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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 13 (17): 852-856, 2010
ISSN 1028-8880

The Effect of Manipulations of Incubation Temperature on Embryonic and Post-hatching Growth of Native Saudi Chickens

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Abstract: Embryonated egg is an ideal, environment in which to investigate the effects of incubation temperature on the development of the chick embryo. The objective of the current study were to investigate the effect of increasing the incubation temperature of chick embryo by 1.2°C for 7 days (ED4 to ED11) on the body movement and mass of native saudi chick embryo. This objective was extended to examine the influence of pre-hatching temperature on post-hatching growth. Therefore, a total of 180 hatching egg of native Saudi chicken divided into two equal groups incubated at temperature 37.5°C. The incubation temperature was raised to 38.7°C from ED4 to ED11 in treated group before being returned to the control group incubation temperature (37.5°C). The study revealed that elevating the incubation temperature of the eggs of native Saudi chicken by just 1.2°C, from 37.5 to 38.7°C, during embryonic days (ED) 4-11 causes significant increase in embryonic movement as demonstrated in day 8 in the chicks incubated at 38.7°C together with an increase in embryonic development, the embryos incubated at higher temperature were heavier in weights and exhibit significantly longer legs than the controls in ED12 and 15. The increase in pre-hatching incubation temperature (38.7°C) did not reveal any significant effects on post-hatching growth or of feed conversion efficiency.

Key words: Embryo, activity, weight, growth, pre-hatching

INTRODUCTION

Native Saudi chickens have been known for their poor performance (Al-Aqil, 1998). Al-Yousef *et al.* (1999) found an average egg production ranged between 37-52% when the native breed were fed the recommended levels of arginine and lysine amino acids by NRC in 1994. Later, Najib and Basiouni (2004) improved level of egg production of the breed by 67.86% as levels of arginine and lysine were increased in the diet to 1.5 and 1.2%, respectively. The same authors concluded that local saudi chickens might have the potential to perform better as a level of some amino acid risen up and suggested that arginine and lysine requirement of native saudi chicken could be around 1.5 and 1.2%, respectively (Najib and Basiouni, 2004).

Avian embryogenesis can be manipulated by alteration of the temperature during incubation of the hatching egg. Investigations in turkeys showed that a higher temperature during early embryogenesis positively affects the myogenesis accompanied with a higher muscle fiber number (Werner *et al.*, 2010). However, in broiler alteration of the temperature also affects the meat quality. The hatch rate and broiler chick weight did not show any difference in hatching eggs of the Cobb 500 broiler incubated at 37.5°C during the whole incubation period at normal temperature, or at 38.5°C during Embryonic Day (ED) 7 to 10 (Werner *et al.*, 2010). The same authors demonstrated that, after 36 days the final body weights and the cumulative feed conversion rates were not different in the normal and high temperature groups.

It is well known that the embryonic environment can influence the growth of the embryo in many species. In particular, the effect of temperature on subsequent growth has been studied for a long time in fish (Johnston, 2006) but also, more recently, in the development of birds (Maltby *et al.*, 2004; Hammond *et al.*, 2007) and reptiles (Booth, 1998, 2006). The effects of small differences in incubation temperature, applied throughout incubation have been shown to influence growth of the long bones in the chick leg. However, the mechanisms by which this is occurring are unclear (Brookes and May, 1972; Hammond *et al.*, 2007). In addition, application of short-term high temperature, influence embryonic bone

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development in the rat, probably through activation of heat shock (Kimmel *et al*., 1993; Harrouk *et al*., 2005).

Interestingly, Hammond *et al*. (2007) demonstrated that, increasing the temperature of chick incubation by only 1°C for 3 days during early incubation has a significant effect on the motility and body mass of the chick embryo. In the present study we are suggesting that since saudi local chicken experienced survival brooding and breeding in extremely hot dry environment reaching 45.2°C and relative humidity 4.3% during the day in summer (Al-Helal, 2003), the incubation of hatching egg under such condition is supposed to be a bit higher than others breeds imported from cold environment. This study aimed to investigate the effect of increasing the incubation temperature of chick embryo by 1.2°C for 7 days (ED4 to ED11) on body movement and mass of local saudi chick embryo and the influence of pre-hatching temperature on post-hatching growth.

MATERIALS AND METHODS

Hatching eggs: A total of 180 hatching egg of native saudi chicken were obtained from poultry farm of the research station, King Faisal University and incubated in two incubators (Hatchmaster A automatic incubator, Brinsea Product Ltd. Sanford England) during the current experiment (2010).

Incubators setting: The setting temperature of the two incubators were monitored and optimized to the required temperature (37.5°C) and continued throughout embryonic growth for the control and for the treated group (38.7°C) from ED4 to ED11 before being returned to the control group incubation temperature.

