The Eurasia Proceedings of Science,
Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2018

Volume 2, Pages 201-208

ICRES 2018: International Conference on Research in Education and Science

Effects of Light on Egg Performance and Behaviour in Japanese Quails (*coturnix coturnix japonica*)

Gokce Irem DEMIRCI DEMIRBAS
ISTEK Private Atanur Oguz Anatolian High School

Cuneyt KUBANC
Istanbul University

Abstract: Lighting period (photoperiod) is one of the most important environmental factors affecting on animals. Thus, we aimed to investigate the effect of lighting period on efficient production performance of Japanese quails under controlled environmental conditions via the egg yield and behavioural characteristics. 48 female and 12 male Japanese quails (Coturnix coturnix japonica) were randomly divided into two groups with two replicates. A scheduled lighting program was applied as 7 Light (L): 17 Dark (D), 6L:18D, 5L:19D, 4L:20D, 3L:21D for five-day periods along 25 days in total using a metal halide lamp with an intensity of light at 41.5 lx to the trial group. At the end of observation, 162 eggs without any damage were obtained from the birds exposed to scheduled lighting program whereas the mean number of damaged eggs/total number of eggs (DE/TE) ratio was 37% in control group exposed to normal daylight length. The number of damaged eggs was correlated with the total number of eggs ($p<0.01$ vs. control) and egg weight ($p<0.0001$) in trial group. Egg weight was also found to correlate with body weight ($p<0.01$ vs. control). During observational experiments any significant difference was recorded in wing stretching, drinking and playing in both groups. However, birds exposed to shortened light headed for less feeding and laying ($p<0.05$ vs. control) and had leaning to aggressive behaviours such as shouting or stridulating, feather and egg pecking and cannibalism. In conclusion, adding darkness to lighting program contributes energy saving with the equal or even improved production performance in aviaries.

Keywords: Behaviour, Egg production, Lighting program, Quail

Introduction

Commercial quail is one of the alternative sources for animal protein foods especially in underdeveloped countries. Therefore, Japanese quails are mostly kept in battery cages with the purpose of benefiting their eggs and meat (Jatoi et al 2013b). Production performance studies with broilers (Altan et al 1998), quails (Sarıca 1998) and pheasants (Tepeli et al 2000) are mostly focused on feed intake, feed conversion ratio, egg quality, effects of various environmental conditions as light.

Light, as a powerful exogenous factor in control of many physiological and behavioural processes, is one of the most important environmental factors affecting broiler performance and physical activity (Olanrewaju et al 2006, Bayram & Özkan 2010, Ma et al 2013). Light intensity, colour and photoperiodic/scotoperiodic regimes have different effects on physical activities of broiler chickens (Olanrewaju et al 2006). In particular, manipulation of light intensity is a widely adopted management tool (Deep et al 2012) affecting broiler production, behaviour and welfare (Bayraktar et al 2012). Therefore, many light patterns have been applied so far, such as continuous lighting (Mahmud et al 2011, Jatoi et al 2013b), near-continuous lighting (Olanrewaju et al 2006, Bayraktar et al 2012), light and dark periods (Bayram & Özkan 2010, Schwean-Lardner et al 2012), intermittent lighting programs (Rahimi et al 2005, Olanrewaju 2006, Mahmud et al 2011, Jatoi et al 2013b, Ma et al 2013) different colours of light (Olanrewaju et al 2006) and various light sources (Ghuffar et al 2009) to rear broilers in numerous studies conducted in various countries. Mostly, broilers have been kept on a

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continuous or nearly continuous lighting schedule to maximize feed intake and grow rate (Rahimi et al 2005, Bayram & Özkan 2010 Schwean-Lardner et al 2012). In order to improve welfare and save energy alternative programs with shorter daylight lengths may be applied (Bayram & Özkan 2010). Many studies in different countries showed that different light regimens have significant effects on weight gain and disease problems (Mahmud et al 2011). For instance; birds exposed to near-continuous light had less feed efficiency, but showed higher mortality than birds exposed to longer dark period (Schwean-Lardner et al 2012). Therefore, most of the recent researches have headed for limited light regimens to improve production in broilers due to the low physical activity of birds during darkness (Mahmud et al 2011).

