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The Influence of Duration of Lighting on the Productive Performance of Japanese Quail

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Abstract | The purpose of this study was to investigate the influence of the duration of lighting on the productive performance of Japanese quail. A total of 225 one-day-old, colored and unsexed of Japanese quail were utilized. The chicks were randomly distributed into 3 equal treatments, with 75 chicks per treatment. Each treatment included of 3 replicates, each replicate contained 25 chicks. Different lighting systems were applied to the chicks starting from one day old until the end of the study period on 42 days old, as follows: for the first treatment T1 (control) the birds were exposed to continuous lighting for 24 hours during the day. During the second treatment (T2), the birds were exposed the to 10 hours of continuous light from 8 a.m to 6 p.m, followed by 14 hours of intermittent light, alternating 2 hours of darkness and 2 hours of light. The third treatment: involve exposing birds to 11 hours of continuous light from 7 a.m to 6 p.m, followed by 13 hours of intermittent light, alternating with 1 hour of darkness and 2 hours light. The results indicated that the birds of treatment T2 achieved a significant increase ($P<0.05$) in the average of live body weight at the ages of 14, 28, and 42 days. There were no significant differences between the three treatments on the average of total weight gain during the study stages. The amount of feed consumed by treatment T2 increased significantly at the age of 14 days, while at the age of 28 days, treatments T2 and T3 was outperformed significantly. The feed conversion ratio was increased significantly for treatment T2 during the first 14 days of the birds age, while at the age of 28 days both treatments T1 and T2 have significantly excelled. There were no significant differences in the percentage of mortality between the three treatments during the study stages. Based on these finding, it is plausible to conclude that the intermittent lighting system reduction electricity costs and improve performance of birds.

Keywords | Influence, Duration, Lighting, Productive, Japanese quail

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INTRODUCTION

One of the most important environmental factors influencing avian growth and production is light (Cassone and Kumar, 2015). A light signal stimulates the axis of hypothalamus-thyroid-gonad, which controls food intake and initiates metabolic pathways in the body. This suggests that light plays a major role in regulating avian growth and production processes, among other environmental factors (Raabe et al., 2023). Various lighting systems used on poultry have been shown in several studies to have a significant impact on their productive traits; thus, numerous programs have been explored to try to improve these traits (Rahimi et al., 2005). Continuous lighting schemes improve feed intake, which speeds up development, according to Renden et al. (1991). This could not, however, result in higher feed conversion ratios or profitable outcomes. Research on lighting systems has therefore increased as a result of interest in adjusting lighting durations to enhance the health and productivity of birds (Olanrewaju et al., 2006). Consequently, several investigations have been applied to lighting programs that are both continuous and intermittent (Schwean-Lardner et al., 2014). The change in human lifestyle, economic development and the rise in the level of living, led to the search for sources rich in nutritional elements such as poultry products that characterized by a high percentage of animal protein (Nafea et al., 2019; Al-Tawash et al., 2020; Nafea, 2018). As a result, many countries have begun to work on raising different types of poultry such as Japanese quail (Adeola, 2006) The demand for its products has increased due to the high quality of these products in terms of nutritional value and palatability.

Despite its small size and weight, this bird is distinguished by its exceptional feed conversion efficiency, rapid growth, and suitability for breeding in the Iraqi environment (Abdel-Azeem et al., 2001; Hasan, 2013). Therefore, this study aimed to compare the effect of different lighting durations on the most important productive indicators of Japanese quail to determine the best one for breeding.

MATERIALS AND METHODS

Experimental design and chick management

This study was conducted in Al-Diwaniyah City, Republic of Iraq, for a period of 42 days, where 225 chicks of Japanese quail one day old, colored and unsexed, with an average initial weight of 6.42 gram, were used. They were randomly distributed into 3 equal treatments, with 75 chicks per treatment. Each treatment It consists of 3 replicates; each replicate contained 25 chicks. The chicks were raised in iron mesh floor cages, the dimensions of each cage were 60 × 60 × 70 cm (length × width × height) in a hall where all appropriate measures were taken for breeding, this hall was divided into three sections by insulating wooden panels to prevent light penetration. Each section included three sectors. The temperature of the house was 33°C during the first week and then it was reduced by 2ºC weekly, until reaching a temperature of 22 ºC. All housing and care conditions were similar for all treatments except the lighting duration. Feed and water were provided ad. libitum throughout the study period. Different lighting programs were applied to treatments from one day old until the end of the study period at the age of 42 days.

