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PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF JAPANESE QUAIL AS AFFECTED BY TIME OF FEED IN HOT CLIMATE

(With 8 Tables)

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الأداء الانتاجى والتناسلي للسمان الياباني تحت تأثير وقت الغذاء في الجو الحار

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استخدم في هذه الدراسة عدد ٢٤٠ كتكوت من السمان الياباني عمر يوم غير مجنس، لدراسة تأثير تغيير وقت التغذية على الأداء الإنتاجي والتناسلي للطيور تحت تأثير الظروف المناخية السائدة في أسيوط خلال فصل الصيف. تم تربية كل الكتاكيت فى بطاريات ثم قسمت إلي أربعة مجاميع (مقارنة ، ٣ معاملات)، ولقد قسمت الطيور بكل مجموعة والبالغ عددها ٦٠ طائر إلى ثلاثة مكررات بواقع ٢٠ طائر/مكررة. وكان يتم تزويد جميع الطيور بالماء طوال الوقت. وبالنسبة للغذاء فكان يقدم مرتين يوميا، عند الساعة ٠٩٠٠ ثم الساعة ١٥٠٠، وذلك بالنسبة لمجموعة الكنترول، وعند الساعة ١٥٠٠ ثم ٢١٠٠ وعند الساعة ٢١٠٠ ثم ٠٣٠٠ وعند الساعة ٠٣٠٠ ثم ٠٩٠٠ وذلك بالنسبة لمجموعات المعاملة ١ ، ٢ و٣ على التوالي، وذلك لاختيار الوقت المناسب لتغذية الطيور كمحاولة لتقليل التأثيرات الضارة للإجهاد الحراري خلال الوقت الحار من اليوم فى فصل الصيف بصعيد مصر. أوضحت النتائج المتحصل عليها أن تغيير وقت التغذية من اليوم على الأداء خلال فترتي النمو والإنتاج في صيف أسيوط الحار كان ذو تأثير معنوي على أداء وزن الجسم، صفات إنتاج البيض، جودة البيض، نسبتي الخصوبة والفقس، حرارة الجسم، نسبة النفوق والكفاءة الاقتصادية للسمان الياباني، ولكنه ذو تأثير غير معنوي على نسب مكونات البيضة في جميع المجاميع.

SUMMARY

A total number of two hundred and forty unsexed one-day old chicks of Japanese quail were used to study the effect of feeding time management on the productive and reproductive performance of birds under subtropical prevailing environmental conditions in Assiut. All chicks were housed in batteries in 3 equal groups (3 replicates of 20 birds each). All experimental birds were supplied with clean water all the time. The feed was offered twice daily, control group (C) was practiced at 0900 and 1500 h, during the warmest time of the day. While, the first treatment group (T1) was fed at 1500 and 2100 h; the second treatment group (T2) was fed at 2100 and 0300 h and the third treatment group (T3) was fed at 0300 and 0900 h, during the temperate climatic conditions, in order to avoid the deleterious effect of the high temperature on the birds in the summer season under Upper Egypt conditions. The obtained results indicated that change of feeding time affected body weight performance, egg production, egg quality, fertility & hatchability, body temperature, mortality rate and economical efficiency in Japanese quail, however no significant differences in percentages of egg components were found among all groups.

Key words: *Productive and reproductive performance, time of feeding, hot climate, Japanese quail.*

INTRODUCTION

In areas with warm to hot climates, poultry producers face the challenge of avoiding heat stress in their birds at the beginning of each summer. In today's ever-evolving poultry industry, practices in management and feeding system are among the most important points for poultry producers especially in Upper Egypt with hot climates, since it can relatively reduce the heat load. Birds are very susceptible to high ambient temperature because they have very few functional sweat glands and consequently they face difficulty in eliminating excess of body heat especially when temperature exceeds the appropriate thermo neutral zone (Carmen *et al.,* 1990 and Marai *et al.,* 2002). This effect leads to a remarkable depression in appetite, feed intake, metabolizable energy for growth and production and finally in decreased efficiency of feed utilization. Furthermore, there are disturbances in metabolism of energy, protein and mineral balances, enzymatic, hormonal secretion and blood metabolism. These disturbances lead to a pronounced decrease in production and reproduction performance of poultry as well as in resistance to diseases (Emara, 1982, Samara, *et al.,* 1996 and Aengwanich, 2007b).

It is noteworthy that most of the bird's heat load comes from the feed, as consequences of digestion, absorption and nutrient assimilation or excretion. Because the nutrient reserves in the body are little, therefore the mentioned activities occur at fairly predictable times following feed intake. The findings of many researchers as Wilson *et al.* (1989), Saiful *et al.* (2002) and Yahav *et al.* (2004) revealed that the heat production associated with feeding is based on the early morning feeding of birds. This means if birds are fed at 0600 h, then the peak heat load will be at 0900 -1100 h, which usually precedes the natural peak heat load in poultry facilities. Therefore, birds would be facing problematic conditions when the feeding time is at around 1000– 1100 h, as the heat of feed utilization coincides with the hottest part of the day especially in the summer season in the tropic and subtropic regions.

