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Exploring the Effects of Various Light Sources on Vascular Development and Growth in Embryonic Eggs

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Abstract:
This experimental research pursued to examine how various artificial light sources influence the embryonic development of fertilized eggs. Four eggs were chosen and placed individually in separate wooden boxes. Each box featured a wooden bar at the top, which held a light bulb of a distinct color or type (such as red, green, blue, and white). To facilitate direct exposure of the developing embryos to the light and enable internal observation, a small opening was meticulously created in the shell of each egg. The eggs were maintained in a controlled environment with consistent exposure to specific light conditions over a designated timeframe. Observations were conducted to assess changes in embryonic activity, vascular development, movement, and overall growth. The results indicated that different types and colors of artificial light had distinct effects on embryonic development. For instance, red and green lights were linked to accelerated development and increased movement, whereas blue light seemed to hinder growth. White light served as a control, exhibiting neutral effects. These findings imply that light exposure, particularly regarding wavelength and intensity, can significantly affect metabolic activity and developmental progress in avian embryos. This study enhances our understanding of how external environmental factors, such as artificial lighting, can influence biological growth processes during the early stages of life.

Keywords: Artificial light, Embryonic development, Fertilized eggs, Light wavelength, Eggshell hole, Avian embryo, Light exposure, Colored light effect, Egg development, Light intensity, Embryo, Red light, Green light, Blue light, White light, Shell structure, Controlled environment.

Introduction:

The growth of bird embryos inside eggs is a sophisticated and intricately controlled process that is affected by numerous environmental factors. Among these, light exposure has been identified as a key factor influencing embryonic development, hatching rates, and the quality of chicks. Although light plays a crucial role in the development of birds, the exact impacts of light on bird eggs are still not well understood. This lack of understanding is important, considering the potential effects on poultry farming, conservation efforts, and our overall comprehension of developmental biology (1).

Bird eggs are affected by environmental conditions, with light being a significant factor that influences embryonic development. In natural environments, eggs experience different levels of light exposure, which can vary based on nesting locations, parental behaviors, and the time of day. Nevertheless, due to the rising use of artificial lighting in poultry farming and the increasing worries about the impact of light pollution on wildlife, it is crucial to examine how light affects bird eggs (2).

1. **Poultry Production:** Enhancing incubation conditions to boost hatch rates and chick quality can result in higher productivity and lower mortality rates.
2. **Conservation Biology:** Creating approaches to counteract the impacts of environmental changes, like light pollution, on avian populations can aid in the preservation of at-risk species.
3. **Developmental Biology:** Acquiring knowledge about the mechanisms involved in light influenced developmental processes can enhance our basic understanding of embryonic growth.
4. **The intensity and duration of light:** The intensity and duration of light will greatly influence the development of embryos and the success of hatching in birds.
5. **Effects of different wavelength:** Various light wavelengths will exert unique effects on the embryonic development of birds and the quality of the chicks.
6. **Impacts on incubation period:** Enhancing light exposure during the incubation period can lead to better hatch rates and improved chick quality in poultry farming (3).

Light exposure plays an important role in the timing of development of avian species, influencing the reproductive physiology, behavioral patterns and migratory activities of the species. The following outlines these effects in detail:

Physiological Processes of Reproduction: Research has demonstrated that even the low levels of illumination (0.3 lux) can accelerate reproductive development of avian species and induce earlier onset of breeding and molting. In such urban environments, light pollution both interrupts natural photoperiods and this phenomenon is especially pertinent (4).

In comparison to those in the control group under natural dark conditions, urban birds subjected to artificial light at night (ALAN) showed functional testicular development 26 days earlier. The influence of ALAN on post breeding migration timing in migratory songbirds can therefore be demonstrated. Fledging and colony departure dates of nestlings exposed to white light with 5 lux intensity during the night were later than those under natural darkness or green light. White light has a greater effect on post breeding movements than green light (5).

Birds are also sensitive to light exposure and it can affect daily activity patterns, singing behavior and stress hormone levels. In this case, birds under ALAN began singing earlier than those under dark nights. Studies have shown that different wavelengths will have different impacts on behavior, some studies have indicated that red light and longer wavelengths may increase productivity of laying hens (6).

The regulation of circadian rhythm: Melatonin levels and core clock genes are two ways that light exposure can control circadian rhythms in birds. Reproductive development and clock gene expression can be impacted by monochromatic light, such green light (7).

Material and Methods:

Material used:

1. Eggs(8).
2. Boxes (4).
3. Colored light bulbs (4 different colors).
4. Holders (made of paper or wood).
5. Wooden bar (to suspend the bulb above the egg).
6. Possibly a power source (e.g., electricity) for the bulbs.

