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Original Research Article

Effect of Using Different Colored LED Lights on Gonads, egg Number and Weight in Japanese Quails

Key words

LED;
light color;
quail;
reproduction

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Abstract: Artificial lighting plays a crucial role in regulating the maturation of the reproductive system of birds during puberty and thus affects their reproductive capacity. The aim of this study was to investigate the morphometric effects of the use of different coloured light-emitting diodes (LEDs) on the gonads of male and female Japanese quail (*Coturnix coturnix japonica*). The experimental groups were also examined with regard to egg count, weight, fertility and hatchability. A total of 240 quails of mixed sex were subjected to three different light colours, namely white, green and blue LEDs. The anatomical condition of the birds was examined at 42 days of age. To evaluate the potential effects of the different light colours on the number and weight of eggs, a cohort of 12 female and 3 male quails from each group were observed for an additional 30 days under identical experimental conditions and light exposures. An assessment was conducted to determine the differences in the number and weight of eggs between the different groups as a function of the number of days. The use of LED lights in different colours had no significant effect on the development of the testes in males and the ovaries in females. Between days 42 and 72 of the experiment, there were no discernible differences in the egg quantities of the quails, reared under different light colours. However, the eggs in the blue light group had a higher weight than those in the white light group. Ultimately, the use of white, green and blue LED lamps for photostimulation had no discernible effect on the growth of testes and ovaries, with the exception of egg weight.

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Introduction

Lighting significantly influences poultry performance and exercise levels (1), affecting metabolic functions like feeding, digestion, and various physiological and behavioural processes. Birds perceive light through brain regions such as the pineal gland, pituitary gland, hypothalamus, and retina (2). Extra-retinal photoreceptors in these areas play a crucial role in regulating diverse biological processes in domestic poultry, including circadian rhythms, annual cycles, breeding behaviour, and the release of reproductive hormones (3, 4).

Research has investigated the effects of different light durations and intensities on the laying hens' reproductive processes, growth, sexual maturation, and reproductive performance (5–7). However, there are few studies on the effects of light wavelengths on Japanese quails. The wavelength of light affects the sensitivity of birds', which are the most sensitive at a wavelength of 562 nm within the 315-750 nm range. For broilers, blue (400–480 nm) and green (545–575 nm) light stimulates growth. Green light promotes early growth; changing light conditions further accelerate growth (8, 9). Green-to-blue or green-to-green-blue lighting enhances meat quality, body, and muscle growth during female broiler rearing (10). Yet, green light exposure during embryogenesis alters weight gain and breast muscle size in male broilers without affecting meat quality or composition (11). Green-to-blue and blue-to-green light exchanges increase broiler growth and productivity

(12). Monochromatic green light during incubation stages enhances muscle growth by augmenting satellite cell quantity and diversity (13). A combination of red and green light might mimic the effects of monochromatic red light on increasing egg production in laying hens (14).

Studies in laying hens suggest different types of light-emitting diode (LED) light affect the gorwth (14, 15) and reproduction of the animals (16). However, the effects of different LED types on the reproductive development of quails before and after puberty have only been studied to a limited extent. The aim of this study was to investigate the effects of different light sources on morphometric measurements of testes, the number of pre-ovulatory follicles, and the number, weight, fertility, and hatchability of eggs in Japanese quails. Initially, we investigated the morphometric impact of different coloured LED lights on the reproductive organs of male and female Japanese quail (*Coturnix coturnix japonica*). Additionally, we observed the number and weight of eggs in the experimental groups under identical conditions to understand their effects on eggs and fertility..

Material and methods

Birds, Bird Facilities, and Experimental Design

The Animal Care and Use Committee of Aydin Adnan Menderes University granted ethical approval (64583101/2023/28) for the experimental procedures. The study took place at the Poultry Research Unit in Turkey, where 240 mixed-sex Japanese quail (*Coturnix coturnix japonica*) were housed in a masonry shed divided into three light-isolated rooms over a 10-week period. The initial temperature was 33 °C, gradually reducing by 3 °C weekly until reaching 23 °C, while maintaining relative humidity between 50 and 60%.

The quail chicks were kept in chick rearing cages with a size of 90 cm (width) x 45 cm (depth) x 25 cm (height), and in the same position, number of feeders and drinkers throughout the experiment. Different 9 W LED bulbs (CT-4277 CATA, Turkey) were tested in the rooms, emitting blue (480 nm), green (560 nm), and white light (400–770 nm) at an intensity of 20 lx, positioned above the cages. The photoperiod was set at 24 hours of light and 0 hours of darkness (24L:0D) throughout the experiment.

