55.5 ± 4.6	87.1 ± 0.4
Moderate heat (MH)	39.1 ± 0.6	55.8 ± 6.3	91.4 ± 0.6
Severe heat (SH)	41.9 ± 0.8	56.5 ± 5.8	95.4 ± 0.6
Week 2 (8-14 days)			
Severe cold (SC)	27.4 ± 0.4	58.4 ± 4.9	75.8 ± 0.4
Moderate cold (MC)	30.2 ± 0.9	59.9 ± 6.1	79.9 ± 0.6
Thermal comfort (TC)	33.3 ± 0.7	55.2 ± 4.5	83.4 ± 0.4
Moderate heat (MH)	35.8 ± 1.3	54.8 ± 3.0	86.7 ± 0.7
Severe heat (SH)	39.1 ± 0.6	55.1 ± 5.4	91.2 ± 1.0
Week 3 (15-21 days)			
Severe cold (SC)	23.8 ± 0.8	58.5 ± 5.9	70.8 ± 0.5
Moderate cold (MC)	26.8 ± 0.7	59.7 ± 6.9	75.2 ± 0.6
Thermal comfort (TC)	30.0 ± 0.9	58.0 ± 5.9	79.4 ± 0.5
Moderate heat (MH)	32.9 ± 0.7	57.9 ± 4.7	83.3 ± 0.7
Severe heat (SH)	35.8 ± 0.5	59.1 ± 4.4	87.6 ± 0.8

The recorded temperature and air relative humidity values were close to those proposed for each thermal environment in the methodology (Table 2), indicating that there was adequate control of the thermal environment of the chambers.

To date, no BGTHI values specific for meat-type quails were published in literature. Therefore, the values obtained in the present study were compared with data obtained in broilers, as these data are

available in literature. We believe that the current data could be used as the foundation of a data base for future evaluations of thermal comfort of quails based on BGTHI.

Oliveira *et al*. (2006) observed that BGTHI comfort values for broilers are in the range of 81.3 ± 0.31 in the first week of life, approximately 77 in the second week, and 74.9 ± 1.65 in the third week. It may be inferred that, in the case of quails, those values correspond to severe cold. Santos *et al*. (2002) assumed that minimum BGTHI limits before causing cold stress are 78.6 in the first week of life, 67.4 in the second week, and 65.0 between the third and sixth week. Therefore, it may be assumed that the quails submitted to moderate (MH) and severe heat stress (SH) suffered most, as their environmental limits were relatively outside the optimal BGTHI ranges for broilers according to each age group. However, in order to determine if thermal comfort BGTHI values are the same for broilers and for quails, live performance must be evaluated.

Table 3 shows mean body weight on day 7, feed intake, feed efficiency, and livability values of individual quails between one and seven days of age. As shown in Table 3, only body weight on day 1 was not statistically different among treatments (p≥0.05). This indicates that initial body weight was uniform, precluding any possible effect of initial body weight on any of the evaluated performance parameters.

Feed intake, weight gain, feed efficiency, and livability determined in 7-d-old quails were significantly different (p≤0.05) between thermal stress and control treatments.

The quails housed in the SH environment (42 °C) presented 10.28% lower body weight at seven days of age (29.28 g) than those housed in the TC environment (36 °C) because BGTHI values was extremely high, impairing the performance of those birds. These results are consistent with those obtained by Van der Hel *et al*. (1991), who observed that the exposure of day-old

Table 3 – Body weight gain at day 7, feed intake (FI), weight gain (WG), feed efficiency (FI), and livability (LIV) of one- to seven-d-old quails and black-globe temperature and humidity index (BGTHI) as a function of thermal environments.

