



Effect of incubational thermal exposures on the hatchability and early post-hatch growth performance of broiler chickens

SHYAMAL K SOREN¹, SUBRAT K BHANJA², AKSHAT GOEL³ and MANISH MEHRA⁴

ICAR-Central Avian Research Institute, Izatnagar, Uttar Pradesh 243 122 India

Received: 20 July 2018; Accepted: 25 April 2019

Key words: Broiler chicken, Hatchability, Incubation, Post-hatch growth, Thermal exposure

Sudden temperature fluctuation adversely affects the poultry performance. Attention is focused to explore the possibility of thermotolerance. For normal chick-embryo development and successful hatching, the optimum incubation temperature must range from 36.7–37.5°C. Studies indicated that daily cyclical higher incubation temperature (39.5°C), length of exposure (8 h or 12 h) and embryonic age (7d–14 d or 15d–18 d of incubation) improves chicken tolerance to higher ambient temperatures without affecting hatchability (Piestun *et al.* 2008, Yahav 2009). Differences in setter and hatcher temperature also affect the development of whole chicken by modulating post-hatch growth and breast muscle weight (Shinder *et al.* 2009, Marandure *et al.* 2011).

We hypothesized that the thermal exposures during incubation may help in developing thermoregulatory memory, which could be utilized for improving the post-hatch performance of bird when exposed to adverse climatic conditions. The present study was aimed at evaluating the effect of thermal exposures and age of the embryo on the pre and post-hatch performances of broilers.

Fertile eggs (700) were collected from the broiler breeders (36 weeks of age) and were distributed into 7 groups. The eggs were marked, weighed individually and set in a force draft incubator (temp. 37.5°C and RH 60%). At 4th–7th (Early), 11th–14th (Mid) and 18th–21st (Late) day of incubation, 3 groups each were placed in high (39°C, RH 70%) or low (36°C, RH 60%) temperature incubator installed in the same room for 6 h daily after which the eggs were returned back to the standard incubator. The eggs which were kept throughout in the normal incubator were termed as standard. The seven treatment groups were standard incubation, early high (EH), mid high (MH), late high (LH), early low (EL), mid low (ML) and late low (LL).

Hatched chicks were weighed, wing-banded and transferred to electrically heated battery brooders, kept in a well-lit and ventilated open-sided house. Each treatment group had 6 replicates of 8 birds each and reared up to 28d

of age and provided with a standard broiler ration. Food and water were available *ad lib*.

At 8 d and 15 d embryonic age, 6 eggs were broken and the embryo weight (EW) was recorded without yolk sac. Every four 4 h from 481 h to 513 h of incubation, counts of piping or those hatched were recorded to obtain the hatching time for eggs of each treatment group. All un-hatched eggs were broken on the day of hatch (DOH) to ascertain the day of embryonic deaths.

Bi-weekly body weight, weight gain, rectal temperature, internal organ weight and hematological parameters were studied on DOH and 14 d post-hatch (PH) in all the groups. Rectal temperature was measured in 6 birds (3 from both sexes) at DOH and 14d PH using a clinical thermometer.

The statistical analysis and interpretation of data was done through SPSS software package Ver 16.0 (2007). Hatchery related data were analyzed using Chi square test (χ^2). The data was analyzed by ANOVA to evaluate temperature and period of exposure effects. Difference in mean values was considered as significant at the level of 95% ($P < 0.05$) and 99% ($P < 0.01$).

The 8th day EW was lower ($P < 0.05$) in EH temperature exposed eggs than the standard but similar to that of EL group. However, 15th day EW did not differ between high or low temperature, early or mid-period thermal exposed and standard. Previous studies reported inconsistent results where eggs incubated at standard temperature (37.6°C) had heavier embryo than at 36.6°C on 14d of incubation (Yalcin *et al.* 2006, Yalcin *et al.* 2012) and decreasing the incubation temperature by 3°C during 16th–18th d of incubation did not influence either embryo growth or hatchability (Willemssen *et al.* 2011). In the present study, only the early exposure to high incubation temperature affected the embryonic growth. Generally the high or low temperature causes disproportionate development, abnormalities and reduction in growth (Wilson 1991). This is quite evident in our study where higher embryonic mortality (before piping) was observed in EH and EL exposed eggs than MH and ML (Table 1). Walstra *et al.* (2010) also reported lower (0.2–0.5%) embryonic mortality at middle stage of incubation by reducing the incubation temperature from 37.8 to 36.6°C. More embryonic death at early age of incubation might be

Present address: ¹PhD Scholar (dr.shyam04 @gmail.com), ²Principal Scientist (subratcari@gmail.com), ³Post Doctoral Scientist (genesakshat@gmail.com), ⁴Research Associate (dr.manishmehra@gmail.com).