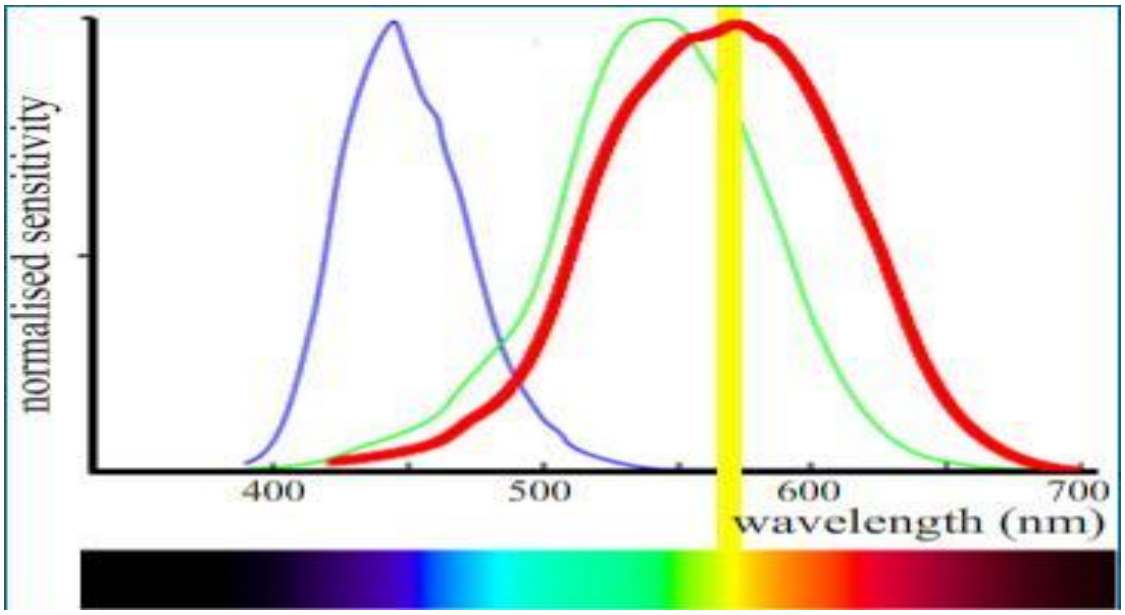
Experimental Design:

1. Randomized Controlled Trial: Divide eggs into groups based on light exposure.
2. Treatment Groups: Each group exposed to a different light condition (e.g., red, blue, green, white light).
3. Control Group: Standard incubation conditions (darkness or standard lighting).

Wavelength of different light:

The wavelength of different light are as follow:

Following graph shows the wavelength of different light:



Procedure:

We utilized four eggs to observe the effects of light and employed four distinct colors of light. We used red, blue, yellow, and green LED bulbs to see how light affected things. We arranged these bulbs, one in each, on a wooden bar with holders. We put an egg-containing carton beneath each bulb. To let light through the shell, the eggs were cracked open. This configuration was maintained for seven days.

The subsequent light sources were utilized: yellow LED, blue LED, red LED, green LED, (one 1W LED lamp for each box) and a control environment (40W incandescent lamp), which was the lighting technique used earlier in that residence. The lighting system was linked to a timer to provide a consistent lighting schedule of 144 hours/7 days (natural + artificial).

Select viable eggs of identical breed and age. Organize eggs into categories according to light exposure (various colors/intensities). Keep a steady temperature (37. 5°C ± 0. 5°C) and humidity (50-60%). Subject eggs to particular light conditions for 7 days. Rotate eggs frequently to avoid sticking.

Record embryonic development, weight loss of eggs, or other pertinent parameters. Compare findings among various light exposure groups. Our primary objective was to experimentally evaluate if eggshell pigmentation is influenced by light intensity within the nest box, while accounting for several ecological characteristics that may affect eggshell coloration. Specifically, we assessed the impact of eggshell thickness, the date of the first egg laid, and the size of the clutch on the diversity of eggshell patterning.

Results:

Average egg weight, percentages of yolk, albumen, shell, and light intensity. Several variables, such as light intensity and color can affect how different light colors affect egg yolks over the course of a seven-day observation period. Observations Over a 7-Day Period: The embryonic development and egg quality of eggs cultured and held under various light settings for 7 days varied.

First day:

Yellow light: I noticed that the egg was not much affected by the yellow light on the first day of my observation. The albumen and yolk seemed to be unaltered, maintaining their natural properties.

Blue light: On the first day of observation, the albumen and yolk showed only a minor shift after being exposed to blue light.

Red light: There was no discernible effect from the red light. The outcomes are comparable, and no notable alterations are noted.

Green light: The albumen got slightly thicker and the yolk slightly thicker when exposed to green light. Additionally, the light-piercing hole on the shell grew a little larger.

Second day:

Yellow light: On the second day, I noticed that the egg was barely affected by the yellow light. The albumen changed slightly, becoming a little thinner, but the yolk's state stayed the same, showing no discernible changes.

Blue light: On the second day, the egg yolk somewhat thickened with blue light exposure, but the albumen was completely unaffected."

Red light: The albumen and egg yolk combined when exposed to red light, giving the mixture a greasy consistency.

Green light: The egg yolk, which was once yellow, has changed, getting a conspicuous whitish layer.

Third day:

Yellow light: We noticed that the yolk was affected by the yellow light, taking on the appearance of a boiled egg. Moreover, insects were drawn to it and began consuming it, as though they had attacked the yolk.

Blue light: Both the albumen and the yolk thickened when exposed to blue light. The yolk absorbed a small amount of the albumen.