Birds were randomly distributed to the treatments as follows:

- T1 (control): Birds were exposed to continuous lighting for 24 hours per day.
- T2: Intermittent lighting program that includes exposing birds to 10 hours of continuous lighting from 8 a.m to 6 p.m, followed by 14 hours of intermittent lighting, 2 hours of darkness, and 2 hours of light.
- T3: Intermittent lighting program that includes exposing birds to 11 hours of continuous lighting from 7 am to 6 pm, followed by 13 hours of intermittent lighting, 1 hour of darkness, and 2 hours of light.

Feeding

Two types of diets starter and growth were used during the study period; their components and chemical composition are shown in Table 1.

Table 1: The type of diets that used in the study and the calculated chemical composition.

Growth diet (22-42 day)	Starter diet (1-21 day)	Components%
55.5	40.25	Corn
5.5	25	Wheat
5.5	2.5	Dehydrated Alfalfa Meal (18%)
10	10	Protein conc.*
20	20	Soya bean meal(44%)
1.5	1	Limestone
1.5	0.75	DiCa Ph.
0.5	0.5	Salt
Calculated chemical composition**		
2800	2600	Metabolizable (energy Kcal/kg feeding)
20	24	Crude protein%
2.26	2.5	Fibers%
3.31	1.3	Lipid%
9.03	9.2	Moisture Content%
5.08	6.6	Ash%
2.5	0.8	Ca%
0.35	0.3	Available p%
140	108.33	Energy to protein ratio

*Concentrated protein for chicken feed, Alblasserdam Holland, WAFI B.V. 40% crude protein, 5% crude fat, 2.20 percent crude fiber, 7.13% moisture, 28.32 percent ash, calcium 4.50%, 2.65% phosphorus, 4.68% available phosphorus, 3.85% lysine, 3.70 percent methionine, 4.12% methionine + cysteine, 0.42% tryptophan, 1.70% threonine, 2107 metabolizable energy, 2.30 percent selenium, and 4% copper. **The chemical composition values were calculated according to N.R.C (1994).

Study stages

The study was divided into 3 stages. The first stage: from 1 until 14 days old. The second stage: from 15 until 28 days old. The third stage: from 29 until 42 days old.

Table 2: The influence of the duration of lighting on the average of live body weight during the study stages (gram/bird) for Japanese quail. SEM: standard error of means.

The treatment	Age by day			
	1	14	28	42
T1	6.42	44.13 b	92.03 b	163.03 b
T2	6.42	45.87 a	93.80 a	166.14 a
T3	6.43	44.20 b	92.56 b	163.06 b
S.M.	6.42	44.73	92.79	164.07
S.E.M	0.005	0.292	0.261	0.552
Significant	N.S	*	*	*

N.S means no significant differences between treatments within a same column, * means. Significant differences between treatments within a same column at a probability level of 0.05. T1: Control treatment continuous lighting 24 hours/day. T2: Intermittent lighting treatment: 10 hours continuous lighting + 14 hours intermittent lighting (2 hours dark + 2 hours light(. T3: Intermittent lighting treatment: 11 hours continuous lighting + 13 hours intermittent lighting (1 hour dark + 2 hours light).