Table 1. Hatchability parameters of high and low temperature incubated eggs

Treatments/period	Pre incubated egg weight (g)	Embryo weight (g)/ 100 g egg weight		Death before piping	Death after piping	Hatch %	Chick weight (g)	CW: EW (%)
		8 d	15 d					
Standard	53.75	2.14 ^b	22.63	12.7 ^y	1.6 ^{sy}	85.7 ^{by}	36.39	67.69 ^{ab}
Early-High (4–7 d)	53.87	1.80 ^a	23.04	14.3	0.0	77.8 ^a	36.59	67.88 ^{ab}
Mid-High (11–14 d)	54.13	–	24.28	6.8	0.0	91.9 ^c	36.51	67.47 ^{ab}
Late-High (18–21 d)	54.02	–	–	9.3	0.0	89.3 ^c	36.99	68.42 ^{bc}
Early-Low (4–7 d)	54.40	1.97 ^{ab}	24.02	16.1	1.6	79.0 ^a	36.69	67.53 ^{ab}
Mid-Low (11–14 d)	54.51	–	23.86	5.2	0.0	92.2 ^c	36.56	67.09 ^a
Late-Low (18–21 d)	54.57	–	–	5.8	0.0	89.9 ^c	37.72	69.08 ^c
SEm	0.23	0.18	0.36	1.65	0.30	2.25	0.18	0.14
<i>Temperature effect</i>								
High	54.01	1.80 ^f	23.66	10.13	0.0 ^r	86.33	36.64	67.84
Low	54.49	1.97 ^s	23.94	9.04	0.54 ^r	87.03	37.02	67.94
<i>Period of exposure</i>								
Early	54.14	1.89	23.53	15.21 ^z	0.81 ^{xy}	78.41 ^x	36.71	67.81 ^b
Mid	54.32	–	24.07	5.98 ^x	0.0 ^x	92.05 ^w	36.46	67.12 ^a
Late	54.29	–	–	7.57 ^x	0.0 ^x	89.59 ^z	37.28	68.67 ^c
<i>Probability</i>								
Temperature	0.61	0.03	0.44	0.60	0.02	0.23	0.14	0.23
Period	0.15	0.01	0.38	0.01	0.01	0.03	0.27	0.05
Interaction	0.11	0.05	0.16	0.01	0.16	0.01	0.54	0.01

A,b,r,s,x,y Mean values in a column having different superscripts vary significantly ($P < 0.05$).

due to the incapability of younger embryo to acclimatize the high or low temperature exposure. In the present study also we have observed higher hatchability in mid or late period thermal manipulation than the early thermal exposure group.

Highest hatchability (92%) was recorded in MH and ML exposed eggs while EH and EL eggs had lower ($P < 0.05$) hatchability than the standard (86%). Lower incubation temperature during third week of incubation allowed normal hatching but increased the incubation period (Willemsen *et al.* 2010). Daily 6 h exposure to 36–39°C during incubation extended the hatching time by 4 h in the present study. Although, this delay in hatching time is less than the previous reports, it is worthwhile to mention that we only reduced or increased the temperature by 1.5°C. However, more early piping was observed in high temperature exposed embryos. Yahav *et al.* (2004) also reported that the hatchability would improve when eggs were acclimated at 39°C from 16 to 18 d of incubation compared to the standard. In the present study, exposure to a low temperature of 36°C during mid or late incubation period did not affect hatchability, however Salahi *et al.* (2012) reported that hatchability decreased significantly as the severity of low temperature stress increased. More late hatching recorded in eggs exposed to high temperature during early embryonic development, could be attributed to some physiological changes in response to high temperature exposure.

Exposure to high or low temperature at different stages (early, mid or late) of embryo development did not affect the chick weight but their values relative to egg weight (%) were ($P < 0.01$) higher in late (18–21d) thermal exposure (68.67%) than early or mid-thermal exposure groups or standard (67.69%). The interaction between temperature

and period of exposure was significant and eggs having low temperature exposure during late period had higher chick to egg weight ratio than the standard (Table 1). Salahi *et al.* (2012) also reported higher chick yield in low temperature exposed group. Exposure to a high temperature of 38.5°C from 10 to 18 d of incubation resulted in heavier chick, heavier heart, liver and breast muscle weights (Yalcin *et al.* 2006).