The purpose of this study is to investigate the effect of lighting period on production performance of Japanese quail under controlled environmental conditions. For integrative investigation of the effects of lighting period on the complex interrelation between production performance and lighting period, we measured egg yield and behaviour characteristics.

Method

All experiments in this study were approved by the institutional Animal Experimentation Committee of Istanbul University Cerrahpasa Medical School (31653:07.12.2006). Care and handling of the animals were in accordance with the guidelines for Institutional and Animal Care and Use Committees. The current study has been carried out in accordance with the Declaration of Helsinki.

Animals and Housing

Experiments were performed on 48 female, 12 male Japanese quails at 6-weeks of age with a mean± SEM body weight of 245.9±3.1 g. This research was carried out in two laboratories under same environmental conditions except light. Both laboratories' conditions were kept at 20°C±1 and relative humidity rate were adjusted as 37.4 %. Feed (quail pellet feed with 20 % Crude Protein and 2850 Kcal/kg Metabolic Energy) and water were provided ad libitum in all groups during the entire experimental period (Çoban et al 2008, Duve et al 2011).

Experimentation and Scheduled Lighting Program

48 female and 12 male Japanese quails (Coturnix coturnix japonica) were randomly divided into two groups. Birds in Group 1 served as trial group including 12 female and 3 male Japanese Quails (n=2) and exposed to scheduled lighting program as 7 Light (L):17 Dark (D), 6L:18D, 5L:19D, 4L:20D, 3L:21D for five-day periods along 25 days in total. A halogen lamp with 150 W was used to mimic the colour of daylight and photoperiod was provided with an intensity of light at 41.5 lx, calculated according to the formula (Özkaya 1972);

$$\Phi = (E_{on} \times S) / \eta$$

Where Φ is light flux, Eon is light intensity, S is illuminated area, η is performance of light. Calculation was confirmed with the lx meter of 4 in 1 Multifunction Environment Meter. Moreover, birds in Group 2 served as control including 12 female and 3 male Japanese quail (n=2) and exposed to normal day light length.

Measurements and Observations

Throughout the experimental protocol, the weight of individuals and their eggs in each group were daily measured with a high sensitive digital scale (Excell BH-600).
Eggs in every group were collected daily and the total, damaged and undamaged eggs were counted. Damaged egg ratio (%) was calculated as:

$$N_d/N_t$$

Where N_d is the number of damaged eggs, N_t is the number of total eggs.
For behavioural analysis, various types of behaviour patterns were classified as stretching, water drinking, feeding, playing, stridulating and egg-laying of individuals were observed during the entire protocol (Vercellino et al 2012, Vercellino et al 2013).

Statistical Analysis

Values were reported as mean ± SEM. Statistical analysis was performed using GraphPad Prism version 5.0 for Windows (GraphPad Software, San Diego, CA, USA). Two-tailed Pearson Correlation Test was used to analyze the relationships between lighting periods, number of undamaged eggs, egg weight and body weight. A p-value of <0.05 was considered statistically significant.

Results and Discussion

Egg Performance

Total 162 eggs were obtained from the birds exposed to scheduled lighting program. None of them was found to be damaged. However, total 289 eggs were obtained from birds in control group and 108 of them were damaged. In control group, mean value of DE/TE ratio was 37±3 % and mean value for egg weight was 11.97±0.07 g. Minimum egg weight per day was 11.31 g and 12.63 g as maximum egg weight of group exposed to normal day light length. In trial group exposed to lighting program, minimum egg weight per day was 11.94 g, 12.89 g as maximum and mean value of egg weight was 12.34±0.06 g (table 1). The total number of eggs was correlated with the number of damaged eggs in trial group ($p<0.01$ vs. control) but the effect was minor. The number of damaged eggs was also correlated with the egg weight ($p<0.0001$) (table 3).

