

Embryonic Growth, Hatching Time and Hatchability Performance of Meat Breeder Eggs Incubated under Continuous Green Light

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ABSTRACT : The effects of dark-control (D) and continuous green light (GL) exposure of incubated meat-type breeder eggs (Hybro) on embryonic growth from 5 to 15 days of age, hatching time, hatchability per cent and chick hatching weight were investigated in three consecutive experiments at 33, 38, and 41 weeks of age. A total of 798 eggs were used in this study. Eggs were set in an incubator on trays either in the D or under two tubes of 20-watt green fluorescent light during the first 18 days of incubation. Eggs from both treatments were transferred to the dark hatching compartment at 19 days of incubation. The light intensity was in the range of 1,340 to 1,730 lux at the surface of the eggs. GL incubation of eggs significantly ($p < 0.01$) increased weight (expressed as an absolute value) and daily weight gain of embryos at 11 and continued to 15 days of age, hatchability per cent by 4.8%, reduced dead embryos per cent and chick weight at hatch by 37 and 2%, respectively and accelerated hatching time by about 24 h when compared with the D-control incubation. Chicks hatched at 504 h of incubation had significantly ($p < 0.01$) higher body weight, expressed as an absolute value or as a percentage of egg weight, than those hatched earlier at 456 h of incubation. It was concluded that the GL incubation of meat breeder eggs reduced incubation period and chick weight at hatch and increased embryonic growth and hatchability per cent. (*Asian-Aust. J. Anim. Sci.* 2002, Vol 15, No. 12 : 1702-1707)

Key Words : Green Light, Incubation, Embryonic Growth, Hatching Time, Hatchability Per cent, Chick Hatching Weight.

INTRODUCTION

Light is one of the environmental factors that influences embryo growth rate (Laubert and Shutze, 1964; Walter and Voitle, 1972; Isakson et al., 1970; Lauber, 1975; Fairchild and Christensen, 2000), hatchability (Coleman and McDaniel, 1975; Szymkiewicz et al., 1985) and hatching time (Shutze et al., 1962; Lauber and Shutze, 1964; Tamimie and Fox, 1967; Siegel et al., 1969; Adam and Dimond, 1971) of avian eggs. However, light was ignored by incubator manufacturers as an environmental factor in the incubation process of avian eggs. The relatively high percent of hatchability of eggs obtained by modern incubators and the conflicting reports regarding the effects of light on the hatchability performance were probably the main reasons for ignoring it as a factor. It appears that the source and amount of light are probably the most important factors that determine the outcome of any lighted incubation system.

Little is known about the effect of green light incubation on the growth of the embryo and hatchability performance of chicken eggs. The objective of the present study was to determine whether continuous green light incubation (GL) could be used to improve hatchability performance of eggs. The effects of dark-control (D) and GL incubations on embryonic growth, hatching time, hatchability performance and chick hatching weight of meat-type breeder eggs were

investigated.

MATERIALS AND METHODS

A total of 266 freshly laid eggs obtained from a commercial meat-type breeder flock (Hybro, Al-Wadi Pty Limited, Riyadh, Saudi Arabia) at 33 weeks of age were used in the first trial. Eggs were numbered, weighed individually and graded into five weight classes. Eggs weighing between 55 and 58 g, 58.1 and 61 g, 61.1 and 64 g, 64.1 and 67 g and 67.1 and 70 g were separated into five different weight classes. Eggs were assigned to fourteen replicates of nineteen eggs each. Each replicate contained the same number of eggs from each weight class. Seven replicates were randomly assigned to each of the two treatments and evenly distributed into two incubator trays to eliminate any effect for positions. The trial was repeated twice at 38 and 41 weeks of age.

Incubation of eggs

Eggs were set in Maino, force-draft incubator (Model II, Maino Enrico, Co., Italy) and incubated at 37.5°C and 55% relative humidity. The egg compartment of the incubator (85 cm deep, 50.5 cm width and 83.5 cm height) was divided into two compartments with black cloth for the control (dark) and light treatments. The black cloth was used to overcome any problem associated with air movement. The incubator walls were also covered with black sheets of paper to prevent any reflection of light. In a pilot experiment, there were no differences in temperature

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and hatchability of eggs incubated in the two compartments of the incubator. An egg tray was fitted with two green 20-watt fluorescent 50 cm tubes, located 12 cm above the eggs in the compartment of the lighted treatment. Light was turned on constantly during the first 18 days of incubation period. Light availability at the surface of the eggs varied from 1.340 to 1.730 lux as measured with a luxmeter (model RS 203-013, Taiwan).

