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Physiological variations in male Japanese quail (*Coturnix japonica*) reared under different light intensities

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ABSTRACT
This study involved exposing male Japanese quail to a gradual increase in light intensity over a 12-week trial period to alleviate the stress induced by high-intensity lighting throughout the rearing phase. In the trial, 60 birds aged 48 days were allocated into four treatments, each consisting three replications, with each replicate containing five birds. The raising facility was designed to meet the unique requirements of the study. The lighting schedules were established, with a standardized 8-hour dark interval. T1 (control): 16 hours of light; T2: 15 hours of light with a 20-minute intensity increase; T3: 14 hours of light with a 40-minute intensity augmentation; T4: 13 hours. The results revealed no significant variations in the blood plasma biochemical markers, such as glucose, protein, albumin, and globulin, across all treatments. A notable rise ($P \leq 0.05$) in LDL levels was detected in T3 relative to T1 (control) and T4. Moreover, ALT enzyme levels were markedly elevated ($P \leq 0.05$) in T2 and T4 relative to the control group. ALP enzyme levels were markedly increased ($P \leq 0.05$) in T3 relative to the control. No significant differences were observed in the relative weights of internal organs across the treatments. Nevertheless, melatonin hormone levels showed a marked reduction ($P \leq 0.05$) in T3 and T4 relative to T1. The results indicate that the incremental rise in light intensity alleviated stress, increased avian comfort, and improved certain blood biochemical indicators in male Japanese quail.

التغيرات الفسلجية لذكور السلوى الياباني *Coturnix japonica* المرباة تحت شدد ضوئية مختلفة

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الخلاصة

أجريت الدراسة بهدف تقليل الاجهاد المتولد من شدة الإضاءة العالية والمستخدمة في تربية ذكور السلوى الياباني بتعريضها بشكل تدريجي لمدة تجريبية بلغت اثنتا عشرة اسبوعا. أستخدم في التجربة 60 طيرا بعمر 48 يوم، إذ تم توزيع الطيور على أربع معاملات بواقع ثلاث مكررات 5 طير لكل مكرر، صممت قاعة التربية حسب متطلبات هذه الدراسة. تم استخدام عدد ساعات ظلام ثابته وهي 8 ساعات اما عدد ساعات الاضاءة فكانت T1 المعاملة السيطرة وتضمنت 16 ساعة ضوء، T2: 15 ساعة ضوء+1ساعة تدرج في شدة الإضاءة كل 20 دقيقة، T3: 14 ساعة ضوء+2 ساعة تدرج في شدة الإضاءة كل40 دقيقة، T4: 13 ساعة ضوء+3 ساعة تدرج في شدة الإضاءة كل60 دقيقة. بينت النتائج عدم وجود فرق معنوي في صفات الدم الكيموحيوية لبلازما دم ذكور السمان الياباني والتي شملت الكلوكوز والبروتين والالبومين والكلوبيولين لجميع معاملات التجربة، كما اظهرت نتائج صورة الدهن الى وجود إرتفاع معنوي(P≤0.05) فيLDL للمعاملةT3 مقارنة بالسيطرةT1 والمعاملة T4، وكذلك اشارت النتائج الى وجود تفوق معنوي(P≤0.05) لأنزيم ALT فيT2 وT4 مقارنة بالسيطرة، وكذلك تفوق معنوي فيALP (P≤0.05) للمعاملة T3 مقارنة بالسيطرة. كما وبيت نتائج الاوزان النسبية لأحشاء الذكور الداخلية عدم وجود فروق معنوية لجميع معاملات التجربة. كما ولوحظ وجود انخفاض معنوي(P≤0.05) في مستوى هرمون الميلاتونين للمعاملة T3 وT4 مقارنة بالسيطرة T1. وبذلك نستنتج ان التدرج في اعطاء الشدة الضوئية قد قلل من الاجهاد وزاد من راحة الطير وعزز ذلك في تحسين بعض صفات الدم الكيموحيوية لذكور السمان الياباني.

الكلمات المفتاحية : شدة الإضاءة، الصفات الفسيولوجية، السمان الياباني.