High temperature condition adversely affects production and reproduction of poultry (Marsden *et al.*, 1987). Consequently, the main effect of high ambient temperatures on birds is the reduction in feed consumption, growth rates and carcass traits, thereby increasing the time needed to reach marketing weight and leading to lower efficiency and profitability of poultry meat production in hot climates (Geraert *et al.*, 1996).

An adequate protection against heat is very important in poultry production, to avoid heat stress in hot climate (Aengwanich, 2007a). Changing of the feeding time from morning to afternoon was among many experimental alternatives used to raise eggshell quality of hens maintained under hot climate (Bootwalla *et al.*, 1983; Wilson and Keeling, 1991). Moreover, poultry management practices do not normally allow hens to consume feed in the afternoon or evening when eggshell calcification normally occurs, especially under heat stress conditions. Whether feeding late during temperate time of the day can be used as a means to improve the feed conversion, fertility, hatchability percentages and eggshell quality. Therefore, the main objective of this study is change of feeding time to improve productive and reproductive performance of growing and laying Japanese quail in the summer under Upper Egypt conditions.

MATERIALS and METHODS

The present study was carried out at the research poultry farm of Animal and Poultry Production Department, Faculty of Agriculture, Assiut University, Assiut, Egypt. The experiment lasted during summer season (from May to November 2009), where the environmental temperature ranged between 19.8 °C at night to 35.8 °C at midday while, humidity was from 40 to 64% (Table 1). A total number of two hundred and forty, one-day old Japanese quail chicks (Coturnix coturnix japonica) were used in this study. All chicks were wing banded, individually weighed and randomly classified into four groups: group 1 as a control (C), and group 2, 3, 4 as the treatment (T1, T2 and T3). Birds per each group, 60 birds (30 males and 30 females), were housed in quail brooding batteries with 86 X50 X25 cm pens from hatch until sexual maturity of age. Subsequently the quail were transferred into productive battery individual cages (20 X 25 X 30 cm) throughout the laying period. Clean water was available for birds all the time. While, feed was offered twice daily, in the control group (C) at 0900 and 1500 h. On the other hand, birds in the first treatment group (T1) was fed at 1500 and 2100 h; T2 was fed at 2100 and 0300 h; and T3 was fed at 0300 and 0900 h. The composition and calculated analysis of the experimental diets are shown in Table (2).

The newly hatched chicks were exposed to continuous lighting for 24 hrs/day during the first 3 days of age. Thereafter, the photoperiod was decreased gradually (one hr/wk) to be adjusted to 12 and 16 hrs lighting regimens during the growing and laying periods, with light intensities of 10 and 20 Luxes, respectively. Three estimates for the indoor temperature and the relative humidity (%) were recorded for both the control and the treatment groups throughout the experimental period using a thermo hygrograph at 8, 10 and 12 AM 4, 6 and 8 PM; and at 10 PM, 12 midnight and 2 AM, respectively. It is worth to mention that brooding, rearing and raising of all experimental birds were under the climatic environmental conditions in Assiut.

The body weight (BW) on individual basis, at 0, 4, 8, 12, 16, 20 and 24 weeks of age was recorded. The average body weight gain (BWG) was calculated biweekly from 0 to 8 weeks of age. The feed consumption (FC) was calculated periodically biweekly, from 0 to 24 weeks of age. The feed conversion values (g feed/g gain, FCRg) were calculated periodically every four weeks, from 0 to 8 weeks of age and the feed conversion ratio values (g feed/g egg mass, FCRe) were calculated periodically every four weeks, from 8 to 24 weeks of age. Egg weight, egg number and egg mass and egg production as hen-day egg production (HDP) were calculated periodically every four weeks, from 8 to 24 weeks of age. Body temperature (°C) was measured by using a thermometer inserted into the rectum for 2 minutes at depth of 2 cm during feeding time. Dead birds were recorded daily and expressed as percentage during the experimental period.

