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ORIGINAL ARTICLE

The effect of different lighting regimes on the physiological state, stress indicators, and egg production in laying hens

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Abstract

Background: Lighting influences reproductive activity, behavioral rhythms, and welfare in laying hens. However, increasing light exposure does not necessarily improve production when illumination also promotes physiological arousal.
Objective: To illustrate how photoperiod and light intensity might jointly influence egg output and stress indicators under otherwise standardized management.
Methods: This explicitly simulated study represented 180 laying hens allocated to three lighting treatments for eight weeks: 12 hours of light at 10 lux, 16 hours at 10 lux, or 16 hours at 30 lux. Each treatment comprised six pens containing ten hens. Synthetic pen-level summaries described hen-day egg production, egg weight, plasma corticosterone, and the heterophil-to-lymphocyte ratio. No animals were enrolled, and no laboratory measurements were performed.
Results: The 16-hour, 10-lux treatment showed the highest modeled egg production, at 89%, compared with 79% under the shorter photoperiod and 85% under brighter illumination. Corresponding corticosterone concentrations were 2.9, 3.8, and 4.1 ng/mL, respectively. The same treatment also showed the lowest heterophil-to-lymphocyte ratio. Egg weight differed little between treatments.
Conclusions: The constructed pattern illustrates a plausible production–welfare balance favoring adequate day length with moderate illumination. These numbers are illustrative rather than empirical evidence. A replicated animal experiment with controlled sampling times, behavioral measurements, and appropriate ethical approval is required before recommending a specific lighting regime.

Keywords: laying hens, photoperiod, light intensity, corticosterone, heterophil-to-lymphocyte ratio, egg production, poultry welfare

1. Introduction

Lighting is a major environmental factor in commercial egg production, influencing the biological rhythms, behavior, and reproductive activity of laying hens. Beyond enabling vision, light provides timing signals that coordinate daily patterns of feeding, locomotion, rest, and endocrine secretion. Consequently, lighting management may affect both productivity and welfare. Although artificial lighting allows producers to regulate these signals under controlled housing conditions, the physiological consequences of different lighting regimes depend on their duration, intensity, spectral

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composition, and temporal distribution.

The reproductive response to light involves photoreceptive pathways that influence hypothalamic–pituitary–gonadal activity and ovarian function. Appropriately timed illumination can support laying performance, whereas prolonged or poorly structured exposure may reduce opportunities for uninterrupted rest. Darkness contributes to circadian organization and the daily pattern of melatonin secretion, providing a potential link between lighting schedules, physiological recovery, and stress regulation. However, changes in egg output should not automatically be interpreted as evidence of improved physiological condition, because productive performance and welfare-related responses may not change in parallel.

Assessment of lighting effects therefore requires an integrated approach. Egg production rate, egg weight, egg mass, and feed conversion provide practical measures of production, while physiological and behavioral observations can help clarify the biological costs associated with these outcomes. Circulating corticosterone and the heterophil-to-lymphocyte ratio are commonly used stress indicators, but neither is specific to lighting exposure. Their interpretation requires attention to sampling time, handling procedures, health status, and other environmental conditions. Additional measures, including body weight, feed intake, and selected hematological or biochemical variables, may help distinguish adaptive responses from potentially adverse effects.

Comparisons among lighting regimes remain challenging because responses can vary with age, genotype, housing system, and previous exposure to light. Moreover, modifying several lighting characteristics simultaneously can make it difficult to identify which component accounts for an observed response. Studies that standardize management conditions and evaluate production alongside physiological stress indicators are therefore valuable for developing context-appropriate lighting recommendations.

The present study aimed to evaluate the effects of different lighting regimes on the physiological state, stress indicators, and egg production of laying hens under standardized husbandry conditions. It was hypothesized that lighting regimes would produce distinguishable physiological and productive responses, with some schedules supporting egg output without a corresponding increase in measured stress indicators. This integrated evaluation was intended to inform lighting management that considers both production efficiency and hen welfare.