Table 1 EW (g/individual/cage), BW (g/individual/cage), DE/TE, and EW/BW (%) ratio in two groups

	Control				Trial		
	DE/TE (%)	EW (g)	BW(g)	EW/BW	EW (g)	BW(g)	EW/BW
Min	10	11.31	249.2	0.04	11.94	240.20	0.04
Max	67	12.63	261.2	0.05	12.89	248.30	0.05
Mean	37±3	11.97±0.07	255.3±0.53***	0.04	12.34±0.06	245.3±0.46	0.05

Body Weight

Birds exposed to lighting program in trial group had 240.2 g body weight per day as minimum and 248.3 g as maximum and 245.3±0.5 g as mean value of body weight whereas 249.2 g as minimum, 261.2 g as maximum body weight and 255.3±0.53 g ($p<0.0001$) as mean value for body weight in control group (table 1). The egg weight was correlated with body weight in the trial group ($p<0.01$) (table 2) and, EW/BW was found to be correlated with egg weight in both trial and control groups (table 2-3); but egg weight was not found to be correlated with the ratio in control group on contrary to trial group ($p<0.0001$) (table3). There was no correlation between body weight and the total number of eggs in both trial and control groups (table 2-3). However, number of damaged eggs in control group was significantly correlated with EW/BW ($p<0.0001$) (table 3).

Table 2. Correlation among TE, EW, BW and EW/BW in trial group

Trial	TE	EW	BW	EW/BW
TE		p>0.05	p>0.05	p>0.05
EW	p>0.05		P=0.0086 $r^2=0.26$	p<0.0001 $r^2=0.93$
BW	p>0.05	p=0.0086 $r^2=0.26$		p<0.0001 $r^2=0.50$
EW/BW	p>0.05	p<0.0001 $r^2=0.93$	p<0.0001 $r^2=0.50$	

Table 3. Correlation among TE, EW, BW and EW/BW in control group

Control	TE	DE	EW	BW	EW/BW
TE		P=0.01 r^2=0.23	p>0.05	p>0.05	p>0.05
DE	P=0.01 r^2=0.23		P<0.0001 r^2=0.55	p>0.05	P<0.0001 r^2=0.54
EW	p>0.05	P<0.0001 r^2=0.55		P=0.98 r^2=0.00003	P<0.0001 r^2=0.99
BW	p>0.05	p>0.05	p>0.05		p>0.05
EW/BW	p>0.05	P<0.0001 r^2=0.54	P<0.0001 r^2=0.99	p>0.05	

Behavioural Features

As behavioural features were compared between two groups; there was not a significant difference in wing stretching, drinking and playing in both groups (p>0.05). However, birds in trial group showed lesser feeding and egg laying and even no aggression behaviours such as shouting or stridulating (p<0.05 vs. control group) (figure 1).