Embryonic movement counting: The examined eggs were removed from the incubator, windowed (Korn and Cramer, 2007) and the whole body embryonic movements were counted by the aid of stereomicroscope (Leica EZ4,) daily for 5 min per embryo from ED6 to ED8 (Oppenheim, 1966). After observation, the egg was resealed and replaced in the appropriate incubator. All measurements in this study were taken by the same researcher, although a random sample were blinded and recorded by an independent researcher to ensure validity of the measurements. Embryos from ED12 to ED18 were killed by decapitation and weighed using sensitive electronic balance.

Body weight gain and feed conversion measurement: Day old chicks were tagged, weighed and transferred to the experimental farm cages and fed *ad libitum*. The body weight gain and feed intake were recorded weekly to calculate feed conversion ratio and efficiency.

Statistical analysis: Data were analyzed by repeated measurements Analysis of Variance (ANOVA) and the statistical significance between means was compared using Student's t-test; $p<0.05$ was considered significant. All tests were performed using computer package of the statistical analysis system (SAS, institute, 2002).

RESULTS

Chick embryo activity: The present results revealed that, the total movements (Mean±SD per 5 min) of the chick embryos incubated at 38.7°C were significantly ($p = 0.05$) increased (31±7.5) compared to control (15.3±2.8) incubated at 37.5°C on ED8 as shown in Fig. 1.

Chick embryo weight: The chick embryo weight (Mean±SD (g)) was parallel with embryonic movement as the chicks incubated at the higher temperature (38.7°C) were significantly ($p = 0.05$) heavier (4±0.6) on ED12 and (9.7±0.9) on ED15 than the controls (2.8±0.3 and 7.3±0.6, respectively). However, insignificant differences were shown on ED18 (Fig. 2).

Chick embryo body growth and feathering: The feather and body growth were faster in the chicks incubated at 38.7C compared to the control which was incubated at 37.5°C (Fig. 3).

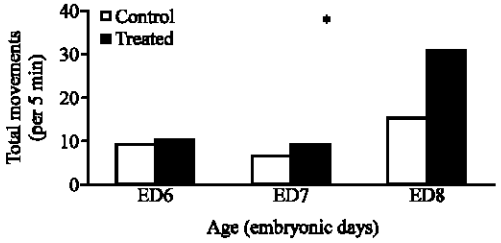

Fig. 1: Mean number of embryonic movements per embryo in a 5 min period. *$p<0.05$. Sample sizes: ED6, n = 5; ED7, n = 5; ED8, n = 5

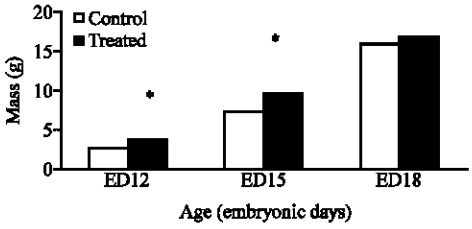

Fig. 2: Total embryo wet mass of chicks sampled between ED12 and ED18. *$p<0.05$. Sample sizes: ED12, n = 15; ED15, n = 15; ED18, n = 15

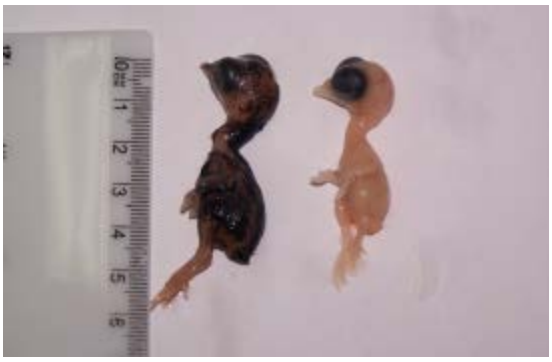

Fig. 3: Representative total chick embryos, top limb, lower limb and feather at ED12 raised at higher temperature (38.7°C; T) and the controls (37.5°C; C)

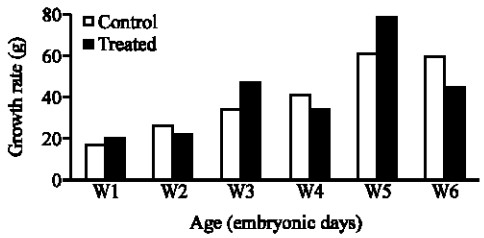

Fig. 4: Chick growth rate post-hatching plotted weekly. Week 1, n = 25; week 2, n = 25; week 3, n = 25; week 4, n = 25, week 5, n = 25 week 6, n = 25

Table 1: Feed conversion efficiency in control and treated chicks 6 weeks post-hatching (n = 25)

	Feed conversion efficiency	
Weeks	Control	Treated
1st	0.4±0.01	0.4±0.01
2nd	0.3±0.02	0.3±0.02
3rd	0.4±0.01	0.3±0.01
4th	0.2±0.02	0.2±0.02
5th	0.2±0.03	0.2±0.03
6th	0.2±0.01	0.2±0.01

Post-hatching growth rate: The post-hatching growth rate in treated group (38.7°C) remained comparable to control group (37.5°C; Fig. 4). Similarly, the feed conversion efficiency was the same in both examined groups (Table 1).