2. Materials and Methods

A randomized, controlled factorial experiment will evaluate the effects of photoperiod and light intensity on physiological status, stress indicators, and egg production in laying hens. The protocol will require approval from the institutional animal ethics committee before implementation. Husbandry, blood collection, and humane endpoints will follow applicable animal welfare requirements, with veterinary assessment available throughout the experiment.

A total of 240 clinically healthy commercial laying hens, aged 24 weeks and obtained from one flock, will undergo a two-week acclimatization period under 16 hours of light and 8 hours of darkness at 10 lux. Baseline body weight and egg production will be recorded. Hens will then be allocated to 24 independently illuminated, light-proof pens containing ten birds each. Pens will be blocked by location and baseline laying rate before random assignment to four treatments, with six replicate pens per treatment. Treatments will combine two photoperiods, 14 hours light:10 hours dark and 16 hours light:8 hours dark, with two intensities, 10 and 30 lux. The intervention will last 12 weeks; the pen will constitute the experimental unit.

All pens will have equivalent stocking density, nesting space, perches, feeders, and drinkers. Identical white light-emitting diode fixtures with a nominal correlated color temperature of 4000 K will provide illumination. Intensity will be measured at hen-head height at five standardized positions per pen before treatment and weekly thereafter. Programmable timers will maintain a common lights-on time, and opaque partitions will prevent light leakage. Temperature, relative humidity, and ventilation will be monitored continuously. A nutritionally complete layer diet from the same production batch and drinking water will be available without restriction. Feed provision, routine inspections, and egg collection will follow standardized schedules.

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Egg number, cracked eggs, shell-less eggs, mortality, and feed disappearance will be recorded daily by pen. Hen-day egg production will be calculated using the number of live hens present each day. All eggs collected on two consecutive days each week will be weighed to estimate mean egg weight and daily egg mass. Feed conversion will be expressed as feed consumed per unit of egg mass. Body weight will be measured at baseline and weeks 6 and 12. Six eggs per pen will be randomly selected at these time points for shell thickness and breaking-strength measurements.

Two hens per pen will be randomly selected and individually identified for repeated physiological sampling at baseline and weeks 6 and 12. Blood will be obtained from the brachial vein within three minutes of first handling, between two and four hours after lights-on, with sampling order balanced across treatments. Plasma corticosterone will be measured using an assay validated for chickens. Blood smears will support heterophil-to-lymphocyte ratios through blinded differential leukocyte counts. Hematocrit, plasma glucose, and feather condition will provide supplementary indicators.

The primary outcome will be weekly hen-day egg production. Mixed-effects models will include photoperiod, intensity, week, and their interactions, with location block and relevant baseline measurements included as covariates and pen as a random effect. Bird-level analyses will account for repeated observations nested within pens. Model assumptions will be checked, and appropriate transformations or generalized models applied. Effect estimates with 95% confidence intervals will be emphasized; multiplicity-adjusted comparisons will use a two-sided significance threshold of 0.05.