Thermal environment (°C)	BW d7 (g)	FI (g/bird)	WG (g/bird)	FE	LIV (%)	BGTHI
SC - 30	33.21a	40.31a	24.12a	0.60a	76.11a	79.3±0.6
MC - 33	32.75a	38.90a	23.45a	0.60a	88.89a	83.3±0.7
TC - 36	31.50a	37.69a	22.37a	0.59a	97.78b	87.1±0.4
MH - 39	32.56a	28.72b	23.31a	0.81b	97.22b	91.4±0.6
SH - 42	29.28b	34.08a	20.07b	0.59a	96.11b	95.4±0.6

SC: severe cold; MC: moderate cold; TC: thermal comfort (control environment); SH: severe heat; MH: moderate heat. Means followed by different letters in the same column are different from the control treatment at 5% probability level by the test of Dunnett.

chicks to high temperatures reduced weight gain. In another study, those authors verified that the exposure of chicks to high temperatures during the first week of life causes weight loss. Grieser *et al*. (2012), studying the weekly growth and development of meat-type quails between one and 42 days of age reared at temperatures between 30 and 32 °C, obtained 22.59 g weight gain.

The quails maintained in the SC (30 °C) and MC (33 °C) environments had higher feed intake compared to those housed in TC (36 °C). Despite not significant, the quails in treatments SC (30 °C) and MC (33 °C) presented 6.95% and 3.21T higher feed intake, respectively, than those in the TC (36 °C) treatment. It may be inferred that quails housed in cold environments used only net energy for maintenance, and that this energy was more efficient for the maintenance of homeothermy due to heat storage and conservation. Consequently, their weight gains were similar to that obtained in TC (36 °C). Therefore, quails reared in cold environments may present the same weight gains as those reared in thermal comfort. However, when achieving their physical limit, feed conversion ratio worsens. Quails in TC (36 °C) loss heat by sensitive heat loss processes, with no energy expenditure.

The results of the present study also show that quails submitted to heat stress tend to reduce their voluntary feed intake in an attempt to reduce heat increment, expending energy for thermoregulation. Silva *et al*. (2012), evaluating the nutritional requirements of quails, found that quails, as other poultry species, modulate their feed intake as a function of environmental temperature.

Otutumi *et al*. (2010) verified that meat-type quails reared at 30 °C had a feed intake of 39.04 g during the same period evaluated in the present experiment (1-7 days of age).In 2009, the same authors, evaluating the performance of meat-type quails maintained at a maximum temperature of 26.5 °C, obtained 39.84 g/bird/period for feed intake and 22.92 g/bird/period for weight gain, which are close to the values determined in the present study in birds in the SC (30 °C) and MC (30 °C) treatments.

The feed intake results of quails in the MC (33 °C) and TC (36 °C) groups are consistent with the findings of Grieser (2012), who evaluated the performance of 1- to 42-d-old quails weekly and obtained 38.90 g/bird/week, which value is the equal to that found for the MC group.

Environmental temperature also influenced feed efficiency, (p≥0.05), with better value obtained in

quails of the MH environment compared to those of the TC group. This may be explained by the lower feed intake of the MH group (28.72 g/bird/period). Birds attempted to maintain their body temperature within the limits of homeothermy by reducing feed intake, and therefore, the production of body heat. These values are also linked to the high BGTHI values in the MH treatment.

As shown in Table 3, the TC environment (36 °C) promoted high livability (97.78%), whereas the SC (30 °C) and MC (33 °C) environments resulted in lower livability values. The quails reared at low temperatures during the first week of life needed to adjust their physiology to try to maintain constant body temperature, but some failed, resulting in the higher mortality observed in the cold environment groups.

The BGTHI values of these two treatments were lower than that of treatment TC (36 °C), demonstrating that the best BGTHI value for quails during the first week of rearing is 87.1±0.4. The opposite happened with quails maintained in the MH (39 °C) and SH (42 °C) environments. The obtained average livability values demonstrate that homeothermal animals, specifically meat-type quails, suffer with low temperatures in the first days of life, possibly because their thermoregulatory system is not fully developed yet. The results also show that young quails (starter phase) tolerate heat stress better than cold stress. This finding is consistent with May & Lott (2000), who worked with temperatures of 28-32 °C in broilers during the first seven days of life and observed that lower temperatures resulted in higher mortality.