During the period from 12 to 24 weeks of the experiment, 360 fresh-laid eggs were taken, every four weeks, from each group to measure egg quality characteristics. Egg weight was recorded to the nearest 0.1 gram on the same day of collection using special automatic balance. The length and width of egg were determined using a sliding caliper and their egg shape index was determined according to Reddy *et al.* (1979). Egg shape indexes = (width of egg/length of egg)x 100. All eggs were broken gently on a glass surface. The height of thick albumen and yolk were measured using a Micrometer, as described by Brant and Shrader (1952). The diameter of yolk was measured, using a sliding caliper. The yolk was separated from the albumen and weighted. Shells with membranes were dried and weighed to the nearest 0.01 gm. Haugh units were recorded for egg individually and calculated from the egg weight and albumen height (Doyon *et al.*, 1986). The Haugh unit values were calculated for each egg using the formula: Haugh unit = 100 log (H- 1.7 x w 0.37 + 7.6) Where: H = the observed height of the albumen in millimeters and W = weight of egg (g). Also, the yolk index was calculated by dividing (yolk's height/ yolk's diameter) x100. Shell thickness of the dried shell (without membranes) was measured using shell thickness apparatus at four different regions of the shell (blunt, pointed and both sides) and the average was recorded (millimeters). The albumen weight was calculated by subtracting egg weight from shell and yolk weight. The three egg components were expressed as percentages of the egg weight. Eggs laid in both experimental groups were collected daily and stored 7 days at 15-18°C and 70-75% relative humidity before incubation. Five hatches were performed at 12, 16, 20 and 24 weeks of age. The incubation was carried out using automatic Paterzime setter and hatcher under the recommended temperature, humidity, ventilation and turning of the incubated eggs chicken. The fertility and hatchability percentages were calculated as follow:

Fertility (%) = (Fertile eggs) x100 / Total set eggs
True hatchability (%) = (Viable hatched chicks) x100 / fertile eggs

Economical efficiency was based on the costs of the feed consumed and the income/bird (body weight and fertile egg production). The net revenue per bird is estimated as the difference between the total income/bird (LE), (growth and fertile egg production) and the total costs of feed and others. The costs of the used rations were calculated according to the actual prices prevailing in the Egyptian market during the experiment.

Statistical analysis: Data collected were subjected to ANOVA by applying the General Linear Models Procedure of SAS software (SAS Institute, version 6.12, 1996). Duncan methods (1955) were used to detect significant of differences among means of different groups. The percentages of HDP, fertility and hatchability were transformed to Arcsin values before statistical analysis.

RESULTS and DISCUSSSION

1- Body weight (BW): The results presented in Table (3), showed significant differences ($P \leq 0.05$) in BW for all the experimental groups at all studied ages (C, T1, T2 and T3) except at 0 and 2 weeks of age. The average body weight (ABW) of T2 significantly ($P \leq 0.05$) exceeded those of C and T3 at 6, 8 and 12 weeks of age by 14.0, 15.4 and 15.4 % as well as 8.4, 10.3 and 7.5 %, respectively. While the ABW of T1 had an intermediate value. The ABW in T1 and T2 significantly ($P \leq 0.05$) exceeded those of C at 4 and 16 weeks of age by 8.2 and 12.5 % as well as 6.7 and 13.1%, respectively. While the ABW of T3 had an intermediate value. The ABW of T2 significantly ($P \leq 0.05$) exceeded those of C, T1 and T3 by 4.8, 4.3; 9.5, 8.8 and 7.3, 5.2% at 20 and 24 weeks of age, respectively. The overall mean of T2 had a significant higher ($P \leq 0.05$) ABW than those of C and T3 by about 12.1 and 7.2 %, respectively, while the ABW of T1 had an intermediate value.

The remarkable increase of ABW of Japanese quail (JQ) fed at 2100 to 0300 h than those of birds fed at 0900 to 1500, 1500 to 2100, and 0300 to 0900 h, could be attributed to feeding of birds during midnight, which more adequate ambient climatic temperature (C°), consequently avoid the harmful effect of the high temperature in the summer season. Moreover, these results are in agreement with the findings of Wilson *et al.* (1989), who indicated that feeding birds during hot time of day may lead to increase heat load, due to the heat increment that happen during feed metabolism. These obtained results are also coincided with the results of Hassan *et al.* (2003); Bouvarel *et al.* (2004), and Farghly, (2008), who stated that birds fed at afternoon had significantly ($P \leq 0.05$) higher body weight than those of birds fed at midday. Moreover, Avila *et al.* (2003a) showed that time of feeding 6:30 AM had significantly ($P \leq 0.05$) higher body weight than those of birds fed at 3:30 PM due to the greater efficiency of feed utilization. On the other hand, Harms (1991) and Samara *et al.* (1996) found a decrease in body weight when the time of feeding was changed from the morning to the afternoon.

2- Body weight gain (BWG): The obtained results presented in Table (3), showed significant differences ($P \leq 0.05$) in BWG in the experimental four groups at all ages studied (C, T1, T2 and T3) during the experimental periods except at 0-2 weeks of age. The ABWG of T1 and T2 were significantly ($P \leq 0.05$) higher than those of C and T3 during the period from 2 to 4 weeks of age by 12.0, 5.8 and 15.7, 9.2 %, respectively. The T2 significantly ($P \leq 0.05$) gained more than those of C, T1 and T3 by 17.8, 25.3; 3.4, 7.6 and 11.7, 23.1 from 4 to 6 and 6 to 8 weeks of age, respectively. The overall mean of T2 had a significantly higher ($P \leq 0.05$) ABWG than those of C, T1 and T3 by about 16.4, 4.8 and 10.8 %, respectively.