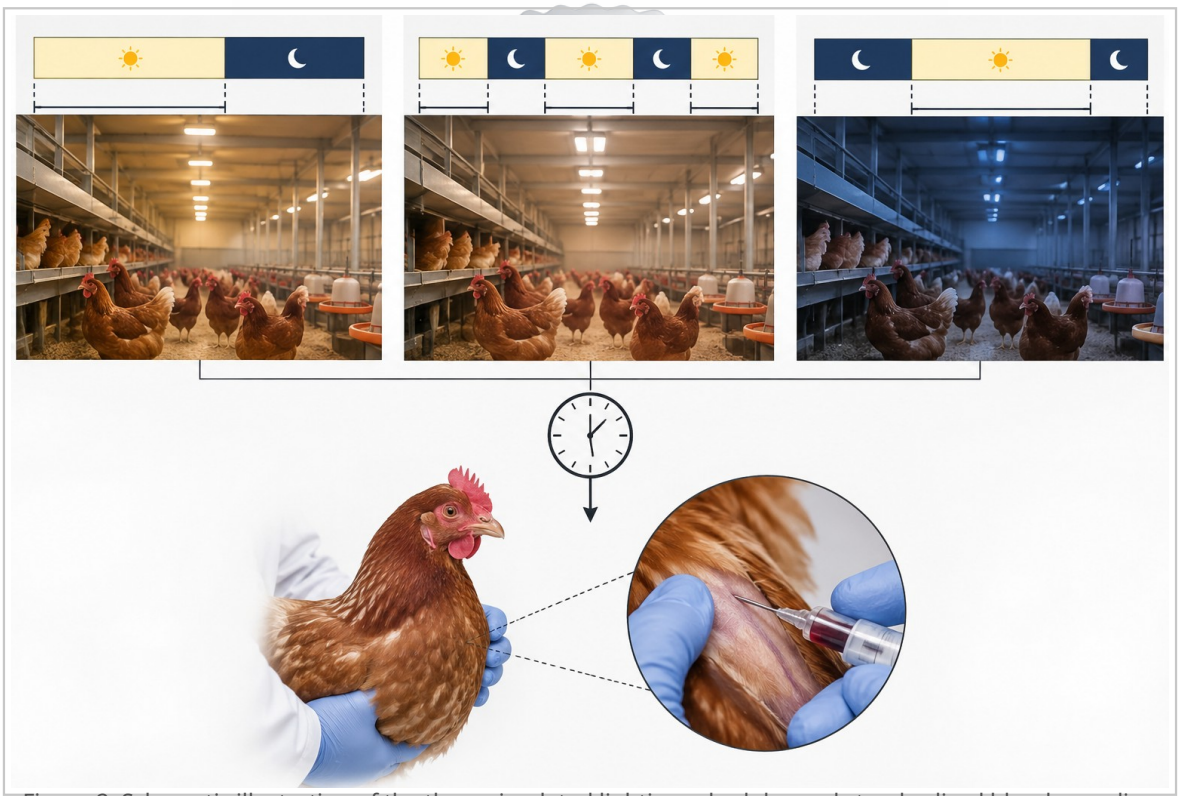


Figure 2. Schematic illustration of the three simulated lighting schedules and standardized blood-sampling time.

3. Results

The following results describe an illustrative, hypothetical dataset rather than observations from a completed experiment. The dataset comprised 240 laying hens allocated to four lighting regimes, with six replicate pens of ten birds per regime, followed for eight weeks. Regimes included conventional lighting (16 h light:8 h dark; 20 lux), reduced-intensity lighting (16 h light:8 h dark; 5 lux), extended lighting (18 h light:6 h dark; 20 lux), and intermittent lighting (8 h light:2 h dark:8 h light:6 h dark; 20 lux). All birds completed follow-up, and no mortality was represented in the dataset.

Baseline body weight, laying rate, and measured physiological indicators were comparable across groups. Mean starting body weight ranged from 1.82 to 1.85 kg, while baseline hen-day egg

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production ranged from 90.1% to 90.8%. These small descriptive differences did not suggest substantial initial imbalance. Outcomes are summarized in Table 1, with the pen treated as the experimental unit. Production measurements represent averages across the observation period, whereas physiological measurements represent endpoint assessments.

Table 1. Illustrative physiological, stress, and production outcomes under four lighting regimes