DISCUSSION

Influence of temperature on embryonic movement: The increase in embryonic activity observed in Saudi native chicken eggs incubated at 38.7°C in this study agreed with the findings of Sharp *et al.* (1999), who stated that temperature is known to affect the growth and differentiation of a number of different tissues, the way in which it could be doing so remains unclear and hypothesized that one way that temperature could affect the musculoskeletal system is by an increase in the number of embryonic movements made by the chick. However, in the present study, the source of the hatching eggs was Saudi chickens which survive in extremely hot environment unlike that used by Sharp *et al.* (1999). Measurements were made between ED5 and ED11 and were not made after ED11 since from this period onwards the movements of the embryo can be constrained by the space in the shell which would lead to the introduction of another variable to the experiments (Bradley, 1999; Bradley *et al*., 2005; Hammond *et al*., 2007).

The present findings confirmed the findings of Oppenheim and Levin (1975) and Hammond *et al.* (2007) who showed that a small rise in the temperature of incubation can have a significant and sustained effect on the motility of the embryo. Indeed, the fact that the embryos show increased activity after a return to the control temperature suggests that the time spent at higher temperature programs the later motility of the chick. This could be through changes to the pattern of muscle innervations or to the metabolism of the muscles. Interestingly, a recent study demonstrates that small temperatures can cause significant changes that persist long after their application, in the fish species such as haddock and salmon as the case in the chick (Martell and Kieffer, 2007; Albokhadaim *et al*., 2007).

Influence of movement on body legs growth and length: The significant difference showed in body and leg length in ED12 and 15 for the chick embryo incubated at 38.7°C from ED4 to ED11 before being returned to the control temperature is interesting and as in the case of the increased motility, suggests that the early time spent at higher temperature is programming later bone development (Kronenberg, 2003). Similarly increased temperature throughout the incubation period has been demonstrated to cause increased long bone length in chicks (Brookes and May, 1972). It has also been demonstrated that short periods spent at high temperature can cause changes to bone development in rodents (Harrouk *et al*., 2005; Kimmel *et al*., 1993). It still remained unclear whether a relatively short exposure to a temperature within a physiological range could have effects on bone growth that would be sustained throughout later development.

The present results showed that the embryos that were more active in movement had longer leg than control which partially consistent with previous reports showing that paralysis of chicks during embryonic development

led to leg bones that were shorter than control (Hogg and Hosseini, 1992; Hosseini and Hogg, 1991a, b; Lamb *et al*., 2003). The effects of increased motility on chick development have been less well characterized, although treatment of embryos with the hyperactivity-inducing drug led to increased chick body mass at ED15 and ED16, along with increased tibial length at these times, although the differences were not significant at ED20 (Heywood *et al*., 2005). Similar experiments showed that the balance of insulin like growth factors can be altered in leg muscles by motility-inducing drugs (McEntee *et al*., 2006).

The results of this study illustrated that incubation environment manipulation in chicken raised in hot environment as in Saudi Arabia is important in determination of chick embryo activity which concurrently influence the growth of the chick. It would be interesting in future studies to examine whether this is the case and, if so, whether this would have any effect on the timing of hatching. Previous studies have shown that decreasing temperature can cause delayed hatch times (Suarez *et al*., 1996), so it might be predicted that our temperature regime might subtly reduce the length of incubation.

Influence of pre-hatching temperature on post-hatching growth: The poor growth and efficiency feed conversion of native Saudi chicken observed in the present experiment was not influenced by pre-hatching temperature manipulation since the birds were genetically known to be poor in production despite of their high tolerance to diseases and height ambient temperature as reported by Al-Aqil (1998), Al-Yousef *et al*. (1999) and Werner *et al*. (2010), who proved the poor performance of native Saudi chicken.

CONCLUSION

The current study concluded that, increasing the temperature of incubation by 1.2°C for 7 days in early development affects a number of parameters during embryonic growth, namely embryonic motility, body mass and long bone length. The poor growth and efficiency feed conversion of native Saudi chicken observed in the present experiment was not influenced by pre-hatching temperature manipulation.

ACKNOWLEDGMENT

The authors thank the Deanship of Scientific Research in King Faisal University for supporting this study (DSR 10036). Authors also thank the staff of research station of the University for their Assistance.

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