Experimental Procedure

These chicks were divided into three groups of 80 quails each—48 males and 32 females—exposed to three different LED light colours (white, green, and blue). On day 42, 60 quails were randomly selected from the replicates (5 from each cage, totaling 20 birds per group) and euthanized by decapitation. Male quail testicles (total 36) were measured for dimensions and weight, while the quantity of follicles was counted in female quails. Photos of each bird were taken on millimetric paper and analysed using BSD-2-licenced Image J software for measurements (Figure 1). This aimed to assess the potential long-term effects of various light colours on morphometric measurements of testes and the number of pre-ovulatory follicles. Furthermore, within each group, 12 female and 3 male quails (excluding those euthanized) were observed for an additional 30 days (between 42nd and 72nd day) under the same light treatments and setup. Daily egg counts and weights were recorded during this period. Hen Day Egg Production (HDEP) has been observed between the 42nd and 72nd day of the trial. Hen day egg production is expressed in percentage (%) (Table 1). The fertilization rate of the eggs was calculated using the formula: (number of chicks hatched / number of eggs placed in the machine) x100. All eggs were incubated in the same incubator.

Statistical Analysis

SPSS 21.0 (Statistical Package for the Social Sciences for Windows, IBM Corp., Armonk, NY, US) was used to analyse the data. The Shapiro-Wilk test was used to determine whether the data were normal. The homogeneity of variances assumption was confirmed using Levene's test. Results from the post hoc Bonferroni test and one-way analysis of variance (ANOVA) test were used to determine whether the variances were homogeneous. If the variances were not homogenous, The Welch test and the post hoc Tamhane's T2 test were used. A statistically significant result was defined as $P < 0.05$.

Results

No significant effects on the morphometric measurements of the testes and the number of pre-ovulatory follicles were observed in the three light-colored groups. In the study with male quails exposed to white, green and blue light, testicular weight, width and length were measured in different light groups (Table 1). Despite these variations in weight, width and length measurements within the light spectrum, the analysis revealed no statistically significant differences in the testicular characteristics of male quails exposed to white, green or blue light. Female quails had an average pre-ovulatory follicle numbers of 3.50 ± 0.93 for white light, 4.63 ± 0.74 for green light, and 4.00 ± 1.31 for blue light across the groups, indicating consistency (Figure 1).

Egg counts between the days 42 and 72 under white, green, and blue lights are summarized in Table 1, with no notable difference among the groups. However, egg weights varied significantly; female quails raised in blue light produced heavier eggs compared to those under white light (P = 0.012) (Table 1). We collected 100 eggs from each group between days 62 and 72 and placed them in the incubator to check their fertilization scores.

Table 1: Comparison of testis, egg, and fertilization values taken at different days and intervals between groups

Variable	Day 42				
	Light-Emitting Diode (LED)				*P*
	n	White	Green	Blue	
Testis Weight (mm)	12	3.13 ± 0.80	2.94 ± 0.57	2.75 ± 0.68	0.421
Testis Width (mm)	12	14.70 ± 1.43	14.27 ± 1.53	14.02 ± 1.54	0.541
Testis Length (mm)	12	23.53 ± 2.85	22.99 ± 1.56	22.28 ± 2.02	0.387
Pre-ovulator follicles number	8	3,50 ± 0,93	4,63 ± 0,74	4,00 ± 1,31	0,111
Testis Relative Weight (%)	12	1,39±0,38	1,32±0,37	1,27±0,31	0,739
Day 42-72					
Egg weight (g)	12	11. 22 ± 0.49^{a}	11.25 ± 0.70^{ab}	11.61 ± 0.78^{b}	**0.012**
Average Daily Egg Number	12	10.00 ± 1.87	10.54 ± 1.44	10.25 ± 1.75	0.649
Hen Day Egg Production (%)	12	83,33 ± 3,17	87,85 ± 2,46	85,42 ± 2,98	0,649
Day 62-72					
Fertilization	100	%77	%79	%68	

Data are expressed as means ± SEM. $^{a, b}$: Means with different superscript letters in the same column differ ($P < 0.05$)

