Effect of a photoperiodic green light program during incubation on embryo development and hatch process

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Abstract: This study was conducted to evaluate the effect of a 12 hours light, 12 hours dark (12L:12D) photoperiod of green light during day 1 to day 18 of incubation time, on embryo growth, hatch performance and the hatch process. In the light group, the monochromatic light was provided by a total of 204 green LEDs (522nm) mounted in a frame which was placed above the eggs to give even spread of illumination. The control group was incubated in complete darkness. Four batches of eggs (n=300 per group per batch) from fertile Ross 308 broiler breeders were used in this experiment. The beak length and crown-rump length compared of embryos incubated under green light were significantly longer than those incubated in the dark condition at day10and day 12, respectively ($P<0.01$). Furthermore, green light exposed embryos had a longer third toe length compared to control embryos at day 10, day14 and day17($P=0.02$). At the group level (n=4 batches), light stimulation had no effect on chick weight and quality at take-off, the initiation of hatch and hatch window. However the individual hatching time of the light exposure focal chicks (n=33) was 3.4h earlier ($P=0.49$) than the control focal chicks (n=36). The results of this study indicated that green light accelerated embryos development and resulted in an earlier hatching.

Keywords: broiler incubation, green light, embryo growth, chick quality, hatch window, hatching time

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1 Introduction

Broiler chickens are often incubated commercially in complete darkness. Under natural conditions, however, avian embryos would certainly receive some light stimulation during development. In the wild, an incubating hen generally comes off her nest once a day, presumably when the eggs would be least subject to heat loss and they are completely exposure to daylight(Duncan et al., 1978). And also when turning the eggs, the mother usually stand up, thereby exposing the eggs to more light and to lower ambient temperature. The temporary exposure to light means that the full spectrum of radiation may potentially reach the surface of the avian eggs. Depending on the nest environment, eggs will experience light from the heating infra-red wavelengths to the potentially mutagenic ultra-violet light. However, base colour pigments of eggshell are likely to control the light that reaches the embryo by blocking light of harmful infrared and UV wavelengths but admitting beneficial

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wavelengths(Maureret al., 2011).Exposing eggs to green light (1340-1730 lux) from 5 to 15 days of incubation can increase growth and hatchability by 4.8%(Shafey and Al-mohsen, 2002).An overall improvement in the embryo/hatchling survival rate was observed in a near-infrared (630–1000 nm) light-emitting diode (LED) treated incubation research. The survival rate decreased by 41.5% in the light treatment group compared to that about 20% in control group, especially with a substantial decrease (68.8%) in third week of incubation. Furthermore, an increase in mean body weight, crown–rump length, liver weight, corrected liver weight, and a decrease in hatchling residual yolk weight were found(Yeager et al., 2005, Yeager et al., 2006). Therefore, light intensity can play an important role for the speed of development of chicken embryo and hatchability. A broader range of studies details the effect of wavelength with green light seemingly the most effective in stimulating embryonic growth and development, and post-hatch growth in chickens. However, few conclusions can be drawn with regards to the optimal light intensity for embryonic development on artificial incubation.The aim of this study was to investigate the effect of a photoperiod of green light during incubation on embryo growth and more specifically, hatch performance and the hatch process.

2 Materials and methods

Animal experiments were performed with the ethics approval from the Royal Veterinary College Animal Ethics Committee.

Four incubation trials were conducted, each using two incubators (alternating between the control and light group). In total, four batches of fertilized Ross 308 eggs (n=300 each group per batch) were obtained from a local supplier (Henry Stewart & Co. Ltd, Lincolnshire, UK) and incubated under standard incubation conditions (BIO-IRIS, Petersime^{TM}). All eggswere candled during transfer and those with evidence of a living embryo were transferred from the turning trays to hatching baskets. After 512h (21days and8hours) of incubation machines were stopped.

