



Effects of Embryonic Thermal Stimulation on Thermoregulatory Response of Crossbred Chickens During the First Week Post-Hatch

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Abstract. Embryonic thermal stimulation has emerged as a promising approach to enhance heat tolerance in poultry. This study aimed to evaluate the effects of embryonic thermal stimulation on thermoregulatory response of crossbred chickens during the first week post-hatch. A total of 200 fertile eggs from a crossbreeding between Bangkok chickens and Lohmann Brown laying hens were randomly allocated into four experimental treatments and five replicates, with 10 eggs per replicate. The treatments consisted of a control (T0) and three embryonic thermal stimulation: T1, T2, and T3. Eggs in T0 were incubated under standard conditions at 37.5°C and 55% relative humidity (RH) throughout the entire incubation period. Eggs in the embryonic thermal stimulation treatments were subjected to elevated incubation conditions of 39.5°C and 65% RH for 6 hours daily from 09:00 up to 15:00. The embryonic thermal stimulation was applied during embryonic days (ED) of 10–18 for T1, ED 12–18 for T2, and ED 14–18 for T3. The hatched chicks were removed from the incubator after 516 hours of incubation and then reared for 7 days. No significant differences were observed for head and shank temperatures among the treatments. A significant difference was observed in cloacal temperature, where chickens from the T2 and T1 groups showed lower temperatures compared to T0, while the T3 group exhibited intermediate values. Breast temperature differed significantly among treatments, with T2 showing the lower values as compared to T0, T1, and T3. This study highlights the significant role of embryonic thermal stimulation on thermoregulatory response of crossbred chickens during the first week post-hatch. Thermal stimulation applied during embryonic days 12–18 was particularly effective, as it contributed to lower body temperatures, indicating a potential enhancement of thermoregulatory response in crossbred chickens.

Keywords: body temperature, climate change, crossbred chickens, embryonic thermal stimulation.

1 Introduction

Climate change has emerged as a critical challenge in the global poultry industry, exerting significant negative impacts on animal welfare, growth performance, and overall

productivity [1,2]. Rising ambient temperatures associated with climate change contribute to the incidence of heat stress, a major constraint in poultry production systems [3,4]. Poultry are highly susceptible to heat stress due to their absence of sweat glands, which limits their capacity for effective thermoregulation [5-7]. Consequently, heat stress impairs physiological processes and reducing survival rates, ultimately posing a serious threat to the sustainability of poultry production [8]. In light of these challenges, the development of effective strategies to promote thermal adaptation in poultry has become an urgent priority to ensure the resilience and long-term viability of the industry.

One common approach to mitigate the impact of heat stress in poultry is the use of closed-house systems, which maintain controlled environmental conditions to provide optimal temperature, humidity, and ventilation [9]. However, the high installation and operational costs of these systems pose a significant barrier for smallholder and backyard farmers, who make up a large proportion of poultry producers in developing countries. As a result, alternative and affordable solutions are required to enhance the resilience of poultry to climate-related stressors.

Incubation conditions are critical determinants of hatching success and post-hatch performance in poultry [10-14]. In particular, embryonic thermal stimulation has emerged as a promising strategy to enhance heat tolerance and promote long-term thermoregulation in poultry. This technique involves subjecting developing embryos to carefully controlled periods of elevated temperature during specific stages of embryogenesis, with the aim of influencing the maturation and functional capacity of thermoregulatory mechanisms in the post-hatch period [15-18]. Such interventions have the potential to promote adaptive responses to heat stress later in life, thereby improving the resilience of poultry to environmental challenges [19,20]. While the application of embryonic thermal stimulation has been relatively well-documented in broiler chickens [21-26], its use in crossbred chickens remains limited. In particular, Bangkok x Lohmann Brown crossbred chickens has recently gained attention in Indonesia. This hybrid offers a promising alternative for local markets, where consumers value the superior meat quality and adaptability of Bangkok chickens with the improved productivity of Lohmann Brown [27-29]. However, the thermal adaptability of this crossbred remains poorly understood, especially under conditions of heat stress. Therefore, this study aimed to evaluate the effects of embryonic thermal stimulation on the thermoregulatory responses of Bangkok x Lohmann Brown crossbred chickens during the first week post-hatch.

2 Materials and Methods

A total of 200 fertile eggs from a crossbreeding between Bangkok x Lohmann Brown chickens were obtained from local breeder (UD. Berline Farm, Malang, Indonesia). The eggs were randomly allocated into four experimental treatments and five replicates, with 10 eggs per replicate. The eggs were uniform in terms of weight and shape index, with an average egg weight of 59.87 ± 3.67 g (coefficient of variation: 6.13%) and an average shape index of $79.63 \pm 2.43\%$ (coefficient of variation: 3.06%).

The treatments consisted of a control (T0) and three embryonic thermal stimulation: T1, T2, and T3. Eggs in T0 were incubated under standard conditions at 37.5°C and 55% relative humidity (RH) throughout the entire incubation period. Eggs in the embryonic thermal stimulation treatments were subjected to elevated incubation conditions of 39.5°C and 65% RH for 6 hours daily from 09:00 up to 15:00. The embryonic thermal stimulation was applied during embryonic days (ED) of 10–18 for T1, ED 12–18 for T2, and ED 14–18 for T3. Eggs in each treatment were incubated in four separate but identical incubators. The hatched chicks were removed from the incubator after 516 hours of incubation.