INTRODUCTION

The Japanese quail is a small domestic bird extensively utilized in industrial egg and meat production (Onyewuchi *et al*., 2013). Its principal family is Phasianidae, and it is classified as a migratory bird that traverses between Asia and Europe (Saidu *et al*., 2014). This species possesses several beneficial traits, including rapid growth, early sexual maturity, substantial egg production (approximately 300 eggs per year), brief generational interval (3–4 generations per year), and minimal spatial requirements (200–250 birds/m² in floor systems and 150–200 birds/m² in cages). Japanese quail exhibit reduced susceptibility to prevalent poultry diseases, possess a shorter incubation period (17–18 days), and necessitate less feed (25–30 g/bird/day) (Faitarone *et al*., 2005; Jatoi *et al*., 2013). Lighting significantly affects physiological and behavioral processes, making it a crucial environmental factor in the rearing of Japanese quail, hence regulating reproductive characteristics and production efficiency (Ahmad *et al*., 2023). Poultry farmers must comprehend avian responses to different light spectrum and intensities, as birds possess advanced visual systems that govern most of their behaviors (Mendes *et al*., 2013).

Recent years have seen an increased focus on the impact of light on avian behavior, wellbeing, and physiological traits (Raccoursier, 2016). Illumination management is a crucial element in avian husbandry. The three fundamental elements of lighting management—wavelength, light intensity, and photoperiod duration—significantly influence reproductive success and are essential for chicken production. As long-day organisms, birds require sufficient light for the development, growth, and maturation of their reproductive systems (Patel *et al*., 2016). Lighting is crucial for avian growth since it facilitates the maturation of the reproductive system and enhances feed and water consumption. Low-intensity illumination diminishes pecking and other aggressive behaviors (Blatchford *et al*., 2009). Elevated activity levels and high energy expenditure for locomotion are traits of birds subjected to light intensity over 20 lux, adversely affecting growth and productivity (Jassim & Al-Jugifi, 2023).

Conversely, birds may respond to artificial illumination systems with anxiety and fear (Dissegna *et al*., 2022). Nasr *et al*. (2019) assert that light, both natural and artificial, is an external climatic factor that regulates the behavioral, physiological, and neurological functions of birds. In avians, stress constitutes an involuntary response to external stimuli. In contrast to wild birds, which experience gradual shifts in light at dawn, domestic birds are notably stressed by light exposure. Aggression, hyperactivity, restlessness, feather fluffing, and loud vocalizations exemplify behavioral alterations induced by stress (Katajamaa *et al*., 2021). Light intensity is a crucial factor in artificial lighting that significantly affects the performance, productivity, and welfare of hens. Low-intensity lighting promotes the growth and well-being of quail. The eggs of Japanese quail reared under low-intensity lighting exhibit greater weight and superior quality, both internally and externally. Conversely, excessive activity and heightened sensitivity to bright light render high light intensity detrimental to avian welfare, diminishing resting behavior and fostering aggression (Nasr *et al*., 2019).

This study studied male Japanese quail subjected to sudden high-intensity artificial light to assess the impact of incremental increases in light intensity on their physiological traits, stress responses, and degrees of anxiety and fear.

MATERIALS AND METHODS

The purpose of this study was to ascertain the impact of various intervals of gradual light intensity increase on specific blood parameters and the overall health of male Japanese quail. Sixty male brown Japanese quails, all uniformly weighted at 48 days of age, were obtained from the Ministry of Agriculture's Agricultural Research Center. Five male birds per replication were assigned to each of the four experimental treatments. They were kept in controlled environmental conditions in floor cages. A set 8-hour dark time was included in all treatments, and the light duration was divided as follows:

T1 (Control):16 hours of light.

T2: fifteen hours of light plus a one-hour increase in light intensity every twenty minutes.

T3: two hours of progressively increasing light intensity every forty minutes after 14 hours of light.

T4: 13 hours of light plus a three-hour escalation in light intensity every sixty minutes.

Three Japanese quail were randomly chosen from each replicate (a total of nine birds per treatment) at 131 days of age (12 weeks of the experiment) to provide blood samples. For biochemical blood analysis, wing vein blood samples were extracted. Glucose concentration, total protein, albumin, globulin, cholesterol, triglycerides (TG), high-density lipoprotein (HDL), non-HDL lipoproteins, very low-density lipoprotein (VLDL), low-density lipoprotein (LDL), liver enzymes (AST, ALT, ALP), and melatonin hormone were all measured in these analyses. The relative weights of the internal organs—liver, pancreas, spleen, and testes—were also determined after the sample findings were aggregated and statistically examined.