The hatching time was influenced by thermal exposures. In LH or LL exposed eggs, piping started at 481 h of incubation and by 497 h, around 60% piping occurred in LH group as compared to standard (31.7%). The high temperature increased the piping percentage at 485 h and 489 h of incubation, particularly in late period thermal exposed eggs. However, in high and low temperature exposed groups piping continued till 513 h of incubation, whereas, in the standard most of the piping occurred between 497 h–509 h of incubation. Per cent late hatch was highest in EH exposed eggs (7.9%) followed by LL (4.3%) then EL (3.2%). Periodic thermal exposure also influenced the hatchability on fertile egg basis. Late hatch was more in EL group in comparison to standard (Table 2).

In the present study, we did not find any changes in the BW and BWG of the birds exposed to high or low temperature or at different period of exposure, but their interaction was significant. Additionally, the EH and ML temperature exposed chicks obtained lower BW at 14 d of age but subsequently increased the BW at 28 d of age, indicating compensatory growth mechanism. In continuation, BWG during 0–14 d period was lower ($P < 0.05$) in EH exposed group than MH, EL and LL while at 15–28 d period, EL exposed chicks had lower body weight

Table 2. Piping detail of chicks in high and low temperature incubated eggs

Treatment	Piping (% of fertile egg) at different time (h) of incubation								
	481	485	489	493	497	501	505	509	>513 (late hatch)
Interaction									
Standard	0.0	0.0	6.3	15.9	31.7	44.4	77.8	100.0	0.0
Early-high (4–7 d)	0.0	3.2	14.3	30.2	49.2	63.5	76.2	92.1	7.9
Mid-high (11–14 d)	0.0	4.1	14.9	31.1	55.4	66.2	87.8	98.6	1.4
Late-high (18–21 d)	2.7	16.0	33.3	46.7	60.0	69.3	86.7	98.7	1.3
Early-low (4–7 d)	0.0	1.6	11.3	27.4	41.9	50.0	71.0	96.8	3.2
Mid-low (11–14 d)	0.0	2.6	9.1	26.0	46.8	59.7	87.0	97.4	2.6
Late-low (18–21 d)	1.4	7.2	15.9	27.5	44.9	59.4	76.8	95.7	4.3
SEm	0.4	1.4	1.2	1.0	1.3	0.9	2.3	2.0	0.0
<i>Temperature effect</i>									
High	0.9	7.7	20.8	36.0 ^s	54.9 ^s	66.3 ^s	83.6	96.5	3.5
Low	0.5	3.8	12.1	27.0 ^r	44.5 ^r	56.4 ^r	78.3	96.6	3.4
<i>Period of exposure</i>									
Early	0.0	2.4 ^x	12.8 ^x	28.8	45.6	56.7	73.6 ^x	94.4 ^x	5.6
Mid	0.0	3.3 ^x	12.0 ^x	28.5	51.1	63.0	87.4 ^y	98.0 ^y	2.0
Late	2.1	11.6 ^y	24.6 ^y	37.1	52.5	64.4	81.7 ^{xy}	97.2 ^y	2.8
<i>Probability</i>									
Temperature	0.70	0.31	0.17	0.03	0.01	0.01	0.55	0.31	0.19
Period	0.15	0.01	0.05	0.17	0.25	0.20	0.03	0.05	0.31
Interaction	0.23	0.05	0.01	0.01	0.01	0.01	0.01	0.07	0.03

A,b,r,s,x,y Mean values in a column having different superscripts vary significantly (P<0.05).

Table 3. Post-hatch performance of broiler chicks hatched from high and low temperature incubated eggs