Chicks were then reared for 7 days under controlled conditions, with an average ambient temperature of $31.81 \pm 0.70^\circ\text{C}$ and a relative humidity of $58.91 \pm 9.90\%$. Feed and water were provided ad libitum. A complete feed of Broiler-I was used, containing 21% crude protein, 5% crude fat, 5% crude fiber, 0.95% calcium, 0.5% phosphorus, 1.20% lysine, and 0.45% methionine (PT. Japfa Comfeed Indonesia, Sidoarjo, Indonesia). Continuous lighting for 24 hours daily was provided throughout the experimental period.

The variables observed were body temperature measurements, including cloacal, head, breast, and shank temperatures. Cloacal temperature was measured using GP Care digital thermometer with a flexible tip (Global Pharma Pte Ltd, Singapore, Singapore). The head, breast, and shank temperatures were recorded using Polygreen KI 8176 infrared thermometer (Polygreen Germany GmbH, Stahnsdorf, Germany). Body temperature data were collected from 3 chicks per replicate. Data were analyzed using one-way analysis of variance and significant differences among treatments were determined at $P < 0.05$. When significant differences were detected, means were further separated using Duncan's multiple range test. Data analysis was done using IBM SPSS Statistics 25 (IBM Corp., Armonk, USA).

3 Results and Discussion

The effect of embryonic thermal stimulation on the thermoregulatory responses of crossbred chickens during the first week post-hatch is presented in Table 1. A significant difference ($P < 0.05$) was observed in cloacal temperature, where chickens from the T2 and T1 groups showed lower temperatures compared to T0, while the T3 group exhibited intermediate values. Similarly, breast temperature differed significantly among treatments ($P < 0.05$), with T2 showing the lowest values, while T0, T1, and T3 presenting higher and comparable values. No significant differences ($P > 0.05$) were observed for head and shank temperatures among the treatments. A significant difference ($P < 0.05$) was observed in cloacal temperature, where chickens from the T2 and T1 groups showed lower temperatures compared to T0, while the T3 group exhibited intermediate values. Similarly, breast temperature differed significantly among treatments ($P < 0.05$), with T2 showing the lowest values, while T0, T1, and T3 presenting higher and comparable values.

Table 1. Effects of embryonic thermal stimulation on thermoregulatory response of crossbred chickens during the first week post-hatch

Variables	T0	T1	T2	T3	SEM	P-value
Cloacal temperature (°C)	41.57 ^b	41.03 ^a	40.96 ^a	41.31 ^{ab}	0.078	0.010
Head temperature (°C)	37.74	37.61	37.54	37.64	0.093	0.910
Breast temperature (°C)	40.29 ^b	40.00 ^b	39.19 ^a	40.02 ^b	0.139	0.017
Shank temperature (°C)	39.92	39.73	39.52	39.56	0.200	0.909

^{ab}different superscript within the same row indicate a significant different ($P < 0.05$)

The observed differences in thermoregulatory responses, particularly the lower cloacal and breast temperatures in the T2 group, suggest that embryonic thermal stimulation applied during ED 12–18 may effectively enhance the development of thermoregulatory mechanisms in crossbred chicks. Interestingly, while T1 (ED 10–18) also resulted in lower cloacal temperatures, the effect was less consistent across other measured variables, suggesting that earlier stimulation may trigger different adaptive responses. The partial effect observed in T3 (ED 14–18) further highlights the importance of timing, as initiating thermal stimulation later in embryogenesis may limit the window of influence on key developmental processes. These findings underscore the significance of both the timing and duration of thermal stimulation in shaping the thermoregulatory capacity of chicks after hatching. Application of embryonic thermal stimulation during ED 12–18 likely coincides with critical stages of embryonic development, including the maturation of the hypothalamic-pituitary-thyroid axis and the establishment of thermosensitive neurons in the central nervous system [17,21,30]. Embryonic thermal stimulation also has been shown to modulate heat shock proteins and antioxidant-related genes expression [31–33], improve dermal vascularization and reduce skin thickness [34]. These physiological adaptations may contribute to a more efficient thermoregulatory response post-hatch. In agreement with this finding, several previous studies also found that embryonic thermal stimulation could notably decreased body temperature of chickens in the post-hatch period [35–37].

The reduction in cloacal and breast temperatures observed in the T2 group holds important practical implications for poultry production, particularly in environments where heat stress is a major constraint. Lower body temperatures in newly hatched chicks may indicate enhanced thermoregulatory capacity, potentially reducing heat-related mortality and minimizing production losses during the rearing period [20,25,38]. Furthermore, improved thermal adaptation may contribute to enhanced welfare by minimizing the physiological disorder associated with heat exposure [38–40]. These findings suggest that thermal stimulation during ED 12–18 could offer a low-cost and non-invasive strategy to support sustainable poultry production in tropical regions where high environmental temperatures are a crucial challenge.

4 Conclusion

This study demonstrates the significant role of embryonic thermal stimulation in shaping the thermoregulatory responses of crossbred chickens during the first week post-hatch. Thermal stimulation applied during embryonic days 12–18 was particularly effective, as it contributed to lower body temperatures, indicating a potential enhancement of heat stress resilience in crossbred chicks. These findings suggest that targeted thermal stimulation during critical periods of embryonic development may serve as a practical strategy to improve the thermal adaptability of poultry, particularly in regions where high environmental temperatures pose a persistent challenge to production efficiency and animal welfare. While these results provide important insights into the short-term effects of embryonic thermal stimulation, additional studies are necessary to explore its broader implications across the production cycle.

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