Statistical analysis was conducted using SAS statistical software version 9.1 in a one-way fashion after a Completely Randomized Design (CRD) (SAS, 2012). At a significance level of 0.05, Duncan's multiple range test (Duncan, 1955) was used to determine whether the changes in means were significant.

RESULTS AND DISCUSSION

Table 1 demonstrates that steady light intensity increases had no significant effect on biochemical blood parameters. Glucose, protein, albumin, and globulin levels stayed statistically complementary across all exploratory situations, suggesting that these metabolic signs are opposing to the light force differences executed in this study.

Table 1: Effect of Different Durations of Gradual Increase in Light Intensity on Glucose, Protein, Albumin, and Globulin Levels in the Plasma of Male Japanese Quails

Traits	Treatment				*Sig.*
	T1	T2	T3	T4	
Glucose Mg100ml-1	218.4±1.70*	214.42±0.76	221.13±0.97	222.62±7.25	N.S.
Total protein Mg100ml-1	3.13±0.14	3.45±0.40	3.35±0.21	3.05±0.57	N.S.
Albumin Mg100ml-1	1.68±0.11	1.813±0.13	1.81±0.12	1.46±0.28	N.S.
Galbulin Mg100ml-1	1.44±0.03	1.64±0.26	1.54±0.13	1.59±0.29	N.S.

* Values represent mean ± standard error.
** N.S.: means there are no significant differences between treatments at a significance level ($P \leq 0.05$).
-T1 control treatment included 16 hours of light, T2: 15 hours of light + 1 hour of light intensity gradient every 20 minutes, T3: 14 hours of light + 2 hours of light intensity gradient every 40 minutes, T4: 13 hours of light + 3 hours of light intensity gradient every 60 minutes

Analysis of plasma lipid characteristics (Table 2) revealed that cholesterol, triglycerides (TG), HDL, NHDL, and VLDL concentrations were not significantly different across experimental groups. However, LDL levels accompanied a important increase ($P \leq 0.05$) in T3 (three-step light intensity increase accompanying 40-minute intervals) compared to T1 (control: 16 hours light + 8 hours dark) and T4 (three-step light force increase with 60-minute intervals). No significant difference was noticed between T3 and T2 (three-step light intensity increase with 20-minute intervals).

This elevation in LDL levels concede possibility be connected to Fatty Liver Hemorrhagic Syndrome (FLHS), that is from hepatic fat growth resulting from metabolic disorders in fowl. The progressive changes in light force can have inferred this increase by affecting normal liver function and advancing hepatic lipid build-up (Qiu *et al*., 2021; Jassim & Al-Jugifi, 2022).

Table 2: Effect of different durations of gradual increase in light intensity on the lipid profile of blood plasma of male Japanese quails

Traits	Treatment				*Sig.*
	T1	T2	T3	T4	
Cholesterol $Mg100ml^{-1}$	197.56±28.13	231.45±28.07	249.25±13.09	197.56±28.13	N.S.
TG $Mg100ml^{-1}$	187.19±53.31	206.02±30.86	153.48±17.19	187.19±53.31	N.S.
HDL $Mg100ml^{-1}$	105.59±15.03	117.46±5.69	113.18±6.39	105.59±15.03	N.S.
NHDL $Mg100ml^{-1}$	91.97±13.97	114±23.16	136.07±6.74	91.97±13.97	N.S.
VLDL $Mg100ml^{-1}$	37.44±10.66	41.20±6.17	30.69±3.43	37.44±10.66	N.S.
LDL $Mg100ml^{-1}$	54.53±5.52 b	72.79±16.99 ab	105.37±10.02 a	54.53±5.52 b	0.05

* Values represent mean ± standard error.
** N.S.: means no significant differences between treatments at a significance level (P≤0.05).
a, b: Different letters within the same row indicate significant differences between treatments at a significance level (P≤0.05).
-T1 is the control treatment and included 16 hours of light, T2: 15 hours of light + 1 hour of light intensity gradient every 20 minutes, T3: 14 hours of light + 2 hours of light intensity gradient every 40 minutes, T4: 13 hours of light + 3 hours of light intensity gradient every 60 minutes.