Studied characteristics

The data related to the productive characteristics was recorded for each stage. Chicks were weighed at the beginning and end of each stage of the study. The difference between the final and initial weight of the birds of each stage was observed. The amount of feed intake was calculated as the difference between the amount of feed provided to the birds and the feed remaining, divided by the number of birds at the end of each day of the experiment. Feed conversion ratio was computed from the quotient of feed intake to body weight gain for each stage throughout the experimental period. Mortality rate was calculated as a percentage of the number of birds in each replicate during the study stages to the total number of chicks at the beginning of the experiment. At the end of the study period, 5 birds were slaughtered from each replicate, dressing ratio. It has been calculated as a percentage by dividing the carcass weight without viscera into the final of live body weight (Al-Fayad *et al*., 2011).

Statistical analysis

Data were analyzed based on a completely randomized design by using the General Linear Models Procedure in SAS (2013). Pens were treated as the experimental unit. Significant differences among treatment groups were further analyzed using Duncan's multiple-range test (Duncan, 1955). A significant level of (0.05) was implemented.

RESULTS AND DISCUSSION

Average of live body weight and weight gain

The results of the statistical analysis, as shown in Table 3, indicated no significant differences in the average of live body weight between the treatments on the first day of the chicks' age, while a significant superiority (P≤0.05) was observed for treatment T2 compared to the control treatment (T1) and T3 during the first , second and the third stage of the study, the average of live body weight of treatments T1 T2 T3 at the age of 14 days was (44.13, 45.87 and 44.20) gram/bird , while at the age of 28 days the weights were (92.03, 93.80 and 92.56) gram/bird , the final live body weight at 42 days of age was (163.03, 166.14 and 163.06) gram/bird, respectively. There were no significant differences between the treatments T1 T2 T3 in the average of weight gain during the study stages and totally, as shown in Table 4 the average of daily weight gain during the study period (42 days), where a significant superiority (P≤0.05) was observed for treatment T2 compared to the rest of the treatments, amounting to 3.79 gram/bird for treatment T2 and 3.72 gram/bird for treatment T1, while treatment T3 amounted to 3.72 gram/bird. Nonexistence of significant differences in the weight of one-day-old chicks may be due to the homogeneity of the hatching eggs which the chicks hatched from it, the weight of the hatched chick represents the natural reflection of the weight of the hatching eggs, as there is a direct relationship between them (Al-Salhie and Al- Swdani, 2013). The significant superiority in the average of live body weight of the T2 treatment during the three study stages (14, 28, 42 days) as explained by Lein *et al*. (2007) because of the increasing of feed consumption of birds exposed to the intermittent lighting system compared to those which exposed to the continuous lighting system, causing an increase in body weight, or because of the increasing of darkness duration reduces the bird's body's energy needs during darkness as a result of reducing the metabolic rate, which was positively reflected in the live body weight (Classen, 2004). It may be due to the increasing of secretion of melatonin hormone, which has been proven to be secreted more during the dark period from the pineal gland, which acts as an antioxidant and helps remove free radicals from the bird's body, enhance bone growth and differentiation of bone membranous tissue cells, and improve mineral metabolis (Roth *et al*., 2001).

The reason for the decrease in the average of live body weight of the control treatment T1 may be due to the early sexual maturity of the birds in this treatment, because the length of lighting duration led to stopping or reducing the secretion of growth hormone due to the negative correlation between sex hormones and growth hormone (Al-Fayad *et al*., 2011). According to studies by (Abbas *et al*., 2008; Yildiz *et al*., 2009; Kalaba *et al*., 2016) the birds

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grown under intermittent illumination programmes had considerably greater average live body weights than birds reared under continuous lighting programmes. Gharib *et al.* (2008); Bayram and Ozkan (2010); Petek *et al.* (2010), and Amakiri *et al.* (2011) showed no appreciable differences in the mean live body weight of birds among treatments exposed to different illumination settings, which was in contrast to these findings. The weight increase results were comparable to those of Mosleh *et al.* (2014); Olanrewaju *et al.* (2018) and Manfio *et al.* (2019) who found no discernible impact on the average weight gain of birds by shortening the time of lighting. This outcome contradicted the findings of Sun *et al.* (2017) who found that intermittent lighting programs significantly increased the birds' total weight gain rate when compared to continuous lighting.