Eggs were turned every 2 h. Each egg was transferred to a separate small compartment in the hatching tray at the 19th day of incubation, for chick identification at hatch. Hatching tray was divided into small hatching compartments using thin sheets of mesh wires. Eggs were examined by candling at 6 and 12 days of incubation and infertile eggs and eggs containing dead embryos (ED; 1-12 days) were removed, respectively. The hatching compartment was set at 37°C and 65% relative humidity until the morning 22nd day of incubation, at which time, chicks, pips (unhatched eggs with live (PL) or dead embryos (PD)) and late dead embryos (LD; unhatched eggs with unbroken shell) were counted. Late dead embryos were counted from 12 to the morning of 22nd days of incubation. The hatchability percentage (HP) was calculated based on fertile eggs. Hatching time was recorded every 12 h. Chicks were removed every 12 h intervals from 444 to the 504 h of incubation and hatching weight were recorded to the nearest 0.1 g.

In the second and third trials, three eggs per treatment were removed for the weight of embryos on the 5th, 7th, 9th, 11th, 13th and 15th days of incubation. Eggs were broken open and embryos were separated and weighed individually after removing the yolk sac and wrapped thoroughly with a tissue paper. Measurements were made of embryonic growth every two days from 5 to 15 days of age, hatching time, HP, PL, PD, ED, LD and chick weight at hatch.

Data were subjected to analysis of variance (SAS Institute, 1985). All per cent data were transformed using arc sine square root percentage transformation before analysis. Differences between treatment means were tested using the least significant difference (LSD) procedures when significant variance ratios were detected.

RESULTS

Embryo weight, expressed both on an absolute (g) and a percentage (embryo weight \times 100/egg weight) basis, daily weight gain (gm/day) of embryos incubated in D and GL treatments are presented in Table 1. The GL incubation of eggs and age of the embryo significantly ($p<0.01$) increased the weight as an absolute or a percentage and daily weight gain of embryos. There were interactions of incubation treatment by age of embryo for weight (g) and daily weight gain of embryos ($p<0.02$) and embryo weight percentage ($p<0.04$). The weight (g) and daily weight gain of embryos

at 11, 13 and 15 days of age were higher in the GL treatment compared with the D treatment. Embryo weight percentage of the GL group at 11 and 13 days of age was higher than those of the D treatment.

Eggs incubated under the GL conditions hatched earlier; approximately 50% of hatched occurred after 456 h of incubation (90% of the period required for all eggs to hatch of 21 days, Figure 1). Whilst, the commencement of hatch from the D group of eggs lagged behind the GL treatment by about 12 h; approximately 6.5% hatched occurred after 456 h of incubation. The calculated weight mean of hatch times were 465 and 489 h of incubation for the GL and D groups, respectively.

Eggs incubated under the GL condition had significantly ($p<0.01$) higher HP and lower ED, LD and PL than those incubated under the D-control treatment (Table 2). There were significant differences ($p<0.01$) in HP, ED, LD and PL among the three trials. LD was significantly influenced by an interaction between incubation treatment and trial. The GL incubation of eggs obtained from 33 (trial 1) and 41 (trial 3) weeks old flocks produced significantly ($p<0.01$) lower percentage of LD embryos than those obtained from 38 (trial 2) weeks old flock. However, the percentage of LD embryos of the D incubated eggs was significantly ($p<0.01$) reduced as the age of the flock increased.

The effects of GL incubation on chick hatching weights, expressed both on an absolute and percentage basis are shown in Table 3. The GL incubation significantly ($p<0.01$) reduced chick weight at hatch expressed as an absolute value and percentage basis. There were significant ($p<0.01$) differences in egg weight and chick weight at hatch as an absolute value or as a percentage of egg weight ($p<0.05$) among the three trials. Egg weight and chick weight (g) increased with age of the flock from 33 to 42 weeks of age in trial 1 to 3. However, there was no significant difference in chick weight as a percentage of egg weight between trial 2 and 3.

