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# Light colour and intensity alters reproductive/seasonal responses in Japanese quail

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## HIGHLIGHTS

- Light colour and intensity affect gonadal growth in Japanese quail.
- Japanese quail are sensitive to light colours and intensity.
- Short wavelength, low intensity, and blue light have a negative impact on the gonads of Japanese quail.
- Longer wavelength and red light have a positive impact on the gonads of Japanese quail.

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## ABSTRACT

An extensive literature is available on the photoperiodic responses of avian species but studies on light colour and wavelength from light emitting diode (LED) sources on reproduction are limited. Hence, an experiment was designed to study the effect of different colours and intensities of light on the reproductive responses of Japanese quail. Three-week old quail were exposed to five different light conditions with a long photoperiod (LD 16:8): WT (white fluorescent light 100 lux as control), W LED (white light emitting diode, 30 lux), B LED (blue LED, 30 lux), G LED (green LED, 30 lux) and R-LED (red LED, 30 lux). The cloacal gland size, an indicator of androgenic activity, was monitored weekly. The results indicated an early initiation of gonadal growth in WT quail which continued and maintained a plateau throughout the period of study. On the other hand, in general low intensity light, there was a decreased amplitude of the reproductive cycle and the quail exposed to different colour lights (green, red and blue lights) used different incubation times to initiate their gonadal growth and exhibited a gonadal cycle of a different duration up to 15.5 weeks. Thereafter, the gonad of quail of all the LED groups started developing again (including the blue LED exposed quail which remained undeveloped until this age) and attained the increased degree of growth until 26.5 weeks of age. During the second cycle, gonads of green and red light exposed quail continued to increase and maintained a plateau of development similar to WT exposed control while white and blue LED exposed quail exhibited spontaneous regression and attained complete sexual quiescence. Based on our study, it is suggested that long term exposure to blue LED light of low intensity may induce gonadal regression even under long-day conditions (LD 16:8), while exposure to green and red lights appears to maintain a constant photosensitivity after one complete gonadal cycle.



## 1. Introduction

Day length, colours and the intensity of light affect the behaviour of various organisms [1,2,3,4] including avian species such as quail [5], broiler chickens [6], black headed bunting [7,8] and domestic chicks [9]. Reproduction together with behaviour of avian species is also affected by these factors [10–26]. Studies of the black headed bunting (*Emberiza melanocephala*) indicate that its photoperiodic response system can discriminate between different wavelengths of light and requires a minimum light intensity threshold for photo-stimulation [27]. There are differential effects of wavelength and intensity of light on the circadian processes mediating photoperiodic regulation of daily and seasonal responses in the bunting [27]) and circadian behaviour on the Indian Weaver bird, *Ploceus philippinus* [28].

The visible spectrum of light is composed of seven colours of the rainbow (VIBGYOR) starting from violet to red, violet is having the shorter wavelength (380 nm) and red having the longer wavelength (750 nm). With reference to wavelength, the red light was found to be stimulatory whereas blue or green to be inhibitory for gonadal growth in the European starling, *Sturnus vulgaris* [29], English sparrow, *Passer domesticus* [30], duck [31], fowl [32], quail [5], migratory bunting

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[20,33], black headed bunting, *E. melanocephala* [34,7,8] and red headed bunting, *Emberiza bruniceps* [21]. A study on the migratory black headed bunting (*E. melanocephala*) indicates that the response to LD cycle varies with the wavelength of the light and the bunting's circadian system appears to be differentially sensitive to light at different times of the day. However, wavelength alone does not seem to determine the photoperiodic induction of gonad, since blue light at high irradiance was also photo-inductive, although at lower irradiance the longer wavelength was inductive and the shorter one (blue) was not inductive [32].

Studies with broilers using regarding monochromatic light suggested that green and blue lights stimulate growth [35]. The green light stimulated the growth of birds at an early age, and shifting birds to a different light environment at 10 or 20 days of age further stimulated growth [36]. Green to blue or green to green-blue mixed lighting during the rearing period of female broilers improved body and muscle growth and meat quality [37]. On the other hand, green light during embryogenesis enhanced the weight gain after hatching of male broilers, increased breast muscle growth, and improved the feed conversion ratio, but it did not cause any noticeable change in the chemical composition of breast muscle or meat quality [38]. Thus the application of the green to blue and blue to green light exchanges can be used to improve growth and productive performance in broilers [39]. Stimulation with monochromatic green light during incubation period promotes muscle growth by enhancing the proliferation and differentiation of satellite cells in late embryonic and newly hatched stages [40]. A combination of red to green light may be comparable to monochromatic red light in enhancing egg production in laying hens [41]. Large number of studies reports the effects of photoperiod or daylength on the reproduction of birds, including Japanese quail [11,12,14,16]. But, the reports on the effects of different wavelengths and intensities on the reproduction are limited in Japanese quail [5]. Moreover, unlike the threshold photoperiod required to initiate gonadal stimulation, the threshold intensity necessary to elicit gonadal growth in birds is not well documented. However, the latter may also vary as in the case of species-specific daylength studies. In equatorial species, melatonin secretion relays light intensity information than the photoperiod length, which is almost constant throughout the year [26,42].