Treatment	Body weight (g)			Body weight gain (g)		FCR
	0 d	14 d	28 d	0–14 d	15–28 d	
Interaction						
Standard	36.36	241.80 ^{abc}	468.02	205.48 ^{abc}	226.76 ^{abc}	1.646
Early-High (4–7 d)	36.61	229.84 ^a	467.72	194.93 ^a	237.42 ^{bc}	1.636
Mid-High (11–14 d)	36.33	250.00 ^{bc}	454.83	213.67 ^{bc}	206.54 ^{ab}	1.616
Late-High (18–21 d)	36.97	242.36 ^{abc}	464.10	205.42 ^{abc}	222.87 ^{abc}	1.634
Early-Low (4–7 d)	36.82	255.10 ^c	453.16	218.28 ^c	197.23 ^a	1.616
Mid-Low (11–14 d)	36.59	237.10 ^{ab}	485.23	200.51 ^{ab}	249.90 ^c	1.639
Late-Low (18–21 d)	37.60	249.20 ^{bc}	468.79	211.60 ^{bc}	215.53 ^{abc}	1.602
SEm	0.20	1.92	4.84	1.85	4.14	0.014
<i>Temperature effect</i>						
High	36.64	241.15	462.06	204.51	220.91	1.63
Low	37.02	246.56	470.19	209.55	223.63	1.62
<i>Period of exposure</i>						
Early	36.71	242.01	460.70	205.30	218.69	1.62
Mid	36.46	243.42	470.34	206.95	226.92	1.63
Late	37.28	245.75	466.42	208.47	220.68	1.62
<i>Probability</i>						
Temperature	0.39	0.12	0.52	0.13	0.96	0.98
Period	0.26	0.80	0.77	0.86	0.73	0.94
Interaction	0.91	0.01	0.23	0.01	0.01	0.79

A,b,r,s,x,y Mean values in a column having different superscripts vary significantly (P<0.05).

gain than that of EH and ML. Significantly poor FCR in low temperature exposure groups than the standard at 6 weeks of age (Ipek and Sahan 2006) is contrary to the current study, where late period low temperature conditioned chicks had apparently better FCR than the standard chicks at 14 d of age (Table 3).

At DOH the rectal temperature did not differ due to temperature or period of exposure, but their interaction was

significant (P<0.01). The chicks having ML (40°C) or LL (40.4°C) exposure had higher rectal temperature than the standard (39.2°C). The higher rectal temperature in low thermal exposed chicks might be due to higher embryonic metabolism during the incubation period, which was evident from the lower yolk sac weight in those chicks. However, in our previous study with egg type chicks (White Leghorn) lower rectal temperature was observed at DOH in low

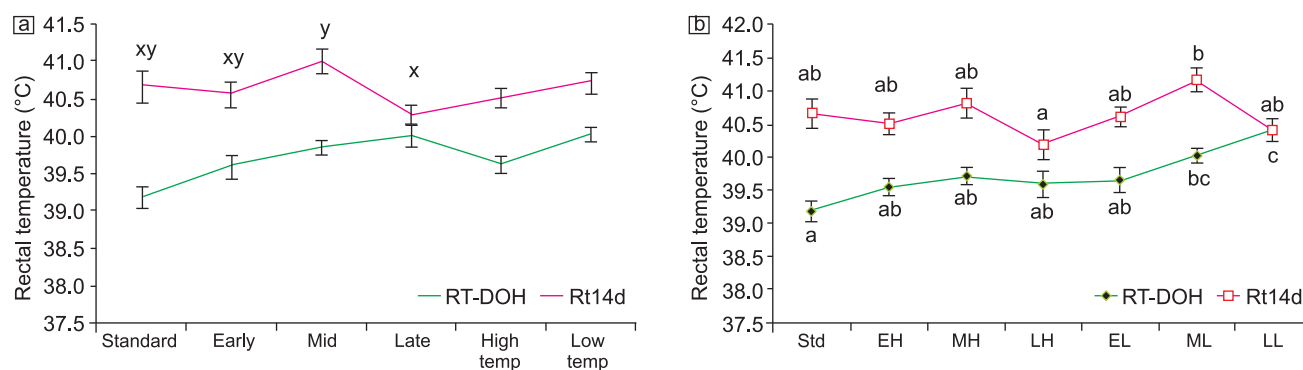


Fig. 1. Rectal temperature of broiler chicks at day old and 14th day post hatch when exposed to high or low temperature during incubation. a) Main effect, b) Interaction effect. Means with different alphabets denotes the significant variation ($P < 0.05$) between period of exposure (x, y, z) and temperature (r, s) and interaction (a,b,c).

temperature exposed embryos (Soren *et al.* 2012). This difference could be attributed to the strain of bird (slow or fast growing) used in this study. Several authors have stated that at early stage, embryos have immature body temperature regulation and feedback mechanisms, which cause changes in the thermoregulatory threshold response (Nichelmann and Tzschentke 2002). At 14d PH Late period thermal exposure chicks had lower rectal temperature than that of mid period exposed chicks. The ML temperature exposed chicks had higher rectal temperature than the LH exposed chicks (Fig 1 a and b).