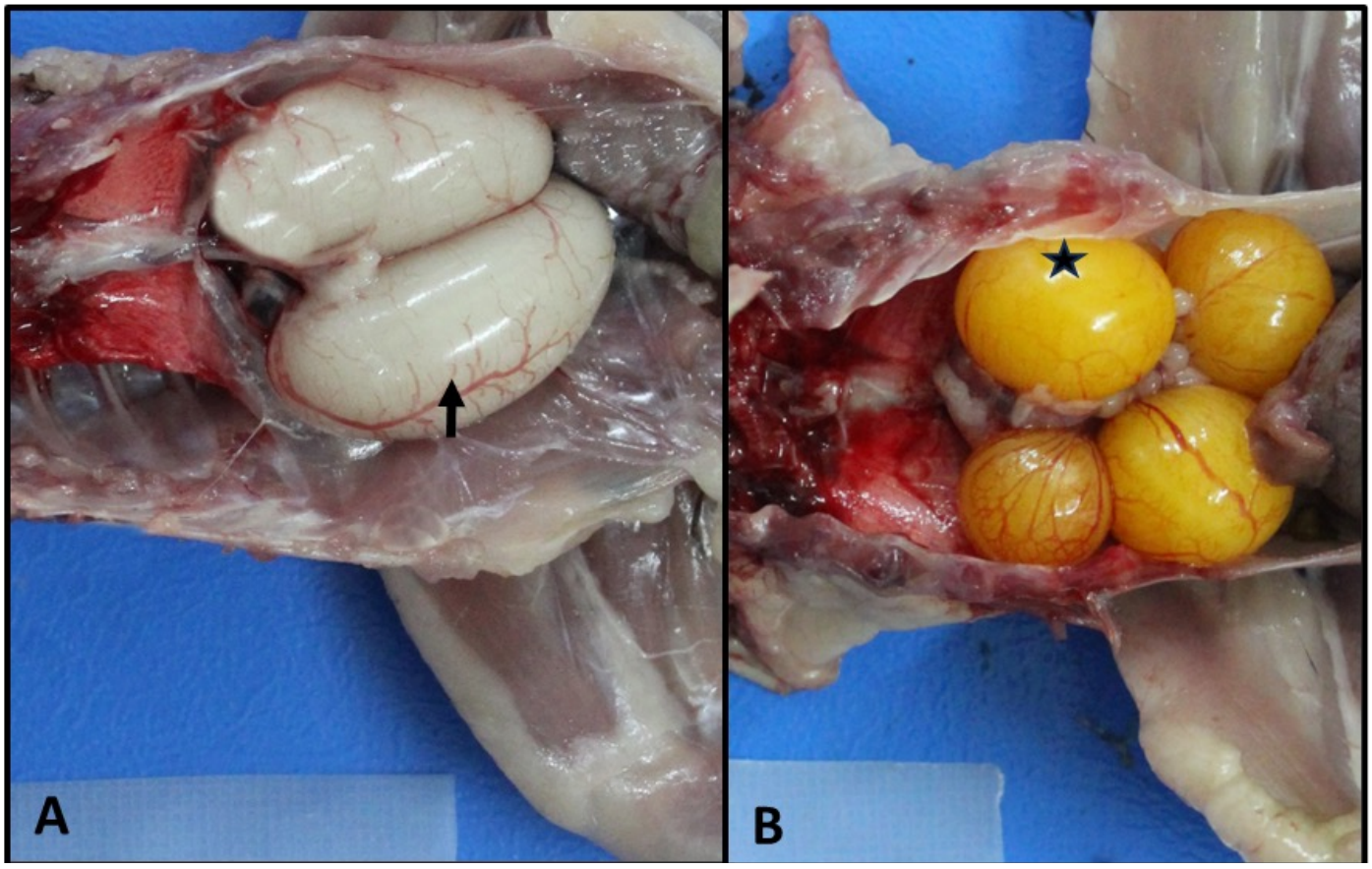

Figure 1: Representation of testicles (A) and pre-ovulatory follicles (B) with measurement paper. Black arrow; testis, black star; pre-ovulatory follicle

Upon evaluating the data, we found that out of 100 eggs in the white light group, 77 hatched. Of the remaining 23 eggs, 8 were early deaths, 6 were late embryonic deaths, and 9 were infertile eggs. For the green light, 79 chicks hatched out of 100 eggs. Of the remaining 21 eggs, 6 were early deaths, 7 were late embryonic deaths, and 8 were infertile eggs. In the blue light experiment, 68 chicks hatched from 100 eggs with 19 of the remaining 32 eggs recorded as early deaths, 4 as late embryonic deaths, and 9 as infertile eggs.

Discussion

The regulation of the hypothalamic-pituitary-gonadal axis in avian reproduction is influenced by light, activating retinal and extra-retinal photoreceptors (17). Opsin-containing photoreceptive cells, sensitive to diverse wavelengths, are the first light perceivers (18). The stimulation intensity of different wavelengths affects each photoreceptive cell individually. Shorter wavelengths like blue (400–500 nm) and green (500–600 nm) not only stimulate the retinal photoreceptors more strongly, but also suppress the reproductive axis, which affects the growth and behavior of birds (4, 17). Red light, with greater transcranial penetration (600–700 nm), primarily stimulates extra-retinal photoreceptors (4). However, the physiological effects of these wavelengths seem to vary across bird species. For instance, studies on broiler chickens show that blue and green light promotes growth (9), while red light enhances egg production in laying hens (14). In quails, exposure to green and red light appears to be beneficial for both female and male gonadal cycles (19).