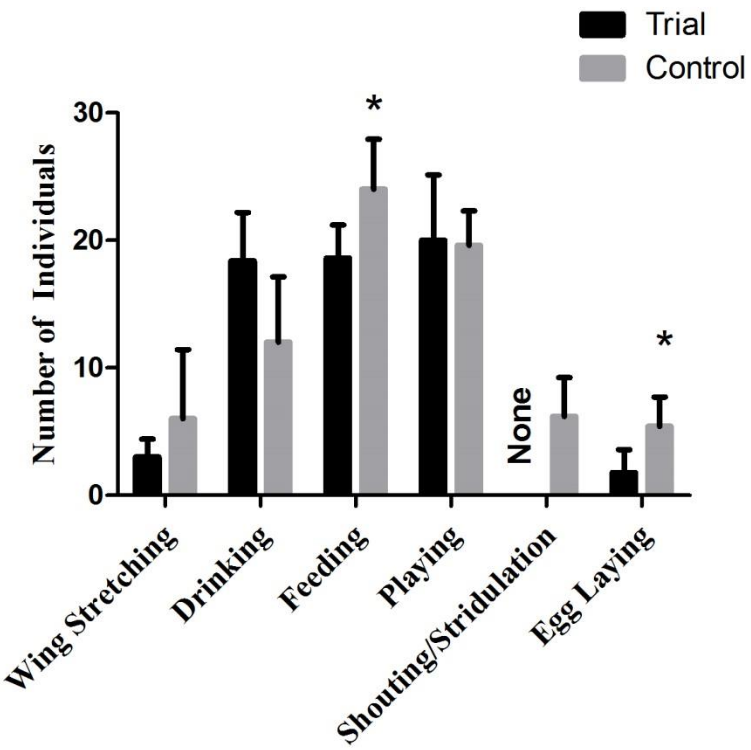

Figure 1. Behavioural features observed in trial and control groups

The results of the present study showed that the birds exposed to scheduled lighting program starting from 7h light and 17h darkness had the most production of egg during 5h light and 19h darkness applied. The most remarkable point of this finding was that the production performance of this group is 100% and the eggs obtained from these birds were all undamaged.

There are many factors affecting on egg performance such as diets, feeding time and method (Kocaman et al 2006), alternatives for feeding ingredients (Yıldırım & Öztürk 2013, Ertaş et al 2006, Tekeli et al 2005, Karaoğlu et al 2004, İpek et al 2003, Bozkurt et al 2001), cage density (Kum &Kocaoğlu-Güçlü 2006), age (Şeker et al 2005), body weight (Jatoi et al 2013a), egg weight, and heat stress (Ertaş et al 2006), besides light factors (intensity, colour, and photoperiod).

Results on production performance seem to be closer to Kocaman et al (2006) who previously reported a negative and significant correlation between the air content (CO_2) in aviaries and relative humidity and egg production. Moreover similar results were found by Narinç et al (2010), who determined that total number of eggs in selection group of their study as 107.92 with a peak performance value of 90.41%. Our results regarding to the number of eggs were also similar to small close-bred flocks in imported group of Jatoi et al (2013a); in mean egg weight were lower than the heavy close-bred flocks'. In another study of Jatoi et al (2013b) had the highest egg production in the group exposed to shorter lighting hours as in our research. When we compare the results with ours, we thought that the production performance may be increased as the lighting hours get shortened. Even, the egg weight of the shorter lighted group of Jatoi et al (2013b) is closer to the result of group exposed to standard lighting program in ours. Kum and Kocaoğlu-Güçlü (2006) applied just the opposite of our starting point for lighting program (17h light and 7h darkness)and got the results closer but lower than ours. Şeker et al (2005), Nazlıgül et al (2001), and Yıldırım & Öztürk (2013) applied 16 h light and 8 h darkness in their studies. As the results in egg weight of Yıldırım and Öztürk (2013) were closer to ours; the results of egg weight in Nazlıgül et al (2001) and Şeker et al (2005) were lower than our results.

İpek et al (2003) and Tekeli et al (2005) added Cu at limited levels to laying-hen diets and observed that this heavy metal had a positive effect on egg production and egg weight. İpek et al (2003) used Cu with Zn in diets. These heavy metals are important trace elements needed at very limited values in the organisms. So up to a limit value it is possible to say that adding these metals to pellet feed may affect in a positive way but must be careful to accumulation and harms of these elements in the organisms. For egg weight, we suggest applying shorter lighting program to hens rather than to adding these metals to their diets, because the results of our study were very closer to heavy metal applied ones (12.34 ±0.06 g).

Ertaş et al (2006) investigate the effect of mussel shell supplementation as calcium source on egg production and egg weight in heat-stressed layer Japanese quails and stated that supplementation of mussel shell to the diets improved egg production and egg weight. Mussels are the bio indicator organisms in aquatic ecosystems and this means they accumulate the aquatic pollution, mostly known heavy metals containing Cd, Cu, Pb, Zn, at very high concentrations. By adding the shells of these organisms to the fodder of laying-hens it is possible to say that food chain continues and the bioaccumulation gets higher and higher up to next organism. The result of this study is closer to our results in terms of egg weight; but lower than our production performance.

Bozkurt et al (2001) added zeolite to fodder at different levels and stated that this had a positive effect on DE/TE ratio. But the results of this study gave us an idea that adding zeolite to fodder and scheduled lighting as 5h lighting/19h darkness to quails may be applied to improve egg performance in aviaries. Because we had no damaged eggs if we add zeolite at a limited value with energy saving procedure this may also increase the production performance to up levels.