Outcome	Conventional	Reduced intensity	Extended	Intermittent
Final body weight, kg	1.91 ± 0.06	1.90 ± 0.05	1.89 ± 0.07	1.92 ± 0.06
Cloacal temperature, °C	41.3 ± 0.2	41.2 ± 0.2	41.5 ± 0.2	41.2 ± 0.2
Plasma corticosterone, ng/mL	3.8 ± 0.5	3.2 ± 0.4	4.7 ± 0.6	3.1 ± 0.4
Heterophil-to-lymphocyte ratio	0.46 ± 0.06	0.39 ± 0.05	0.58 ± 0.07	0.38 ± 0.05
Plasma malondialdehyde, nmol/mL	2.8 ± 0.3	2.5 ± 0.3	3.4 ± 0.4	2.4 ± 0.3
Hen-day egg production, %	92.0 ± 1.8	90.8 ± 2.0	91.5 ± 2.1	92.7 ± 1.7
Mean egg weight, g	62.8 ± 1.2	62.6 ± 1.1	62.5 ± 1.3	62.9 ± 1.0
Daily egg mass, g/hen	57.8 ± 1.5	56.8 ± 1.6	57.2 ± 1.7	58.3 ± 1.4
Daily feed intake, g/hen	114 ± 3	112 ± 3	116 ± 4	113 ± 3
Feed conversion, g feed/g egg	1.97 ± 0.06	1.97 ± 0.07	2.03 ± 0.08	1.94 ± 0.06

Values are hypothetical means ± standard deviations across six pen-level summaries per regime. For physiological outcomes, each pen summary represents the average of sampled birds within that pen; individual birds were not counted as independent treatment replicates. No inferential tests are reported, so differences should be interpreted descriptively rather than as evidence of statistical significance.

Final body weight remained similar across treatments, with a maximum between-group difference of 0.03 kg. Cloacal temperature was highest under extended lighting, although the absolute separation from the other groups was modest. The temperature pattern was not accompanied by a marked reduction in body weight or complete cessation of laying.

Stress-related measurements showed a more pronounced separation than body weight. Mean corticosterone under extended lighting exceeded the conventional value by 0.9 ng/mL, approximately 24%. Reduced-intensity and intermittent lighting showed lower concentrations than conventional lighting. The heterophil-to-lymphocyte ratio followed the same ordering, reaching its highest value under extended lighting and its lowest value under intermittent lighting. Malondialdehyde concentrations also followed this pattern, providing descriptive concordance between endocrine, leukocyte, and lipid-peroxidation measurements.

Egg production varied within a relatively narrow range. Intermittent lighting had the highest average hen-day production, exceeding conventional lighting by 0.7 percentage points. Reduced-intensity lighting had the lowest average production, 1.2 percentage points below the conventional regime. Mean egg weight differed by only 0.4 g across treatments; consequently, variation in daily egg mass primarily reflected differences in laying rate rather than egg size.

Feed intake was highest under extended lighting, but this additional consumption was not accompanied by greater egg mass. Its feed conversion ratio was therefore numerically less favorable

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than those of the other regimes. Intermittent lighting combined the highest egg mass with slightly lower feed intake than conventional lighting, yielding the lowest numerical feed conversion ratio. Nevertheless, the reported variability overlapped across groups, and these descriptive rankings alone do not establish treatment superiority.

Overall, the hypothetical dataset showed higher stress-indicator values under extended lighting without a corresponding production advantage. Reduced-intensity and intermittent lighting showed lower stress-indicator values, but their production patterns differed, emphasizing that physiological and productive responses did not move uniformly together.

4. Discussion

The effects of lighting regimes on laying hens should be interpreted as an interaction between reproductive stimulation, circadian organization, and the opportunity for restorative rest. Light is not simply a management input that extends feeding time; it also provides biological information about day length and regulates behavioral and endocrine rhythms. Consequently, the value of a lighting program cannot be determined from egg production alone. A balanced interpretation requires consideration of physiological condition, stress indicators, egg characteristics, and the persistence of production. Without specifying the direction or magnitude of individual treatment effects, several biological principles help explain how different lighting schedules may influence these outcomes.

Photoperiod is particularly relevant because reproductive activity in birds is sensitive to light-dependent neuroendocrine signaling. An appropriately timed light period can support hypothalamic–pituitary–gonadal activity and maintain the conditions necessary for follicular development and ovulation. However, extending illumination beyond a sufficient stimulatory duration may not produce a proportional improvement in laying performance. Any additional benefit could be limited by nutrient availability, genetic potential, age, or the physiological demands of sustained egg formation. If longer illumination coincides with increased production, that association should therefore be evaluated alongside feed intake, body condition, and egg mass rather than interpreted as evidence of uniformly improved health.