In the light group, the monochromatic light was provided by a total of 204 green LEDs (522nm, 0.5W Power PLCC4 SMT, AVAGO TECHNOLOGIES) mounted in a frame, which was placed above the eggs to give an even spread of illumination.The light-dark cycle (12L:12D) was in the first 18 days of incubation and darkness was in the last three days for the concern of potential adverse effects. The light cycle,controlled using a timer,consisted of one hour continuous illumination in high intensity (H:1200-1400 lux) and 11 hours in low intensity (L: 100-130 lux) during the light period(Testo Luminous intensity measuring instrument 545, GmbH&CO. Germany), then continuous dark (D) for the other 12h dark period. A dark (no light) incubation was the control group.

Samples of three eggs or chicks selected randomly from each group were collected at eight incubation stages: day 10, day 12, day 14, day 16, day 17, day 18, day 19 and day 20. The length of beak and third toe (as indexes of skeletal growth) and crown-rump length (CRL) (common indicators of embryo development) were measured. After hatch the number, weight and quality of chicks were recorded and scored by a standard method (Petersime^{TM}). On the group level, the initiation and the end of hatch for the entire batch were monitored by the SynchroHatch sensor (Petersime^{TM}).The hatch window (HW) was defined as the time between the initiation and the end of hatch.The hatching time of individual focal eggs (60 focal eggs in each group) was determined using the eggshell temperature as previously described by Romanini et al.(2013). Data were expressed as means ± SEM and differences between control and test groups were analysed using SPSS(PASW statistics 18).

3 Results

3.1 Hatch performance

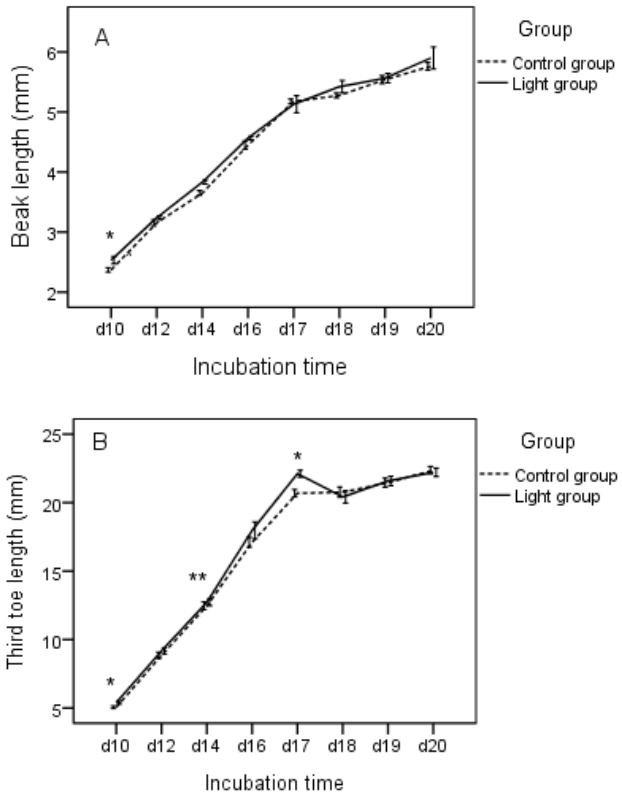
There was no effect of light treatment on chick quality and chick weight taking into account batch effect.

Table 1 Chick quality and chick weight of control group and light group from four batches (mean ±SEM)

	Control group	Light group (n=314)	*P*-value
Chick quality, %	97.9±0.2	97.8±0.3	0.7
Percentage of first class chick, %	70.9	71.7	
Chick weight, g	43.2±0.7	43.4±0.7	0.5

3.2 Embryonic development

Light treatment had an effect on beak length (*P*=0.006), third toe length (*P*=0.02) and crown-rump length (*P*=0.005)at specific stages (n=12 embryos/group) but not throughout the incubation period.The beak length (Figure1 A) and crown-rump length (Figure1 C) compared of embryos incubated under green light were significantly longer than those incubated in the dark condition at day 10 and day 12, respectively (*P*<0.01). Furthermore, green light exposed embryos had a longer third toe length (Figure1 B) compared to control embryos at day 10, day 14 and day 17 (*P*=0.02).