Red light: The yolk and albumen had previously mixed together, but by the third day, they had changed into a distinct structure when exposed to red light.

Green light: We observed that after being exposed to green light, the part of the eggshell where I had made a hole totally disintegrated, and a membrane encased the yolk, while the albumen was absorbed into the yolk.

Fourth day:

Yellow light: On the fourth day, the two components combined, leading to insects beginning to feed on the mixture, effectively merging with it.
Blue light: The yolk and albumin blended in such a manner that the albumin was absorbed by the yolk, resulting in the emergence of a blood vessel-like structure within the yolk.
Red light: The four-day exposure to red light rendered the mixture viscous, drawing in an insect that commenced feeding on it.
Green light: Exposure to green light led to the development of a membrane-like structure that encased the yolk and albumin.
Fifth day:
Yellow light: By the fifth day, the albumin and yolk had significantly deteriorated, with flies joining the insects in feeding on them.
Blue light: Under blue light, the albumin was absorbed into the yolk, resulting in a thinner mixture.
Red light: Due to red light, the albumin's absorption gave the yolk a more viscous appearance.
Green light: Notable by day five, the yolk had experienced considerable changes. The partial removal of the eggshell to enhance light exposure enabled the underlying membrane to grow and differentiate, ultimately covering about half of the yolk's surface. **Sixth day:**
Yellow light: The observations made on the sixth day were harmful, leading to the deterioration and death of the insects and flies present.
Blue light: Insects began to emerge, particularly on the egg exposed to blue light.
Red light: By the sixth day, the egg had changed to a jelly-like texture.
Green light: Exposure to green light resulted in the yolk and albumin drying out, resembling that of hard-boiled eggs.
Seven day:
Yellow light: Exposure to yellow light resulted in the coagulation of the spoiled yolk and albumen in contact with the shell.
Blue light: Under blue light, the insects blended with the contents, integrating into the structure and initiating the formation of layers adjacent to the shell.
Red light: Red light exposure led to the denaturation of the yolk.
Green light: Green light caused both the egg yolk and albumin to attain a boiled-like consistency.

Discussion:
The results of this research indicate that exposure to artificial light greatly influences eggs, displaying unique effects associated with various light colors. The following discussion analyzes these findings in light of current literature and examines the possible implications.
Artificial lights, especially incandescent or high- intensity LED bulbs, can raise the face temperature of the eggshell. Dragged exposure may lead to microcracks or drying of the external cuticle, which reduces shell strength and increases vulnerability to contamination (7).
Different Multicolored lights can produce different heat situations(red and yellow lights generally emit further heat than blue or green). Uneven heating can beget expansion/ compression stress on the shell, weakening its integrity over time (8).
The eggshell is primarily made of calcium carbonate ($CaCO_3$). UV or high- energy visible light may contribute to print- declination of the external shell subcaste over long ages, though this effect is minimum in typical artificial light setups unless UV is present (9).

The cuticle (the outermost protein rich layer) can degrade with prolonged light exposure, especially under UV or strong white LED lights. This makes the shell more pervious and reduces its natural defensive hedge against bacteria (10-16).

Exposure to light, especially if it warms the shell, can increase water loss through pores and alter CO_2/ O_2 exchange rates. Over time, this can impact shell severance size or internal pressure, though the direct structural change is minimum unless heat is inordinate (11).

Disruption: Consistent or bright light, particularly blue or UV light, may interfere with normal embryonic growth, leading to malformations or premature death. **Dehydration:** The opening in the eggshell enables moisture to exit more quickly. When paired with light exposure, particularly from heat-producing sources, this can dehydrate the egg contents, resulting in a sticky or rubbery texture (12).

Protein denaturation: Constant light exposure, particularly from intense heat sources, can start to denature the egg white (albumen), leading it to lose its transparent, thick consistency and become opaque or cloudy. **Microbial contamination:**A puncture weakens the egg's inherent protection. Light has the ability to either hinder or encourage microbial growth, based on its type. UV light can diminish microbes. Bright, warm light can promote bacterial development, leading to spoilage or odor (13-15).

Color and texture changes: Pigments in the yolk can deteriorate or lose intensity when exposed to bright light. The yolk may solidify or alter in color (greenish or gray) if the egg is subjected to heat or influenced by bacteria. In experiment, where small holes were made in the eggshell and different artificial lights were used localized light and heat exposure near the hole could weaken the area and bedget shell thinning or abrasion. Still, it may indicate light- convinced declination or humidity loss, if any shell came brittle or darker (14).

Conclusion:

In this experiment, four fertilized eggs were positioned in individual boxes, each subjected to a distinct artificial light source attached to wooden bars with bulb holders, with tiny holes created in the eggshells to monitor the internal impacts of light. Artificial light penetrating a hole in an eggshell harms the internal conditions, resulting in yolk deterioration, microbial spoilage, and embryo death (if fertilized). The type and intensity of light greatly influence the result, with UV and heat-emitting lights causing the highest level of harm. The existence of a hole along with exposure to artificial light significantly undermines egg quality and viability within a week.

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