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Effects of monochromatic light sources on sex hormone levels in serum and on semen quality of ganders

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ABSTRACT

Light is an essential external factor influencing various physiological processes, including reproductive performance, in birds. Although several attempts have been made to understand the effect of light on poultry production, the effect of light of a particular wavelength (color) on the reproductive function in geese remains unclear. This study evaluated the effect of various monochromatic light sources on the levels of sex hormone and on semen quality of ganders. Of 30 male White Roman geese in their third reproductive season (average age = 3 years), 27 were divided into three groups receiving monochromatic white or red or blue lights. The birds were kept in an environmentally controlled house with a lighting photoperiod of 7L:17D for six weeks as the adaptation period. The photoperiod was subsequently changed to 9L:15D and maintained for 24 weeks. Three ganders at the beginning of the study and three from each group at the end of the adjusting period and the 20th and 30th week of the study period were sacrificed, and their testes and blood samples were collected for determining the sex hormone levels. Semen samples were collected for determining semen quality parameters, including the semen collection index, sperm concentration, semen volume, sperm motility, sperm viability, sperm morphology, and semen quality factor. The results showed that the testosterone and estradiol levels remained unchanged in all three groups at all time points. The ratio of testosterone to estradiol of ganders exposed to white light was significantly higher than that of ganders exposed to red light at the 30th week ($P < 0.05$). Semen collection index and sperm viability of ganders exposed to blue light were significantly the lowest ($P < 0.05$). Moreover, sperm motility, sperm viability, and percentage of morphologically normal spermatozoa of ganders in white light were the highest ($P < 0.05$). In conclusion, the results of this study suggested that artificial illumination with white light may maintain a better semen quality than that with red or blue lights in ganders.

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1. Introduction

Light is an essential external factor influencing various physiological processes in birds (Olanrewaju et al., 2006). Seasonal reproduction in birds is regulated primarily by

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the photoperiod (Leska et al., 2012). Geese are seasonal breeders and have a clock-like breeding pattern of reproductive activity under natural lighting conditions (Wang et al., 2005).

Artificial illumination is widely applied in the modern poultry production of chickens, turkeys, ducks, and geese. Studies have demonstrated that windowless houses and artificial short-day lighting systems effectively regulate the reproductive performance of geese (Lia et al., 1996; Wang et al., 2005). Moreover, controlling the reproductive activity of geese to shift or extend the reproductive season was demonstrated to be beneficial, thus reducing the need for breeders to import geese (Wang et al., 2005).

Artificial illumination enhances growth, reproduction, and wellbeing of poultry (Cao et al., 2008; Olanrewaju et al., 2006). Patterns of artificial illumination, such as the light schedule, intensity, and wavelength, critically influence reproductive performance. A wide variety of lighting programs and devices are available to poultry producers, each of which possesses unique characteristics and applicability in the industry (Olanrewaju et al., 2006).

In birds, light with different wavelengths has varying stimulatory effects on the retina photoreceptors and results in physiological and behavioral changes that affects growth performance and gonadal development (Woodard et al., 1969; Pyrzak and Siopes, 1986; Lewis and Morris, 2000). Avian reproductive activity is tightly related by gonadotropin releasing hormones (GnRH) and gonadotropin inhibitory hormone (Ottinger and Bakst, 1995; Tsutsui et al., 2010). Upon photo-stimulation, GnRH stimulates the release of follicle stimulating hormone and luteinizing hormone, which increases the synthesis of steroid hormones, triggers gonadal development (Baxter et al., 2014) and thus affects the breeding of birds. The wavelength (or color) of a light source plays a major role in growth performance and reproductive traits in chickens (Olanrewaju et al., 2006). Green and blue light stimulate growth in the early growth period. However, when chickens approach sexual maturity, red light is effective in stimulating sexual hormonal pathways, ovarian weight, and the number of follicles culminating in egg production (Cao et al., 2008; Hassan et al., 2013; Kim et al., 2013; Rozenboim et al., 2004). The management of light source exposure is essential for the optimal fertility and hatchability in the poultry industry (George, 1973; Noirault et al., 2006).

Ganders show a relatively limited testicular development at adulthood, which results in a lower sperm production per unit time and lower percentage of morphologically normal spermatozoa compared with other species (Chełmońska, 1972; Lukaszewicz, 2010). Studies have elucidated the patterns of luteinizing hormone, prolactin, steroids, and thyroid hormones in ganders (Gumułka and Rozenboim, 2014; Shi et al., 2007). Testosterone and estradiol play a vital role in the development and function of testes and male reproduction (Leska et al., 2012, 2015; Liu et al., 2008; Rivas et al., 2002). Moreover, different stimuli of peripheral hormones are associated with sperm production, semen quality, and overall reproductive activity (Gumułka and Rozenboim, 2014; Liu et al., 2008). Although the effect of light on poultry production has been studied, the effect of a light of a particular color on the sex hormone levels and reproduction in ganders remains unclear. Therefore, this study evaluated the effect of various monochromatic light sources on sex hormone levels in serum and on the quality of semen of ganders.

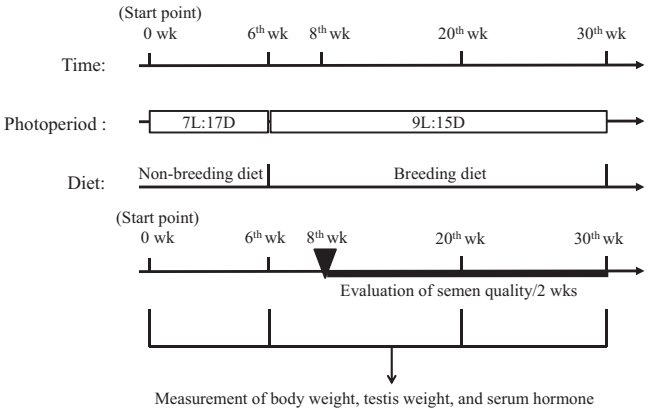

Fig. 1. Experimental scheme.

2. Materials and methods

2.1. Experimental birds, management, and monochromatic light treatment

In total, 30 White Roman ganders in their third breeding season were used (average age = 3 years). The care and use of geese followed the Regulations of Laboratory Animals, Changhua Animal Propagation Station, Livestock Research Institute, Council of Agriculture, Taiwan. The ganders were raised in stainless cages (50 cm wide × 80 cm high × 65 cm long) at an ambient temperature of 28 °C.

The experimental scheme is illustrated in Fig. 1. First, the ganders were raised in an environmentally controlled house (ECH) with the lighting photoperiod of 7L:17D. They were restrictively fed with a non-breeding diet containing 13% crude protein (CP) and 2350 kcal of metabolizable energy per kg (ME/kg) for six weeks (the adjusting period). Subsequently, the photoperiod was adjusted to 9L:15D and the ganders were fed with breeding diets containing 18% CP and 2700 kcal of ME/kg (Table 1) *ad libitum*. Drinking water was freely accessed during the entire experimental period. The treatments included the use of three monochromatic light sources, i.e., blue (wavelength 460–475 nm), red (wavelength 620–630 nm), or white light [combing red, green (wavelength 520–530 nm), and blue light] (Yo-Sheng Lighting, Co., Ltd., Taichung, Taiwan) for 24 weeks. Artificial illumination was produced using four 40W fluorescent tubes with an illuminating intensity of 30–40 lx at the height of head of standing birds. The wind flow in the ECH was set at approximately 1 m/s.

2.2. Measurement of the body weight and testis weight and sample collection

Out of 30 ganders, 27 were divided into three groups and received monochromatic white, red, and blue light. Three

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