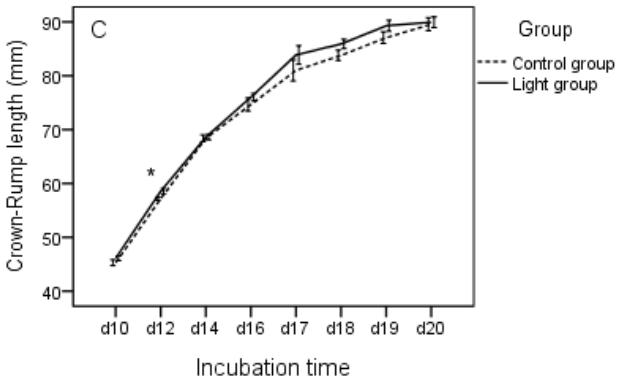


Figure 1 Beak length (A), third toe length (B) and crown-rump length (C) of the control and light exposed embryos or chicks from day 10 to day 21 of incubation time.

3.3 Hatch window and hatching time

There was no effect of light treatment and incubator on the initiation of hatch and hatch window of the entire batch. Both groups started pipping around 467 hours of incubation time.

Table 2 Mean of the start of hatch and hatch window (HW) of four light experiments

Group	Initiation of hatch[a]	HW, h
Control	467.3±0.7	23.0±1.9
Light	467.3±0.7	22.3±1.9
P-value	1.0	0.78

Note: [a] hours of incubation time

Equally, there was no difference in the hatching time of the first focal chicks. However, the average hatching time of focal chicks in the light group was 3.4 hours early than that of the control group(P=0.049).

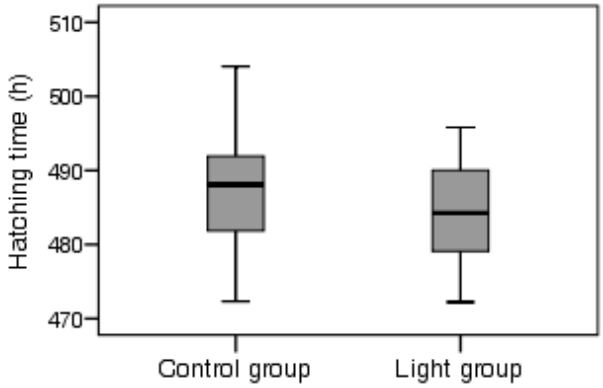


Figure 2 Boxplot of the hatching time of focal chicks in the control (n=36) group and light (n=33) group

4 Discussion and conclusions

Poultry are usually incubated commercially in complete darkness due to concerns about potential adverse effects of light stimulation on performance and economics, for instance, decreased hatchability due to secondary heating (Archer et al., 2009).The present results showed that broiler eggs incubated under green light for the first 18 days resulted in a significant increase in chick beak length, third-toe length and CRL at some incubation stages, but not in body weight and chick quality.Green light stimulation during incubation has been reported to accelerate chick embryos development (Zhang et al., 2012, Zhanget al., 2014).Furthermore, light stimulation may cause the alteration of hormones which in turn affect the hatching behaviors and hatching time. The results of this study showed that light exposed chicks hatched about 3.4 h earlier. Similar effects of light stimulation on the hatch process have been reported by other researchers. Continuous green light (1340-1730 lux) during the first 18 days of incubation accelerates hatching times by about 24h but reduces chick weight at hatch in meat-type breeder(Shafey and Al-mohsen, 2002). Far-red (670-nm) LED-treated (once per day from 0-20 days of incubation) chickens pip (broke shell) earlier and had a shorter duration between pip and hatch(Yeager et al., 2005).Different effects of light stimulation during incubation on hatch time may be due to the spectral characteristics of light and photoperiod applied. In conclusion, an accelerated embryos development and an earlier hatching were achieved in this study through tightly controlled light intensities and wavelengths and applying natural patterns of illumination during incubation. However, the underlying mechanism and alterations in related hormones needs further investigation.

Acknowledgments

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