The relationship of hatch time, egg weight and chick weight is shown in Table 4. Hatch time significantly

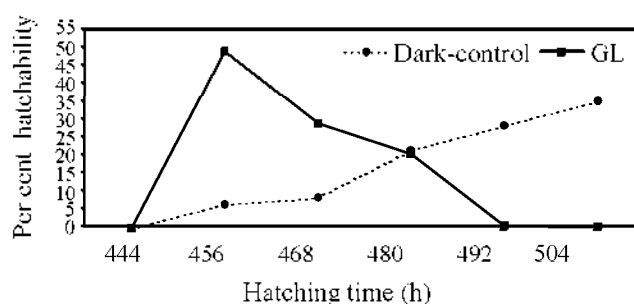


Figure 1. Per cent of hatch chicks from 444 to 504 h of incubation of meat-type breeder eggs under Dark-control and continuous green light (GL).

Table 1. Mean of embryo weight expressed both on an absolute and percentage basis (embryo weight \times 100/egg weight) and daily weight gain of meat-type breeder embryos incubated under dark and continuous green light between 5 and 15 days of age¹

Age (days)	Incubation treatment	Egg weight (g)	Embryo weight (g)	Embryo weight (%)	Embryo daily weight gain (g \times 100/day)
5	Dark-control	63.4 \pm 1.1	0.13 \pm 0.01 ^l	0.23 \pm 0.01 ^h	2.7 \pm 0.09 ^l
	Green light	63.6 \pm 0.6	0.30 \pm 0.02 ^l	0.41 \pm 0.03 ^h	5.7 \pm 0.46 ^l
7	Dark-control	63.7 \pm 1.1	0.94 \pm 0.02 ^b	1.51 \pm 0.01 ^g	13.5 \pm 0.29 ^h
	Green light	63.7 \pm 1.4	1.10 \pm 0.04 ^b	1.72 \pm 0.04 ^g	15.7 \pm 0.65 ^h
9	Dark-control	63.7 \pm 1.2	2.13 \pm 0.02 ^g	3.35 \pm 0.08 ^f	23.7 \pm 0.18 ^g
	Green light	62.9 \pm 1.2	2.43 \pm 0.07 ^g	3.87 \pm 0.04 ^f	27.0 \pm 0.79 ^g
11	Dark-control	63.2 \pm 1.1	5.24 \pm 0.19 ^f	8.29 \pm 0.18 ^e	47.7 \pm 1.73 ^f
	Green light	63.2 \pm 0.8	6.26 \pm 0.06 ^e	9.91 \pm 0.06 ^d	56.9 \pm 0.53 ^e
13	Dark-control	59.2 \pm 1.2	9.13 \pm 0.12 ^d	15.44 \pm 0.11 ^c	70.2 \pm 0.92 ^d
	Green light	59.3 \pm 1.0	10.47 \pm 0.40 ^c	17.66 \pm 0.66 ^b	80.5 \pm 3.12 ^c
15	Dark-control	63.3 \pm 1.6	15.28 \pm 0.10 ^b	24.22 \pm 0.59 ^a	101.8 \pm 0.51 ^b
	Green light	64.1 \pm 1.4	15.91 \pm 0.78 ^a	24.82 \pm 1.17 ^a	106.0 \pm 5.24 ^a
Main effect means					
Incubation treatment :					
	Dark-control	62.6 \pm 0.5	5.33 \pm 0.9	8.61 \pm 1.4	42.2 \pm 5.7
	Green light	62.8 \pm 0.5	5.91 \pm 0.9**	9.48 \pm 1.5**	47.5 \pm 6.1**
Age (days) :					
	5	63.5 \pm 0.6 ^a	0.21 \pm 0.02 ^f	0.32 \pm 0.03 ^f	4.2 \pm 0.5 ^f
	7	63.2 \pm 0.9 ^a	1.02 \pm 0.03 ^e	1.61 \pm 0.04 ^e	14.6 \pm 0.5 ^e
	9	63.3 \pm 0.8 ^a	2.28 \pm 0.06 ^d	3.61 \pm 0.09 ^d	25.4 \pm 0.6 ^d
	11	63.2 \pm 0.6 ^a	5.75 \pm 0.18 ^c	9.10 \pm 0.26 ^c	52.3 \pm 1.6 ^c
	13	59.2 \pm 0.7 ^b	9.80 \pm 0.28 ^b	16.55 \pm 0.46 ^b	75.4 \pm 2.2 ^b
	15	63.7 \pm 1.0 ^a	15.59 \pm 0.39 ^a	24.52 \pm 0.63 ^a	103.9 \pm 2.6 ^a

¹Mean \pm SEM.a,b,c,d,e,f,g,h,j Means within column followed by different superscripts are significantly different ($p < 0.05$).** Significant difference ($p < 0.01$).