The results in Table 3 show that the liver enzymes in the plasma of male Japanese quails were impacted by the various lengths of time that the light intensity was gradually increased. The findings show that there is no discernible variation in AST across all experimental regimens. In contrast to treatments T1 (control: 16 hours of light + 8 hours of darkness) and T3 (gradual light intensity increase three times over 40 minutes), ALT significantly increased (P≤0.05) in treatments T2 and T4, where light intensity was gradually increased three times over 20 minutes and 60 minutes, respectively. In comparison to treatments T1 (control: 16 hours of light + 8 hours of darkness) and T2 (gradual light intensity increase three times over 20 minutes), treatment T3 (gradual light intensity increase three times over 40 minutes) also showed a significant increase (P≤0.05) in ALP. It did not, however, differ substantially from T4 (three steady increases in light intensity during a 60-minute period). The results might be clarified by the presence of ALT and ALP as indicators of hepatic disorders in poultry, as they are detected in the bloodstream at reduced levels and primarily contribute to metabolic pathways within hepatocytes. An elevation in hepatocyte levels signifies hepatocyte injury and liver dysfunction (Sampaio *et al*., 2024). The results demonstrate that extended durations of progressively escalating light intensity lead to elevated liver enzyme levels. Liver enzymes, crucial indicators of hepatic function, are evidently influenced by some increases, albeit lacking statistical significance. Their rise indicates liver damage and abnormalities associated with the study's prolonged light intensity gradients. This increase often indicates heightened intracellular activity or obstruction of bile flow.

Table 3: Effect of Different Durations of Gradual Light Intensity Increase on Liver Enzymes in the Plasma of Male Japanese Quails

Traits	Treatment				*Sig.*
	T1	T2	T3	T4	
AST IU L-1	62.37±1.06*	65.75±1.20	60.8± 1.73	60.32±7.66	N.S.
ALT IU L-1	10.14±0.59 B	14.78±1.46 a	8.84±0.34 b	13.84±1.51 a	0.05
A LP IU L-1	58.38±3.13 b	52.97±2.56 b	90.59±11.72 a	75.23±13.66 ab	0.05

*Values represent the mean ± standard error.
**NS: No significant differences among treatments at a significance level of (P≤0.05).
a, b: Different letters within the same row indicate significant differences among treatments at (P≤0.05). T1 (Control): 16 hours of light. T2: 15 hours of light + 1 hour of gradual light intensity increase every 20 minutes. T3: 14 hours of light + 2 hours of gradual light intensity increase every 40 minutes. T4: 13 hours of light + 3 hours of gradual light intensity increase every 60 minutes.

Table 4 presents the relative weights of interior (testes, liver, pancreas, and spleen) in male Japanese quails. No significant differences (P≥0.05) were noticed among treatments, indicating that the varying light intensity protocols did not substantially affect means growth or relative size.

Table 4: Effect of Different Durations of Gradual Light Intensity Increase on the Relative Weights of Internal Organs in Male Japanese Quails

Traits	Treatment				*Sig.*
	T1	T2	T3	T4	
Testes	3.01±0.48*	3.36±0.49	4.22±0.39	3.85±0.58	N.S.**
Liver	1.95±0.21	2.46±0.23	2.16±0.24	2.54±0.16	N.S.
Pancreas	0.22±0.03	0.27±0.02	0.22±0.07	0.29±0.06	N.S.
Spleen	0.08±0.02	0.11±0.03	0.08±0.02	0.08±0.02	N.S.

* Values represent mean ± standard error.
** N.E.: means there are no significant differences between treatments at a significance level (P≤0.05).
-T1 control treatment included 16 hours of light, T2: 15 hours of light + 1 hour of light intensity gradient every 20 minutes, T3: 14 hours of light + 2 hours of light intensity gradient every 40 minutes, T4: 13 hours of light + 3 hours of light intensity gradient every 60 minutes.