Based on the performance associated to BGTHI and livability results of the present experiment, as shown in Table 3, the TC (36 °C) and MH (39 °C) environments promoted thermal comfort for 1- to 7-d-old quails.

During the second experimental week, significant feed intake and weight gain differences (p≤0.05) when hot and cold environments were compared with the recommended thermal comfort environment. However, treatments had no influence (p≥0.05) on body weight at 14 days of age, feed efficiency, or livability.

Quails housed in cold environments (SC and MC) presented higher feed intake (Table 4). This indicates they increased their feed intake to utilize net energy for maintaining homeothermy (maintenance) rather than for body growth. However, their feed intake was sufficient to promote relatively higher weight gain than those housed in the TC (33 °C) environment. On the other hand, the quails housed in the MH (36 °C)

Table 4 – Body weight gain on day 14, feed intake (FI), weight gain (WG), feed efficiency (FI), and livability (LIV) of 8- to 17-d-old quails and black-globe temperature and humidity index (BGTHI) as a function of thermal environments.

Thermal environment (°C)	BW 14 d	FI (g/bird)	WG (g/bird)	FE	LIV (%)	BGTHI
SC - 27	74.48	95.56b	41.27a	0.43	94.02	75.8 ± 0.4
MC - 30	73.92	89.69b	41.17a	0.46	94.50	79.9 ± 0.6
TC - 33	68.77	83.65a	37.27a	0.45	96.05	83.4 ± 0.4
MH - 36	62.67	66.99b	30.11b	0.45	93.57	86.7 ± 0.7
SH - 39	60.71	54.28b	31.42b	0.58	94.32	91.2 ± 1.0

SC: severe cold; MC: moderate cold; TC: thermal comfort (control environment); SH: severe heat; MH: moderate heat. Means followed by different letters in the same column are different from the control treatment at 5% probability level by the test of Dunnett.

and SH (39 °C) environments presented 19.92 and 35.11% lower feed intake compared with those in the control treatment (TC). This indicates that they reduced their voluntary feed intake to reduce heat increment, and therefore, presented lower weight gain and body weight on day 14. In addition, BGTHI values were higher in those two hot environments. Despite no physiological parameters were evaluated, it was observed that sensitive heat loss were not very efficient in the hot environments. Therefore, latent heat loss (evaporation) was more relevant in these birds. This mechanism of heat exchange produces only heat loss, which seemed to benefit the birds, as they do not present sweat glands. The hot environments caused heat stress, making quails exchange heat with the environment by panting (increased respiratory rate), which was observed during the experiment, in the attempt of maintaining homeothermy.

The feed intake values obtained in the MH (36 °C) and SH (39 °C) treatments are in agreement with the results of Lana *et al*. (2000). The authors found that, under high temperatures, broilers consume less feed and gain less weight, as function of lower feed intake, and that high BGTHI values cause worse broiler performance. Feed intake results of quails in the MC (33 °C) and TC (36 °C) groups, as also found in week 1, are consistent with the findings of Grieser (2012), who weekly evaluated the performance of 1- to 42-d-old quails and obtained 89.36 g/bird/week in those maintained at 29 °C.

Otutumi *et al*. (2009), working with meat-type quails between eight and 14 days of age housed at a maximum temperature of 26.5 °C, obtained feed intake of 89.77 g/bird/period and 39.23 g/bird/period weight gain.

Based on the performance associated to BGTHI and livability results of the present experiment, as shown in Table 4, the SC (27 °C) and MC (30 °C) environments promoted thermal comfort for 8- to 14-d-old quails.