($p < 0.05$) influenced chick weight expressed both on an absolute value or relative weight to egg weight basis. Chicks hatched at 504 h of incubation had significantly higher body weights than those hatched at 456, 468 or 492 h of incubation. Whilst, relative chick weight to egg weight of chicks hatched at 504 h of incubation was higher than that of chicks hatched at 456 h of incubation. There were interactions of hatch time by incubation treatment for chick weights as an absolute value or relative weight to egg weight ($p < 0.05$). The weight (g) of birds hatched at 492 h of incubation was significantly higher in the GL group when compared with that of the D group. Whilst chick weight percentage of birds hatched at 468 h of incubation was significantly lower in the GL group when compared with that of the D group.

DISCUSSION

Results from this study and others (Lauber and Shutze, 1964; Garwood et al., 1973; Coleman and McDaniel, 1975; Lowe and Garwood, 1977) indicate that chicken embryos are very sensitive to fluorescent light (FL). Lighted incubation of eggs results in an increase in cell proliferation rate and overall growth acceleration during early development (Ghatpande et al., 1995). GL incubation of

meat-type breeder eggs increased weights, expressed both on an absolute value and percentage basis and daily weight gain of embryos compared with the D incubation treatment (Table 1). The embryos of the GL treatment grew at a faster rate than did the D treatment, beginning at day 11 of incubation and continuing to day 15 of incubation. Similar findings of FL stimulatory effect on chicken embryonic growth were reported by other research scientists, beginning at 5 to 15 days of age (Garwood et al., 1973; Coleman and McDaniel, 1975; Lowe and Garwood, 1977). Differences in the magnitude of the stimulatory effect of light on embryonic growth found in the literature are related probably to the source and amount of light that reaches the embryo. Ghatpande et al. (1995) demonstrated that the amount of light reaching the developing embryos might determine the stimulatory effect and consequently the amount of growth acceleration that occurred. Egg weight and the length of incubation period are the two main factors that determined the growth of embryo in avian species (Ricklefs and Starck, 1998). The non-significant difference in egg weight between the two treatments suggests that GL incubation has affected embryonic growth rates independent of egg size.

The GL incubation of eggs increased hatchability per cent and reduced dead embryos (ED plus LD) per cent by

Table 2. Mean per cent of fertility, hatchability, and hatchability failures of meat-type breeder eggs incubated under dark-control and continuous green light¹

Incubation treatment	Trial	Fertility (%) ²	Hatch of fertile Eggs (HP) (%)	Early embryo deaths (ED) (%)	Late embryo deaths (LD) (%)	Pipped with live embryos (PL) (%)	Pipped with dead embryos (PD) (%)
Dark-control	1	93.9±2.1	83.3±0.9	5.8±0.4	8.3±0.4 ^a	1.2±0.2	1.4±0.2
	2	91.4±1.8	86.0±0.9	5.0±0.3	7.0±0.5 ^b	0.8±0.1	1.2±0.2
	3	92.1±1.9	89.1±0.6	5.1±0.4	3.7±0.4 ^e	1.0±0.1	1.1±0.2
Green light	1	94.6±1.5	88.6±0.4	3.3±0.3	5.1±0.5 ^d	1.1±0.1	1.9±0.2
	2	93.9±2.1	89.4±0.7	2.2±0.2	6.4±0.6 ^c	0.6±0.1	1.4±0.2
	3	90.8±2.0	92.2±0.3	2.1±0.2	3.4±0.3 ^e	0.8±0.1	1.5±0.3
Main effect means							
Incubation treatment							
Dark-control		92.5±1.2	86.0±0.6	5.3±0.2	6.4±0.4	1.0±0.1	1.3±0.1
Green light		93.1±1.1	90.1±0.4**	2.4±0.3**	4.9±0.4**	0.9±0.1**	1.6±0.1
Trial ³ :							
1		94.2±1.3	85.8±0.8 ^a	4.6±0.4 ^a	6.7±0.3 ^a	1.2±0.1 ^a	1.7±0.2
2		92.5±1.3	87.6±0.7 ^b	3.7±0.3 ^b	6.7±0.4 ^a	0.7±0.1 ^c	1.3±0.1
3		91.5±1.4	90.7±0.5 ^c	3.6±0.4 ^b	3.5±0.2 ^b	0.9±0.1 ^b	1.3±0.2