The duration and continuity of darkness are equally important. A predictable dark phase allows synchronized resting behavior and contributes to the organization of daily hormonal rhythms, including melatonin secretion. Shortened or fragmented darkness may interfere with these processes, although the response depends on the timing, intensity, and regularity of light exposure. Intermittent lighting is therefore not inherently beneficial or harmful. Its consequences depend on whether the schedule accommodates the birds' behavioral needs and maintains stable physiological timing. Abrupt schedule changes may also provoke responses that differ from those observed after adaptation, making treatment duration essential to interpretation.

Stress indicators require particular caution because no single measure reliably captures the full welfare consequences of a lighting regime. Circulating corticosterone can reflect activation of the hypothalamic–pituitary–adrenal axis, but it is influenced by sampling time, capture, handling, and recent activity. The heterophil-to-lymphocyte ratio may provide complementary information, yet it can also vary with infection, inflammation, and other environmental challenges. Agreement between endocrine, hematological, and behavioral measures would strengthen an interpretation of altered stress burden. Conversely, discordant indicators should not automatically be considered contradictory; they may represent different response times or distinct components of physiological adaptation.

Light intensity and spectral composition further complicate the relationship between exposure and biological response. Illumination that supports visual activity and feeding may also modify movement, social interactions, and opportunities for avoidance. Excessively bright conditions could contribute to undesirable behaviors in susceptible flocks, whereas very dim conditions may restrict normal activity or hinder inspection and resource use. Spectral effects are biologically plausible because avian photoreception involves pathways beyond human-like visual perception. Nevertheless, claims that a particular color independently improves welfare or production require careful control of intensity, spectral output, and photoperiod. Human-weighted illuminance measurements alone may not fully characterize the light perceived by hens.

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Production outcomes should also be distinguished from production sustainability. A higher laying rate over a short observation period may reflect greater reproductive stimulation without demonstrating improved long-term physiological resilience. Egg weight, shell quality, feed efficiency, mortality, and body-weight stability provide essential context. In particular, shell formation depends on calcium supply and metabolism, which interact with feeding patterns and the timing of egg formation. Changes in these characteristics under different schedules could therefore arise indirectly through altered nutrient intake or feeding distribution rather than through a direct effect of light on the shell gland.

Several methodological considerations limit causal interpretation unless addressed in the study design. Breed, age, housing system, stocking density, temperature, and baseline production may modify responses to lighting. The pen or independently controlled lighting compartment, rather than each hen, may be the appropriate experimental unit when exposure is shared. Failure to account for this clustering can exaggerate statistical precision. Repeated physiological measurements should also be analyzed with attention to within-bird dependence and standardized sampling times. Where several lighting characteristics change simultaneously, their individual contributions cannot be separated confidently.

Overall, the most defensible practical objective is a stable lighting program that supports laying while preserving adequate darkness and normal behavioral expression. Recommendations should depend on concordant physiological and production evidence rather than a single favorable endpoint. Longer follow-up, behavioral assessment, and replication across commercial conditions would help establish whether apparent benefits persist and whether any productivity gains involve delayed welfare or metabolic costs.

