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Effect of different light sources on reproductive anatomy and physiology of Japanese quail (*Coturnix coturnix japonica*)

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ABSTRACT

Artificial lights are essential for controlling the reproductive tract development of birds during puberty and therefore influence reproductive quality. The aim of this study was to evaluate the effect of different light sources on reproductive anatomic and physiological characteristics of female Japanese quail (*Coturnix coturnix japonica*). A total of 270 birds from one day of age were housed in a masonry shed divided into six rooms with light isolation. Each room was equipped with a different type of light bulb and contained seven cages with five birds in each. The light bulbs tested were: incandescent; compact fluorescent; and light-emitting diode (LED) in the colors white, blue, red and green. The experimental design was completely randomized with six treatments and seven replications of individual birds each. The anatomic and physiological condition of the birds was evaluated at four, eight and 12 weeks of age. The white LED bulb advanced ($P < 0.05$) the sexual maturity by one week, resulted ($P < 0.05$) in higher live weights and greater weight and relative percentage of ovarian stroma, oviduct and ovarian tissue at eight weeks of age. Higher plasma concentrations of estradiol and lipids were also observed ($P < 0.05$) at eight weeks under the white LED bulb. At 12 weeks of age, the magnum and isthmus folding characteristics were better ($P < 0.05$) with the red LED bulb. In conclusion, the photostimulation with the white LED bulb was more efficient at activating the reproductive cycle, hastening the onset of sexual maturity and increasing the development of reproductive organs after puberty.

1. Introduction

Light is an essential part of the physical environment and an important exogenous factor that controls many physiological processes in birds. Among all environmental factors, light is considered the strongest stimulus favoring the development and reproductive activity of these animals (Coban et al., 2008) and is considered a vital tool in the management of birds in the poultry industry (Rozenboim et al., 1998).

Several studies have shown the effects of different lighting durations and intensities on the reproductive functions of laying hens, and their capacity to influence growth (Renema and Robinson, 2001), sexual maturity (Chen et al., 2007) and reproductive performance (Robinson et al., 1998). However, studies related to the effects of different wavelengths of light in Japanese quail are scarce.

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Over the years, the electric lamp with incandescent light emission has been considered the most important light source in the poultry industry. Recently however, different types of lamps have been introduced to the poultry industry, such as fluorescent light bulbs and those based on light-emitting diodes (LED) (Olanrewaju et al., 2006), the latter of which are becoming increasingly popular in poultry houses due to low power consumption and the ability to emit specific wavelengths (Gongruttananun, 2011).

It is known that various species of birds detect light through retinal and extra-retinal photoreceptors. The avian retina has four kinds of simple cones and one double cone, which give birds the ability to view more colors when compared to mammals (Prescott and Wathes, 1999). However, the extra-retinal photoreceptors are the ones related to stimulation of the reproductive process (Baxter et al., 2014). These structures are located in the brain, specifically in the hypothalamus, which receives light energy through the skull and regulates the release of reproductive hormones (Yoshimura et al., 2003).

Studies with laying hens show that different types of LED light can influence growth (Hassan et al., 2013, 2014) and reproductive characteristics (Li et al., 2014) differently. However, there are few studies that describe the effects of different types of LED compared to the incandescent or fluorescent bulbs on reproductive development before and after puberty in quail. Therefore, the aim of this study was to evaluate the effect of different light sources on reproductive anatomic and physiological characteristics of Japanese quail at different ages.

2. Materials and methods

2.1. Animals, animal facilities and experimental design

The study was conducted in the poultry sector of the Animal Science Department of the Federal University of Lavras, located in Lavras, Minas Gerais, Brazil, and was approved by the Ethics Committee on the Use of Animals of the same institution (protocol 028/2014). A total of 270 female Japanese quail (*Coturnix coturnix japonica*) from one day of age were purchased from a commercial hatchery and housed over a 12 week trial period in a masonry shed, which was divided into six rooms with complete light isolation. The rooms were interconnected by a piping system so that the temperature and humidity were the same in all environments. All rooms contained an analog timer (ref. 8769, Brasfort, São Paulo, Brazil) for photoperiod control, a dimmer (Dimmer Light 500W 9240, Gaya, São Paulo, Brazil) for intensity control and a Hobo Logger (Onset Computer Corporation, Bourne, USA) for daily temperature and relative humidity control. During the first three weeks, the air in the shed was heated by an external firewood heating system engaged to a hot air injection system to ensure uniform heating and maintenance of the temperature in all rooms. In the first three days the temperature was kept at $38 \pm 2\,^{\circ}C$ and was then gradually reduced by $1\,^{\circ}C$ every three days. From the third week on, animals were kept in natural environmental conditions and a mean temperature of $24 \pm 3\,^{\circ}C$ was recorded in the shed.

Each room was equipped with a different type of light bulb and contained seven cages (50 cm wide × 70 cm deep × 25.5 cm height) with five birds per cage. The light bulbs tested were: 25W incandescent light bulb (400–1100 nm) (Lewis et al., 2007); 15W compact white fluorescent light bulb (380–770 nm); and 4.4W light-emitting diode (LED) light bulbs in the colors blue (435–500 nm), red (630–700 nm), green (500–565 nm) (Hassan et al., 2013) and white (400–760 nm) (Cao et al., 2008). The light bulbs were installed on top of the cages so that the light intensity on the birds was 15 lx (Deep et al., 2012), which was measured with a lux meter (ICEL LD510, Manaus, Brazil). The photoperiod was set at 23 h light and one hour dark (23L:1D) during the first week of life (Srivastava and Chaturvedi, 2012), 10L:14D from the second to the fifth week and 17L:7D until the end of the experiment (Makiyama, 2012).

Diets were formulated based on corn and soybean meal following the recommendations of Rostagno et al. (2011). The diet for birds up to 35 days of age had 2900 kcal/kg of metabolizable energy (ME), 22.0% of crude protein (CP), 0.9% of calcium (Ca) and 0.375% of available phosphorus (aP); the diet for birds of the production phase had 2800 kcal/kg ME, 18.8% CP, 3.0% Ca and 0.304% aP. Water and feed were provided *ad libitum*.

The experimental design was completely randomized with six treatments and seven replications. Each bird was analyzed independently.

2.2. Experimental procedure

Sexual maturity was defined as the time of the first egg laying (Gongruttananun, 2011). At this moment, parameters such as live weight, age of the bird, egg weight and egg yolk weight were measured.

At four, eight and 12 weeks of age, seven animals per experimental group (one per cage) were randomly chosen, fasted for 12 h and euthanized by cervical dislocation. After euthanasia, the coelomic cavity was opened to access the reproductive tract. Ovary weight was recorded at four weeks of age. At eight weeks of age, the weight of the stroma, which represents ovarian mass without the yellow follicles (Robinson et al., 2003), and oviduct weight and length were measured. At 12 weeks of age, in addition to these variables, the number of yellow follicles present in the ovary and the weight of the largest yellow follicle were also obtained. All variables were expressed in absolute terms and also in relative terms depending on the live weight of the bird. During the dissection, the incidence of internal ovulation, internal oviposition, ovarian regression and follicular atresia was inspected.

To evaluate estradiol and lipid plasma concentrations, 2 ml of blood from each bird slaughtered at eight weeks was collected in Eppendorf tubes by puncturing the brachial vein. The birds were slaughtered and the blood was collected between 1pm and 3pm. After blood collection, the plasma was immediately separated by centrifugation at 3000 *g* for 15 min at $4\,^{\circ}C$ and stored at $-80\,^{\circ}C$ for further analysis. All procedures were done according to the recommendations of the commercial kit manufacturers.