¹ Mean±SEM.² Per cent of fertile eggs.³ Eggs obtained from flocks at 33, 38 and 41 weeks of age for trials 1, 2 and 3, respectively.** Significant difference ($P < 0.01$).ab,c,d,e Means within column followed by different superscripts are significantly different ($p < 0.05$).

approximately 4.8% and 37%, respectively (Table 2). These incubated eggs hatched earlier by approximately 24 h

Table 3. The effect of dark-control and continuous green light incubations of meat-type breeder eggs on chick hatching weight, expressed both on an absolute and percentage basis (chick weight ×100/egg weight)¹

Treatment	Egg weight (g)	Chick weight (g)	Chick weight (%)
Incubation treatment			
Dark-control	60.7±0.3	40.3±0.2	66.3±0.2
Green light	60.9±0.3	39.5±0.2**	64.9±0.3**
Trial			
1	59.1±0.2 ^c	38.4±0.2 ^c	65.0±0.3 ^b
2	61.6±0.3 ^b	40.9±0.3 ^b	66.3±0.4 ^a
3	63.5±0.3 ^a	42.1±0.3 ^a	66.3±0.3 ^a

¹ Mean±SEM.** Significant difference ($p < 0.01$).ab,c Means within column followed by different superscripts are significantly different ($p < 0.05$).

results were in agreement with Coleman and McDaniel (1975) who found more life embryos in the FL incubated treatment of Single Comb White Leghorn eggs when compared with that of the dark treatment. Similar improvement in hatchability were reported from lighted incubation of meat type strain eggs (Szymkiewick et al., 1985). However, these findings were not in agreement with Zakaria (1989) who reported no difference in hatchability of meat-type breeder eggs between FL and dark incubations, nor do they agree with those of Bowling et al. (1981) who reported a reduction in hatchability of White Leghorn eggs due to lighted incubation.

The hatch time of the GL and D treatments of 465 and 489 h of incubation, respectively, revealed that the GL

Table 4. Mean chick weight expressed both on an absolute and percentage basis (chick weight×100/egg weight) of meat-type breeder eggs hatched in different times under dark and continuous green light incubations¹

Incubation treatment	Hatch time (h)	Egg weight (g)	Chick weight (g)	Chick weight (%)
Dark-control	456	58.7±1.1	37.5±0.8 ^f	63.9±0.7 ^e
	468	60.1±0.4	40.1±0.4 ^{cde}	66.7±0.3 ^{ab}
	480	61.5±0.5	41.0±0.4 ^{bcd}	66.7±0.5 ^{ab}
	492	60.7±0.4	39.5±0.5 ^e	65.1±0.7 ^{bcd}
	504	63.1±0.7	42.2±0.3 ^{ab}	67.1±1.0 ^a
Green light	456	58.7±0.4	37.7±0.3 ^f	64.4±0.5 ^{cde}
	468	61.7±0.4	39.8±0.4 ^{de}	64.3±0.5 ^{de}
	480	62.8±0.9	41.5±0.8 ^{bc}	66.0±0.4 ^{abcd}
	492	63.7±1.1	43.5±1.0 ^a	66.2±0.5 ^{abc}
	504	62.7±0.9	41.6±0.5 ^b	66.3±0.8 ^{ab}
Main effect means				
Hatch time (h)				
456		58.7±0.4 ^c	37.7±0.3 ^d	64.3±0.4 ^b
468		60.9±0.3 ^b	40.0±0.3 ^c	65.6±0.3 ^{ab}
480		61.8±0.5 ^b	41.1±0.4 ^{ab}	66.5±0.4 ^a
492		61.4±0.4 ^b	40.4±0.5 ^{bc}	65.8±0.6 ^a
504		63.0±0.5 ^a	42.0±0.3 ^a	66.9±0.7 ^a

¹ Mean±SEM.ab,c,d,e,f Means within column followed by different superscripts are significantly different ($p < 0.05$).