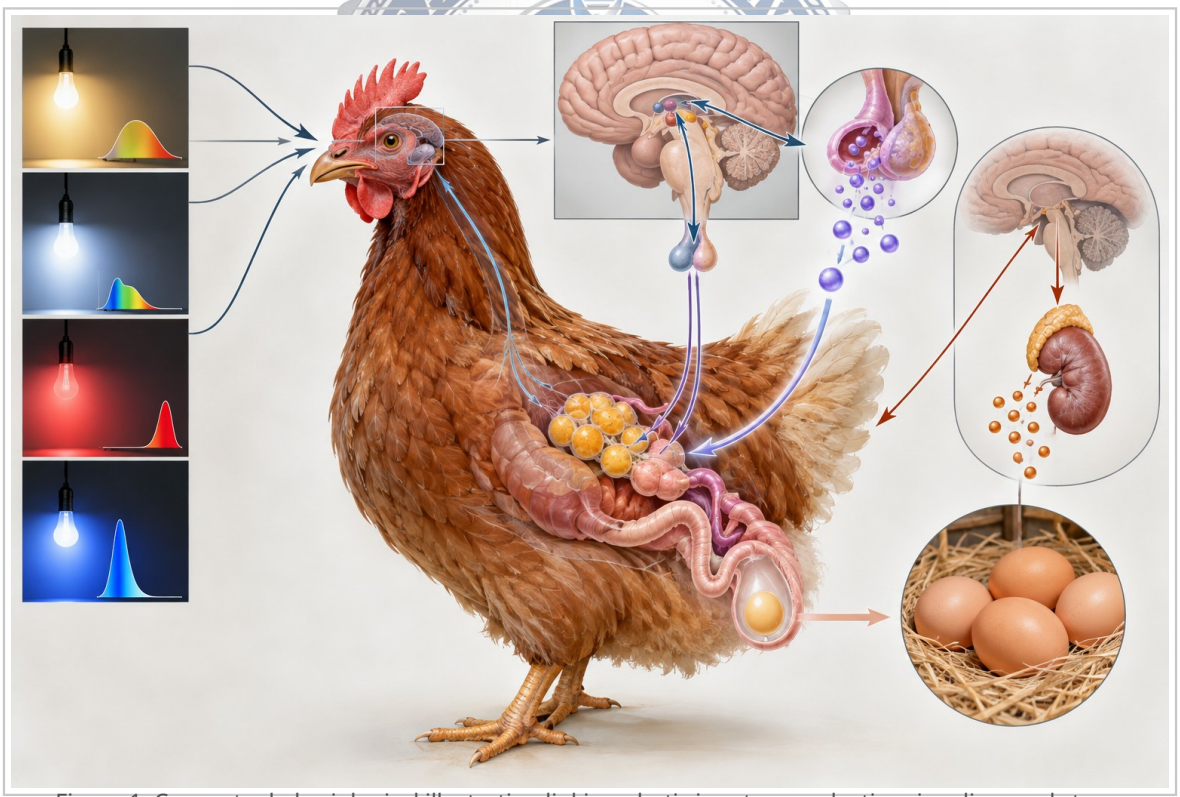


Figure 1. Conceptual physiological illustration linking photic input, reproductive signaling, and stress responses in laying hens.

5. Conclusion

Lighting management should be regarded as an important component of laying-hen husbandry because photoperiod, light intensity, and spectral composition can influence physiological regulation, stress responses, and reproductive performance. The relationship between illumination and egg production is unlikely to be uniformly linear: extending light exposure or increasing brightness does not necessarily provide proportional benefits and may compromise opportunities for rest.

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Consequently, the most appropriate lighting regime should balance productive performance with indicators of physiological stability and animal welfare rather than prioritize egg output alone.

Interpretation of lighting-related responses requires consideration of the broader biological context. Changes in circulating corticosterone, heterophil-to-lymphocyte ratio, or other stress indicators should not be treated as definitive evidence of impaired welfare in isolation. These measures are most informative when evaluated alongside behavioral observations, feed intake, body condition, egg quality, and laying persistence. Likewise, apparently favorable production responses should be assessed for their sustainability and possible physiological costs.

For practical application, consistent light–dark schedules, adequate uninterrupted darkness, and avoidance of abrupt lighting transitions represent biologically reasonable management priorities. However, an optimal combination of lighting duration, intensity, and spectrum cannot be generalized without accounting for genotype, age, housing conditions, and concurrent environmental stressors.

Further controlled investigations with longer follow-up and standardized exposure measurements are needed to distinguish short-term adaptation from persistent effects. Incorporating repeated physiological assessments and comprehensive welfare outcomes would strengthen causal interpretation. Overall, lighting strategies should be selected through an integrated assessment of productivity and welfare, with recommendations remaining proportionate to the quality and scope of the available evidence.

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