Figure 1 demonstrates that plasma melatonin concentrations were significantly decreased (P≤0.05) in T3 and T4 (gradual light intensity increases over 40 and 60 minutes, respectively) compared to the control treatment (T1). However, no significant differences were noticed among T2, T3, and T4.These significant differences maybe attributed to age-related decreases in birds' light sensitivity and lowering melatonin production. According to Ruiz-Jimenez (2021), Saed *et al* ., (2024), avian melatonin secretion and light sensitivity belittle with age, necessitating increased photoperiod length and light intensity to maintain constant melatonin levels and reproductive efficiency. The shorter effective photoperiod in T3 and T4, resulting from longer gradual rising periods, likely contributed to the observed melatonin decline when linked with age-related factors and abated light sensitivity. Reduced melatonin levels are mainly considered advantageous for male reproductive performance in birds, as melatonin exhibits inhibitory effects on avian reproduction. Lower melatonin concentrations promote increased secretion of reproductive stimulators from the hypothalamus, enhancing gonadotropin (FSH and LH) release from the pituitary gland and consequently stimulating testicular spermatogenesis.

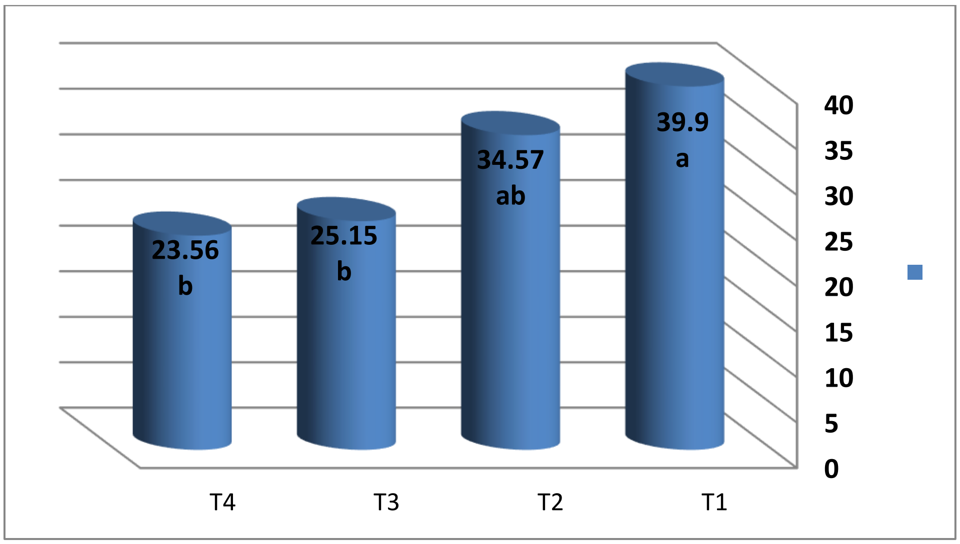

Figure 1: Effect of different durations of gradual increase in light intensity on melatonin levels in blood plasma of male Japanese quails a - , b, c: Different letters indicate significant differences between the means at a significance level (P≤0.05). - T1 control treatment included 16 hours of light, T2: 15 hours of light + 1 hour of light intensity gradient every 20 minutes, T3: 14 hours of light + 2 hours of light intensity gradient every 40 minutes, T4: 13 hours of light + 3 hours of light intensity gradient every 60 minutes.

CONCLUSION

The study finds that Japanese quails' fear and tension, that are usually brought on by hasty exposure to high-intensity light, were lessened apiece progressive increase in light force. Gradual light force increases selectively overwhelmed Japanese cower physiology, accompanying important changes in LDL levels and liver enzymes but not in fundamental biochemical parameters or means weights. The 40-minute break situation (T3) induced ultimate notable changes in LDL levels, suggesting potential metabolic turmoil. Elevated liver enzymes in differing treatments signify hepatic stress from extended light force adjustments. Reduced melatonin levels in more interminable piecemeal light situations (T3 and T4) grant permission enhance generative birth control method discharge. These findings imply calculated light administration could develop cower generative performance while underrating corporeal stress.

CONFLICTS OF INTEREST

The authors reveal that skilled are no conflicts of interest concerning the newspaper concerning this paper.

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