(Figure 1). The GL incubation accelerated hatch times, resulting in approximately 43% more chicks being hatched at 456 h of incubation compared with chicks hatched in the D-control treatment. Hatch time of eggs is influenced by many factors including egg weight and environmental

factors of incubation. Generally a shorter incubation period is associated with smaller egg weight (Smith and Bohren, 1975; Bohren, 1978). However, egg weights of the GL and D treatments were comparable (Table 3). These results suggest that the shorter incubation period of the GL group of eggs is related to the higher growth rates of their embryos. The observation that lighted incubation of chicken eggs reduced hatch time is consistent with other researchers (Siegel et al., 1969; Walter and Voitle, 1972; Coleman and McDaniel, 1975; Bowling et al., 1981) who have reported a reduction in hatch time from 5 h to 3 days due to lighted incubation.

Results from this study showed that egg weight and chick weight at hatch increased with hen age from 33 to 41 weeks of age in trials 1 to 3, as predicted (Table 3). It is well known that egg weight increases with increasing the age of the hen (Lowe and Garwood, 1977; Shanawany, 1984; O'Sullivan et al., 1991). The weight of the chick is proportional to the weight of the egg from which it hatches (Halbersleben and Mussehi, 1922; Morris et al., 1968; Hager and Beane, 1983; Suarez et al., 1997; Bruzual et al., 2000). The reduction in chick weight of the GL group at hatch when compared with that of the D group suggests that the increase in weight at early embryonic stage disappeared at hatching stage. This reduction in hatching weight of the GL chicks may be due to the short incubation period of GL treatment of eggs when compared with the incubation period of the D-control treatment (465 vs 489 h) and/or a greater growth rate of embryos in the D-control group at the late stage of incubation. Further study may be needed to clarify these points. This finding agrees with the results of Gill and Gangwar (1985) and Bowling et al. (1981), but contradicts with the findings of Lauber and Shutze (1964) and Lowe and Garwood (1977). Coleman (1979) and Zakaria (1989) who found no differences in body weight at hatch between lighted and dark incubations of eggs. Whilst Coleman and McDaniel (1975) reported an increase in body weight at hatch of FL incubated eggs. However, in a later study Coleman (1979) found that weight of meat chickens at hatch from eggs incubated under FL was influenced by egg size, whereas chick hatching weights obtained from large size eggs were least affected by light. Hatch time and chick weight as an absolute value or a percentage of egg weight were increased with increasing the weight of the eggs (Table 4). This finding was in agreement with Williams et al. (1951) who reported that embryos of larger eggs required more time to develop and a longer incubation period than did those of small eggs.

There is some disagreement in the literature concerning the effects of lighted incubation on embryonic growth, HP, hatch time and chick weight at hatch. The acceleration of embryonic development depends on the type and amount of light that reaches the embryo. Using different intensities of

FL for the first 40 h of incubation in ovo. Ghatpande et al. (1995) found that the maximum acceleration of growth was obtained at intensity range of 1,500-3,000 lux without any adverse effects as compared with dark-incubated control. The authors found no significant growth-accelerating effect in chick embryo when FL at the density range of 800-1500 lux was used. Gold and Kalb (1976) reached similar conclusion when FL at the density range of 700-1100 lux was used. The difficult equation of lighting system is probably providing the proper amount and quality to chickens embryos.

Results from this and previous lighted incubation studies suggest that there are several factors, which can influence the acceleration of embryonic growth. These include: 1) source, spectra and intensity of light, 2) egg size and eggshell characteristics (pigmentation, porosity, and thickness). Recently, Shafey et al. (2002) concluded that the egg size, pigmentation and conductance of eggshells influenced the amount of light transmitted through the eggshell and consequently the outcome of lighted incubation. Coleman and McNabb (1975) found that the development of embryos with pigmented shells of Japanese Quail eggs is slower than those in unpigmented shells and that depigmentation of eggshells results in early hatching. Both groups were incubated under light.

It is concluded that the incubation of meat-type breeder eggs under continuous green light increased embryonic growth and hatchability per cent and reduced incubation period and chick weight at hatch.

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