Karaoğlu et al (2004) and Bozkurt et al (2001) are the only studies that indicated the DE/TE ratio of their researches among the studies that we scanned through. Bozkurt et al (2001) added zeolite and Karaoğlu et al (2004) added sorghum at certain levels to fodder and noted that the ratios were 1.062 and 0.75 respectively. The two researches were closer to each other in production performance but lower than our results.

Ma et al (2013) investigated the effect of an alternative intermittent lighting program on production performance of laying-hens and their results for egg production seems to be lower than the results of this present study. The percentage of cracked eggs is higher than our investigation.

We noted the mean body weight as 245.3 g in trial group and 255.3 g in control cage. These findings are in same way as Bayraktar et al (2012), a study related with the effects of spot lighting on broiler performance, metal halide group of Ghuffar et al (2009); but far away from the findings of Altan et al 1998. The most interesting point related with body weight results is about the correlations between the parameters. We noticed that body weight was correlated with egg weight and the number of damaged eggs but not correlated with number of total eggs. So it is possible to say that egg parameters as numbers are not related with body weight, may be with feed intake and feed conversion ratio due to the relationship between these parameters and body weight.

According to the observational results we are able to say that long-term lighting period is one of the most important stress factors affecting on production performance in aviaries. In experimental group we noticed that the aggression behaviours as pecking feathers and eggs, preening, and cannibalism mostly between males were decreased, even not observed. We interpreted these results due to shortened lighting period. These results are in the same direction with the study of Wechsler and Schmid (1998). Gilani et al (2012) observed severe feather pecking behaviour type in their experimental group, containing dark brooders. It is shown that the hormone melatonin caused the reduction of locomotor activity in vertebrates. Azpeleta et al (2010) demonstrated this situation in gold fish and showed that the dark period reduces locomotor activity, but when the lights on sense to feeding increased. After all these results of the existing researches, it is possible to say that adding darkness to lighting programs may result in equal or improved production performance and as a decrease in stress level. In previous studies it is stated that increasing the darkness period in lighting program may reduce leg problems and the risk of lameness, and ensure proper eye conditions. One of the negative implications of long scotoperiod is to be hunger due to low vision (Duve et al 2011). This may be the reason of reduction in feed intake and feed conversion ratio.

During darkness period, melatonin, one of pineal gland hormones, responsible for maintaining and regulating circadian rhythms in diurnal species, provides peak and is repressed by light during daylight. This hormone is produced in both pineal gland and retina in birds. Due to production in retina the effect of light predominated than the other environmental factors. In poultry rest and sleep primarily occur during scotoperiod but behaviours like feeding and drinking water mostly occur in day (Schwean-Lardner et al 2014). As Duve et al (2011) we observed feeding in trial group significantly less than control group. They noted that feeding activity was affected by both length and timing of scotoperiod. Similar findings were also noted in Schwean-Lardner et al (2014) in terms of feeding but also drinking. Bayram and Özkan(2010) observed that birds exposed to 16L:8D program turned to rest and sleep less than the other group but behaviours like drinking, pecking, preening were observed higher.

Conclusion

In conclusion, 5 h lighting 19h darkness lighting period is equal or even better production performance in terms of number of eggs and mean egg weight per individual in standard lighting programs used in aviaries. Adding darkness to lighting program helps to save energy with the equal or even improved production performance in aviaries. We hope that this study will be pioneer to the future studies on the relationship among melatonin, darkness period and aggression.

Acknowledgements

None of the authors have any conflict of interest and this study was supported by Istanbul University Scientific Research Projects Fund with the project number T-98/15122006. The authors kindly thank to Assoc. Prof. Dr. Uğur Aksu for his valuable comments on this manuscript.

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Author Information

Gokce Irem Demirci Demirbas
Istek Private Atanur Oğuz Anatolian High School
Balmumcu Mah. Gazi Umurpaşa Sk.
No:26 Balmumcu İstanbul 34349
Contact e-mail: *demirci.gokce.irem@gmail.com*

Cuneyt Kubanc
Istanbul University Faculty of Sciences,
Department of Biology,
Zoology Division, 34134,
Vezneciler, Istanbul/Turkey