Most of the above workers used filters on fluorescent bulb/tubes for the colour light or wavelength source. But, some workers used white/coloured light emitting diode (LED) bulbs for this type of study in poultry like chickens, however such studies are lacking for quail. Lower intensities may have resulted in reduced tissue penetration and less testicular growth. In this context, Gildersleeve and Johnson [43] have suggested that if a threshold intensity necessary to elicit testis growth is not found, growth does not occur. Based on the limited literature on this subject, it appears that the threshold intensity necessary to elicit gonadal growth in birds may be variable and species specific. The eyes may play a role in mediating the photo-sexual reflex in birds in addition to hypothalamic receptors and the pineal gland [44,45]. In spite of large numbers of short-term photoperiodic studies in Japanese quail, limited literatures are available regarding its reproductive responses to different light colours/wavelengths and intensities [5,43],

The aim of this study was i) to compare the long term effect (of approximately 8 months) of fluorescent and LED lights provided for 16 h/day, i.e., long-day length LD (16:8) but at different intensities 100 lux and 30 lux, respectively and ii) to compare the effect of different colours of LED in place of the expensive filters normally used to provide monochromatic light for scientific studies.

## 2. Materials and methods

Japanese quail were kept under different light colours and intensities in photoperiodically controlled wooden chambers and provided with commercial feed-chicken ration: starter up to 6 weeks of age and finisher grower thereafter (purchased from Santosh poultry centre, Cantt, Varanasi) with ad libitum water supply.

Before exposure to the different light conditions, 50 three-week old sexually immature male Japanese quail were weighed and randomly divided into 5 groups (n = 10) WT (white fluorescent tube light), W LED (white LED light), B LED (blue LED light), G LED (green LED light) and R

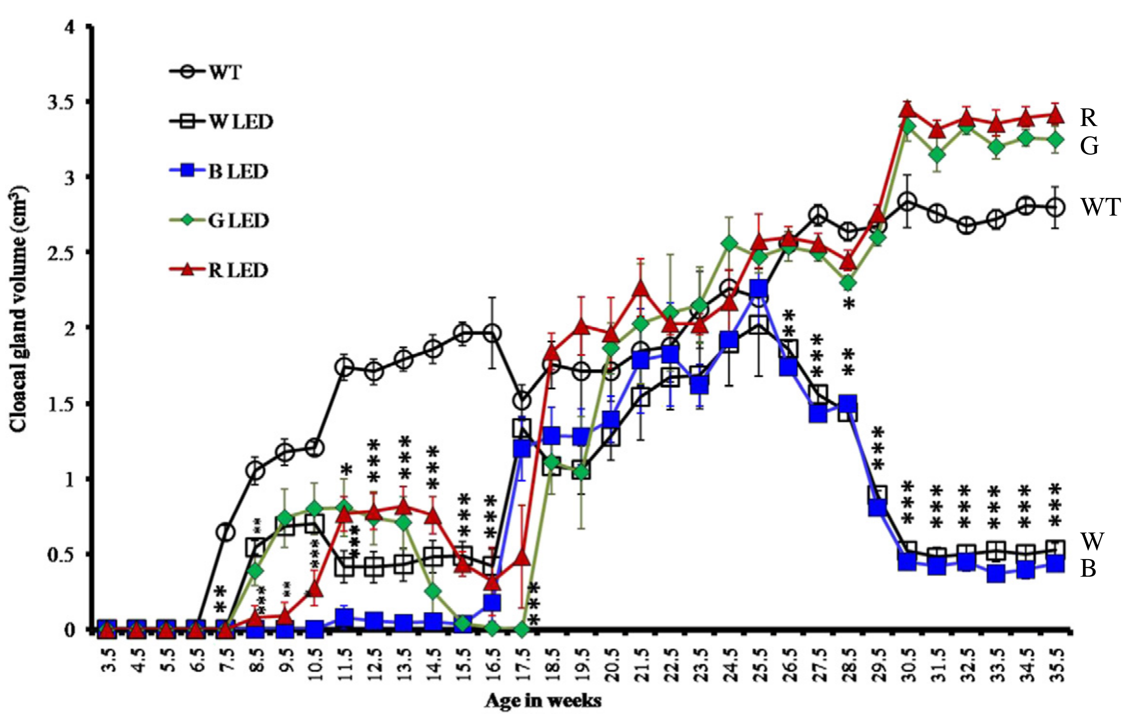


**Fig. 1.** Cloacal gland responses of Japanese quail exposed to long-day (LD 16:8) of different light colours and intensities. Data is presented as Mean ± SEM. *p < 0.05. **p < 0.01. ***p < 0.001. Significance of difference from WT (n = 10). WT = white tube light/fluorescent light (~100 lx). W LED = white LED (~30 lx). B LED = blue LED (~30 lx). G LED = green LED (~30 lx). R LED = red LED (~30 lx).