Our study found no impact on the testicular weights and sizes of male quails from various light wavelengths (white, green, and blue) over 42 days. Similar findings were observed in Rete et al. (2017), where testicular weight on days 35 and 47 remained unaffected by white, green, or blue light exposure (20). However, on the day 57, quails raised in white light exhibited greater testicular weight than quails reared under blue and green light. This difference could be related to the presence of red wavelengths in white LED light, depending on the duration of exposure. Additionally, the development of the cloacal gland may have been affected, as another study found that there appears to be a significant relationship between testicular weight and cloacal gland size (21).

The number of ovaries in female quails was not affected by light of different colours in this study, which is comparable to the study of Almedia et al. (2015), in which the effects of different wavelengths (red, white, blue, green, and yellow) on the female reproductive system in Japanese quails were evaluated for 49 days (22). Ahmad et al. (2023) found no difference in the number of ovaries between white, blue, and green lights after 8 weeks (23), while Bobadilla-Mendez et al. (2016) found the most favourable results with white LED light at the 8th week (24). Studies like Rogers et al. (2015) demonstrated the effect of white LED light on the body weight of quails during the growth phase (25). However, it is known that quails exhibit limited efficiency in responding to blue and green light (26). These differences in the ability of the light sources to influence the sexual maturity of the poultry and the onset of the laying cycle probably explain these observations (27).

The evaluation of egg weights collected daily for four weeks, starting on the day 42 of the experiment, showed that quails reared with blue light produced heavier eggs compared to those reared with white light. Su et al. (2021) compared the weight of duck eggs exposed to different lighting regimes, where hens exposed to white and red light laid smaller eggs than Brown Tsaiya ducks exposed to blue light (28). Hassan et al. (2013) reported that eggs laid under red and white light weighed similarly but were lighter than those laid under blue light (14). In contrast, Ahmad et al. (2023) found no notable variation in Japanese quail egg weight between white, blue, and green light treatments (23). However, our results suggest that stimulation with white light resulted in lighter eggs than stimulation with blue light.

Conclusion

The different light wavelengths had no effect on the gonads of the Japanese quail during the 42-day experiment. However, egg weight in the following four weeks was significantly affected by exposure to blue light. Longer-term and more comprehensive studies, including histopathologic examination of the reproductive organs and assessments of reproductive hormones, are needed to better understand the effects of different light wavelengths on reproductive activity.

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Author Contributions. Ismail Gokce Yildirim: conceptualization, methodology, investigation, writing - original draft, project administration. Ece Koc Yildirim: writing, investigation. firuze Turker Yavas: investigation, formal analysis.

Author Declarations. The authors declare no conflict of interest.

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Vpliv barve led-svetlobe na spolne žleze ter na število in težo jajc pri japonskih prepelicah

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Izvleček: Umetna razsvetljava igra ključno vlogo pri uravnavanju zorenja reproduktivnega sistema ptic med puberteto in s tem vpliva na njihovo reproduktivno sposobnost. Cilj te študije je bil raziskati morfometrične učinke uporabe svetlečih diod različnih barv (LED) na spolne žleze samcev in samic japonskih prepelic (*Coturnix coturnix japonica*). Poskusne skupine so bile pregledane glede števila jajc, teže, plodnosti in valilnosti. Skupno 240 prepelic mešanega spola je bilo izpostavljenih trem različnim barvam svetlobe, in sicer beli zeleni in modri LED. Anatomska kondicija ptic je bila ocenjena pri 42 dneh starosti. Za oceno morebitnih učinkov različnih barv svetlobe na število in težo jajc je bila kohorta 12 samic in 3 samcev iz vsake skupine opazovana dodatnih 30 dni, pod enakimi poskusnimi pogoji in izpostavljenostjo svetlobi. Izvedena je bila ocena za določitev razlik v številu in teži jajc med različnimi skupinami v povezavi s številom dni. Uporaba LED luči različnih barv ni imela pomembnega vpliva na razvoj mod pri samcih in jajčnikov pri samicah. Med 42. in 72. dnem poskusa ni bilo opaznih razlik v številu jajc pri prepelicah, vzrejenih pri različnih barvah svetlobe, so pa imela jajca v skupini z modro svetlobo večjo težo kot jajca v skupini z belo svetlobo. Uporaba belih, zelenih in modrih LED luči za fotostimulacijo ni imela opaznega vpliva na rast mod in jajčnikov, z izjemo teže jajc.

Ključne besede: LED; barva svetlobe; prepelica; razmnoževanje