Table 5 shows mean body weight on day 21, feed intake, feed efficiency, and livability values of individual quails between 15 and 21 days of age. As shown in Table 5, body weight at 21 days of age, feed intake, weight gain, and feed efficiency were significantly different (p≤0.05) between thermal stress and control (TC) treatments. Treatments did not affect livability (p≥0.05).

Quails of the SC (24 °C) and MC (27 °C) presented 18.43 and 12.69% higher average body weight at 21 days of age (g/bird), respectively, than those of the TC (30 °C) treatment. Those birds also had higher weight gain due to their higher feed intake. Despite not statistically significant, quails housed in the SH (36 °C) environment presented 2.93% lower body weight at 21 days than those in the TC (30 °C) treatment. The high BGTHI value resulted in worse performance. Côrrea *et al*. (2007), evaluating different crude protein requirements – but using the same as in the present experiment – for grower meat-type quails, obtained 113.94 g/bird, 105.82 g/bird and 234.29 g/bird for

Table 5 – Body weight gain on day 21, feed intake (FI), weight gain (WG), feed efficiency (FI), and livability (LIV) of 15- to 21-d-old quails and black-globe temperature and humidity index (BGTHI) as a function of thermal environments.

Thermal environment (°C)	BW d21 (g)	FI (g/bird)	WG (g/bird)	FE	LIV (%)	BGTHI
SC - 24	121.60b	127.37b	49.71b	0.40a	96.41	70.8±0.5
MC - 27	115.71b	109.53b	41.79a	0.38a	96.77	75.2±0.6
TC - 30	102.68a	90.26a	33.33a	0.37a	96.99	79.4±0.5
MH - 33	103.64a	89.92a	40.96a	0.46a	93.97	83.3±0.7
SH - 36	99.67a	62.47b	41.23a	0.66b	94.43	87.6±0.8

SC: severe cold; MC: moderate cold; TC: thermal comfort (control environment); SH: severe heat; MH: moderate heat. Means followed by different letters in the same column are different from the control treatment at 5% probability level by the test of Dunnett.

body weight at 21 days of age, weight gain, and feed intake, respectively.

Similarly to body weight at 21 of age, birds in the SC (24 °C) and MC (27 °C) groups presented 41.11% and 21.35% higher feed intake than those in the control group (TC, 30 °C). The quails housed in the cold environments increased their metabolic rate to increase heat production; therefore, their maintenance requirements increased and birds consumed more feed to supply these new maintenance requirements, essential for their survival. On the other hand SH (36 °C) quails had 30.79% lower feed intake than those housed in the control environment. Nascimento e Silva (2010) highlighted that one of the effects of heat stress that causes significant losses is the reduction in feed intake, as birds try to reduce body heat production by reducing dietary energy intake. Both digestion and nutrient absorption generate energy, which is called heat increment when it is released.

Under cold stress, growing animals maintain their feed intake, generating heat increment, and most of the energy that would be used for tissue accretion is utilized for maintenance, worsening performance. This influences bird growth in the subsequent rearing phases, resulting lower productivity, lack of flock uniformity, weight loss, and worse feed conversion ratio (Almeida, 2010).

Relative to weight gain during this period, only the SC (24 °C) was significantly different (p≤0.05) from the control group (TC, 30 °C), with 49.14% higher weight gain.

Based on the results presented in Table 5, it is inferred that SC (24 °C) thermal environment represented the thermal comfort of quails during the third week of rearing in terms of performance (body weight at 21 days of age, feed intake, and weight gain).

CONCLUSIONS

The thermal comfort temperature ranges for meat-type quails in the first three weeks of life are: 36 to 39 °C and BGTHI values between 87.1 ± 0.4 and 91.4 ± 0.6 during the first week; 27 to 30 °C and BGTHI values between 75.8 ± 0.4 and 79.9 ± 0.6 during the second week, and 24 °C and BGTHI of 70.8 ± 0.5 during the third week of rearing;

The best livability values were obtained in quails housed under thermal comfort (36 °C).

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