Table 3: The influence of the duration of lighting on the average of weight gain (gram/ bird) during the study stages for Japanese quail. SEM: standard error of means.

The treatment	Age by day			Average of daily weight gain for 42 days	Total of weight gain (1- 42 days)
	14	28	42		
T1	2.69	3.45	5.03	3.72 b	153.28
T2	2.81	3.41	5.16	3.79 a	159.92
T3	2.69	3.45	5.05	3.72 b	156.30
S.M.	2.73	3.43	5.08	3.74	156.5
S.E.M	0.031	0.021	0.034	0.016	2.933
significant	N.S	N.S	N.S	*	N.S

N.S means no significant differences between treatments within a same column, * means. Significant differences between treatments within a same column at a probability level of 0.05. T1: Control treatment continuous lighting 24 hours/day. T2: Intermittent lighting treatment: 10 hours continuous lighting + 14 hours intermittent lighting (2 hours dark+ 2 hours light (T3: Intermittent lighting treatment: 11 hours continuous lighting + 13 hours intermittent lighting (1hour dark + 2 hours light).

Consumed feed

Table 4 shows the average amount of feed consumed during the study stages and total feed consumed per bird. It is noted that there is a significant superiority ($P \leq 0.05$) for treatment T2 at the age of 14 days (8.81 gram/day) compared to the control treatment T1 (6.98 gram/day) and treatment T3 (7.37 gram/day), A significant superiority ($P \leq 0.05$) was observed at the age of 28 days for treatments T2 and T3 (15.92 and 15.29 gram/day) respectively compared to the control treatment T1 (6.98 gram/day), and there were no significant differences between the three treatments (T1, T2 and T3) at the age of 42 days (20.53, 21.76 and 21.04 gram/bird), respectively and the average of daily feed consumed during the length of study period (13.55, 15.51 and 14.50 gram/bird) and the total feed consumed from 1 to 42 days (569.52, 651.79 and 609.28 gram/bird) respectively. According to Othani and Tanaka (1998) the birds that were exposed to a period of darkness, will go to the feeders actively and quickly and at the same time to consume the largest amount of feed when the lighting returns because the upper part of the digestive tract may be empty, so these birds are ready directly to consume the feed when the lighting period begins, so feed consumption did not decrease with the intermittent lighting system, but on the contrary, it led to an increase in its consumption, while birds that were exposed to continuous lighting showed less activity because of their continued consumption of feed. As Schwean- Lardne *et al.* (2014) explained, the highest level of feed consumption by birds is before turning off the lights in anticipation of the unavailability of feed during the dark period, and also immediately after returning the lights in response to the state of hunger. What we obtained in this study is consistent with the results of the study of Fidan *et al.* (2017) and Helmy *et al.* (2023), who noted that there was no significant effect of the difference in the length of the lighting period to which the birds were exposed on the total amount of feed consumed, And It did not agree with the results of Manfio *et al.* (2019), and Ghanima *et al.* (2021), who showed that the use of the intermittent lighting system led to a significant increase in the amount of total feed consumed by birds compared to continuous lighting.

Table 4: The influence of the duration of lighting on the average of feed consumed during the study stages (gram/ bird) for Japanese quail. SEM: standard error of means.

The treatment	Age by day			Average of feed consumption during 42 days	Total of feed consumed (1-42days)
	14	28	42		
T1	6.98 b	13.33 b	20.53	13.55	569.52
T2	8.81 a	15.92 a	21.76	15.51	651.79
T3	7.37 b	15.29 a	20.85	14.50	609.28
S.M.	7.72	14.84	21.04	14.52	610.18
S.E.M	0.440	0.661	0.317	0.426	17.900
Significant	*	*	N.S	N.S	N.S

N.S means no significant differences between treatments within a same column, * means. Significant differences between treatments within a same column at a probability level of 0.05. T1: Control treatment continuous lighting 24 hours/day. T2: Intermittent lighting treatment: 10 hours continuous lighting + 14 hours intermittent lighting (2 hours dark + 2 hours light(. T3: Intermittent lighting treatment: 11 hours continuous lighting + 13 hours intermittent lighting (1hour dark + 2 hours light).