In conclusion, mid period (11d–14 d) and late period (18d–21d) thermal exposure for 6 h to high or low temperature improved the hatchability but did not adversely affect the embryonic development and post-hatch production performances in broilers.

SUMMARY

In the present study, effect of high (39°C) or low (36°C) temperatures during 4th–7th, 11th–14th and 18th–21st d of broiler embryo development was studied. Incubation temperature did not affect embryo growth, but early exposure had higher embryonic mortality. High temperature causes early pipping, but increased pipping time by 4 h. Mid-period exposure recorded higher hatchability. Late-low temperature exposure had higher chick to egg weight ratio, apparently improved FCR and higher body temperature, while early-high temperature exposure had lower body weight. In conclusion, mid and late period exposure to high or low temperature for 6 h could improve hatchability without affecting post-hatch performances in broilers.

REFERENCES

- Ipek A and Sahan U. 2006. Effects of low stress on broiler performance and ascites susceptibility. *Asian Australasian Journal of Animal Sciences* **19**: 734–38.
- Marandure T, Hamudikuwanda H and Mashonjowa E. 2011. Effect of duration of early age thermal conditioning on growth and heat tolerance in broiler chickens. *Electronic Journal of Environmental, Agricultural and Food Chemistry* **10**: 1909–17.
- Nichelmann M and B Tzschentke. 2002. Ontogeny of thermoregulation in precocial birds. *Comparative Biochemistry and Physiology—Part A* **131**: 751–63.
- Piestun Y, Shinder D, Ruzal M, Halevy O, Brake J and Yahav S. 2008. Thermal manipulations during broiler embryogenesis: Effect on the acquisition of thermotolerance. *Poultry Science* **87**: 1516–25.
- Salahi A, Khabisi M M, Pakde A and Baghbanzadeh A. 2012. Effects of low stress during transportation on hatchability and chick quality of broiler breeder eggs. *Turkish Journal of Veterinary and Animal Sciences* **362**: 159–67.
- Shinder D, Rusal M, Giloh M and Yahav S. 2009. Effect of repetitive acute low exposures during the last phase of broiler embryogenesis on low resistance through the life span. *Poultry Science* **88**: 636–46.
- Soren S K, Bhanja S K, Mandal A B, Mehra M and Goel A. 2012. Effect of incubational thermal manipulation on the embryonic and early post-hatch growth in layer chickens. *Indian Journal of Poultry Science* **473**: 263–68.
- Walstra I, Ten-Napel J, Kemp B and van den Brand H. 2010. Temperature manipulation during layer chick embryogenesis. *Poultry Science* **89**: 1502–08.
- Willemsen H, Kamers B, Dahlke F, Han H, Song, Z, Ansari Pirsaraei Z, Tona K, Decuyper E and Evaraert N. 2010. High- and low-temperature manipulation during late incubation: Effects on embryonic development, the hatching process, and metabolism in broilers. *Poultry Science* **89**: 2678–90.
- Willemsen H, Li Y, Willems E, Franssens L, Wang Y, Decuyper E and Evaraert N. 2011. Intermittent thermal manipulations of broiler embryos during late incubation and their immediate effect on the embryonic development and hatching process. *Poultry Science* **90**: 1302–12.
- Wilson H R. 1991. Physiological requirements of the developing embryo: temperature and turning. *Avian Incubation*. (Ed.) Tullet S.G. Butterworth-Heinemann Ltd. pp 145–156.
- Yahav S. 2009. Alleviating heat stress in domestic fowl: different strategies. *World's Poultry Science Journal* **65**: 719–32.
- Yahav S, Sasson-Rath R and Shinder D. 2004. The effect of thermal manipulations during embryogenesis of broiler chicks *Gallus domesticus* on hatchability, body weight and thermoregulation after hatch. *Journal of Thermal Biology* **29**: 245–50.
- Yalcın S, Ozkan S, Siegel P, Yenisey C and Ak'it M. 2012. Manipulation of incubation temperatures to increase low resistance of broilers: Influence on embryo development, organ weights, hormones and body composition. *Poultry Science* **49**: 133–39.
- Yalcin S, Cabuk M, Babacanoglu E, Buyse J, Decuyper E and Siegel P B. 2006. Heat acclimation during incubation and breeder age influences on hatching performance of broilers. World Poultry Science Association, 12th European Poultry Conference, Verona, Italy.