Feed conversion ratio (FCR)

Table 5 shows the average values of the feed conversion coefficient for the different treatments in total and during the rearing stages. It is noted that during the first stage of the study (at the age of 14 days) its value increased significantly ($P<0.05$) for treatment T2 (3.12) compared

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to the control treatment (2.59) and treatment T3 (2.73). In the second stage (at the age of 28 days) the differences were also significant ($P<0.05$) between the treatments, as treatments T1 (4.67) and T2 (4.67) outperformed treatment T3 (4.43). There were no significant differences between the three treatments T1 T2 T3 in the third stage of the study (42 days) as well as the total feed conversion coefficient (1-42 days). According to Lein *et al.* (2007), the increase in feed intake resulted in an increase in live weight, which explains why the intermittent lighting system had no discernible impact on the totally feed conversion ratio (TFCR). Lein *et al.* (2007) and Helmy *et al.* (2023) they found no significant difference in the TFCR value between birds exposed to intermittent lighting and which was exposed to continuous lighting. These findings of this study are in line with their findings. The findings of Ohtani and Tanaka (1998); Petek *et al.* (2005); Rahimi *et al.* (2005); Onbasilar *et al.* (2007); Mahmud *et al.* (2011); Mustafa and Muneer (2013), and Yang *et al.* (2015) did not support the findings of this study. These studies found that birds exposed to intermittent lighting had a significantly higher average value of the total feed conversion ratio than birds exposed to continuous lighting.

Table 5: The influence of the duration of lighting on the average of feed conversion ratio during the study stages (gram feed/gram weight gain) for Japanese quail. SEM: standard error of means.

The treatment	Age by day			Average of total feed conversion ratio 1-42 days)
	14	28	42	
T1	2.59 b	3.86 a	4.03	3.90
T2	3.12 a	4.67 a	4.21	4.07
T3	2.73 b	4.43 b	4.12	3.89
S.M.	2.81	4.32	4.12	3.95
S.E.M	0.081	0.125	0.044	0.059
Significant	*	*	N.S	N.S

N.S means no significant differences between treatments within a same column, * means Significant differences between treatments within a same column at a probability level of 0.05. T1: Control treatment continuous lighting 24 hours/day. T2: Intermittent lighting treatment: 10 hours continuous lighting + 14 hours intermittent lighting (2 hours dark + 2 hours light(. T3: Intermittent lighting treatment: 11 hours continuous lighting + 13 hours intermittent lighting (1hour dark + 2 hours light).

Percentage of mortality

It is noted from Table 6 that there are no significant differences among the different treatments in the percentage of mortality, during the first (14 days), second (28 days), and third (42 days) stages of the study, as well as the total mortality rate during the study period. However, it is noted that there is a decrease in this percentage in birds of treatment T2 compared to treatment T1 (control) and T3, but this decrease did not reach the level of significance. This supports the findings of Classen (2004), who discovered that birds' vitality is enhanced, and sudden death syndrome is decreased by intermittent lighting. Additionally, it supports the findings of Apeldoorn *et al.* (1999), who found that giving birds enough dark periods reduces their health troubles. These results are in line with those of Hassanzadeh *et al.* (2012) and Schwean *et al.* (2013), who found that intermittent lighting programs significantly decreased the percentage of total mortality, while Özkan *et al.* (2012) and Olanrewaju *et al.* (2018) found no significant differences in the percentage of total bird mortality when using different lighting programs.

Table 6: The influence of the duration of lighting on the mortality percentage during study stages for Japanese quail. SEM: standard error of means.

The treatment	Age by day			Total of mortality percentage 42 -1) days)
	14	28	42	
T1	0.01	0.04	0.02	0.08
T2	0.00	0.01	0.00	0.01
T3	0.01	0.01	0.01	0.04
S.M.	0.006	0.02	0.01	0.04
S.E.M	0.005	0.007	0.006	0.014
Significant	N.S	N.S	N.S	N.S

N.S means no significant differences between treatments within a same column, T1: Control treatment continuous lighting 24 hours/day. T2: Intermittent lighting treatment: 10 hours continuous lighting + 14 hours intermittent lighting (2 hours dark + 2 hours light(. T3: Intermittent lighting treatment: 11 hours continuous lighting + 13 hours intermittent lighting (1hour dark + 2 hours light).

Weight of carcass and percentage of dressing

It is noted from Table 7 that treatment T2 significantly outperformed treatment T1 and treatment T3 in the weight of the cleaned carcass and the percentage of dressing at the end of the study period at the age of 42 days, as the carcass weight for treatments T1, T2 and T3 reached (106.50, 111.45, 106.56) gram respectively, while the percentage of dressing was (65.32, 67.08, 65.22)% respectively. The reason for the superiority of treatment T2 in these two characteristics over treatments T1 and T3 can be attributed to the increase in the live weight of birds in this treatment, because the higher the live body weight, the higher the carcass weight and the percentage of dressing Al-Fayad *et al.* (2011). These findings are in line with those of Olanrewaju *et al.* (2019); Soliman and Hassan (2019); Ghanima *et al.* (2021) and Sodella *et al.* (2022), those who noticed a significant effect of the difference in lighting programs on the percentage of dressing and carcass specifications of the raised birds. It contradicted the findings of Olanrewaju *et al.* (2006) and Fidan *et al.*

(2017), those who observed no significant differences between treatments when using different lighting systems in the percentage of dressing and carcass specifications.

Table 7: The influence of the duration of lighting on the carcass weight and percentage of dressing for Japanese quail on the end of study period. SEM: standard error of means.

The treatment	Carcass weight (gram)	Dressing percentage
T1	106.50 b	65.32 b
T2	111.45 a	67.08 a
T3	106.56 b	65.22 b
S.M.	108.17	65.87
S.E.M	0.869	0.332
Significant	*	*

* means Significant differences between treatments within a same column at a probability level of 0.05. T1: Control treatment continuous lighting 24 hours/day. T2: Intermittent lighting treatment: 10 hours continuous lighting + 14 hours intermittent lighting (2 hours dark + 2 hours light(. T3: Intermittent lighting treatment: 11 hours continuous lighting + 13 hours intermittent lighting (1hour dark + 2 hours light).

It is noted from Table 8 that treatment T2 (2 hours of light and 2 hours of darkness alternately at night), reduced the electrical energy required to light the barn by 33.334%, and treatment T3 (1 hour of light and 2 hours of darkness alternately at night) reduced the electrical energy by 20.834%, compared to the control treatment T1(24 h light).

Table 8: The influence of the duration of lighting to illuminate the hall of Japanese quail during the study period.

Percentage reduction in electrical energy compared to control treatment during 42 days	Percentage of light hours compared to control treatment during 42 days	Number of lighting hours during 42 days	The treatment
-	100	1008	T1
33.334	66.666	672	T2
20.834	79.166	798	T3

CONCLUSIONS AND RECOMMENDATIONS

We conclude from this study that the application of a continuous lighting system during the day and intermittent lighting at night (2 hours of darkness: 2 hours of light) when raising Japanese quail has led to an improvement in the productive performance of these birds, reduced the cost of electricity consumption, and extended the life of electric lamps. Further studies using lighting systems and poultry of other species are suggested.

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NOVELTY STATEMENT

All data, tables, and figures in this manuscript are original. New Statement. This study presents a new approach by applying different lighting programs to Japanese quail. The results observed on the productive performance of these birds for each lighting duration used may indicate their positive effects when raised commercially.

AUTHOR'S CONTRIBUTION

MSM: Methodology, writing original paper and conceptualization.
HHN: Methodology and reviewing.
HGT: Funding acquisition.
OM: Reviewing and acquisition.
All authors have read and agreed to the published version of the manuscript.

Generative AI and AI-assisted technology statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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Links Researchers