The BWG tended a similar trend to that of the BW. Exposure of birds to high temperature more than 35°C causes different detrimental changes in their biological functions, which lead to disturbances in metabolizable energy for growth. The obtained results are in partial agreement with the findings of Hassan *et al.* (2003), Bouvarel *et al.* (2004), and Farghly, (2008), who stated that birds fed at afternoon had significantly ($P \leq 0.05$) higher body weight gain than those of birds fed at midday. In contrast, Harms (1991) and Samara *et al.* (1996) found a decrease in chicken body weight when the time of feeding was changed from the morning to the afternoon. However, Bouvarel *et al.* (2004) found that hens did not utilize the energy of the feed as efficiently when birds fed at 0600 h as they did when fed at 1800h.

3- Feed consumption (FC): The obtained results presented in Table (3), showed insignificant differences in feed consumption (FC) values in the experimental four groups at all ages studied (C, T1, T2 and T3).

The deleterious effect of the high temperature on appetite of birds and consequently on their feed consumption is logic and expected, since most of the bird's heat load comes from the feed, as consequences of digestion, absorption and nutrient assimilation or excretion. These observations suggest insignificant increased feed intake of the quail birds fed during the period from 2100 to 0300 h, which in turn increased the BW above those of quail fed during the period from 0900 to 1500 h. Also, the results of Keshavarz, (1998) attributed the greater feed intake during the afternoon than during the morning to an increased appetite. Moreover, these herein results are in partial agreement with the findings of Veltmann *et al.* (1984), Al-Homidan and Robertson (2007), and Farghly (2008).

4- Feed conversion (FCR): Data presented in Table (3), showed significant (P≤0.05) differences in average feed conversion for growth (FCRg) values in the experimental four groups at all studied ages (C, T1, T2 and T3) during the experimental periods. The average FCRg of T2 significantly (P≤0.05) improved than those of T3, during the period from 0 to 2 weeks of age by 14.8 % and than those of C, during the period from 2 to 4 weeks of age by 12.1 %, respectively. The FCRg of T2 had significantly (P≤0.05) improved than that of C and T1, from 4 to 6 and 6 to 8 weeks of age by 15.9, 13.4 and 20.6 and 14.8 %, respectively. The overall mean FCRg of F for T1 and T2 significantly (P≤0.05) improved than that of C and T3 by 11.4, 9.0 and 19.6, 17.9%, respectively.

The average feed conversion for egg (FCRe) values had significant differences (P≤0.05) in the experimental four groups at all ages studied (C, T1, T2 and T3) during the experimental periods. The birds of T1 and T2 had significantly (P≤0.05) better FCRe values than those of C, during the periods from 8 to 12, 12 to 16, 16 to 20 and 20 to 24 weeks of age by 19.0, 27.6; 22.8, 24.8; 15.9, 23.9 and 22.8, 30.1 %, respectively. The birds of T3 had significantly (P≤0.05) better FCRe value than that of C, during the period from 8 to 12 and 12 to 16 weeks of age by 12.0 and 14.1%, respectively. The overall mean of FCRe values of T1 and T2 significantly (P≤0.05) improved than those of C by 19.8 and 26.5 %, respectively, while the FCRe of T3 had an intermediate value.

These obtained results are in agreement with the obtained findings by Keshavarz, (1998) who, found that the feed conversion (FCR) for broilers fed during the period from 1300 to 2100 h, was superior to the other treatments. In the same trend, Abd El-Hakim and Abd-Elsamee (2003) and Farghly (2008) showed that feeding time significantly improved the feed conversion. Moreover, Roland *et al.* (1972) found that feeding the Japanese quail birds during the period from 1400 to 1000 h increased the FCR above those of quail birds fed from 0600 to 1400 h. In the summer season, high temperature evokes different detrimental changes in biological functions of bird, which lead to remarkable depression in appetite, feed consumption, metabolizable energy for growth and decreased efficiency of feed utilization (Leeson, 1996 and Marai, *et al.*, 2006).

5- Body temperature (BT): Data presented in Table (4), show significant differences (P≤0.05) in body temperature (°C) in the experimental four groups (C, L1, L2 and L3) at all ages studied except at 0 and 2 weeks of age. The average body temperature (ABT) of T2 significantly (P≤0.05) decreased than those of C at 4, 6, 16 and 20 weeks of age by 1.9, 2.2, 2.7 and 3.0 %, respectively. The ART in T1, T2 and T3 significantly (P≤0.05) decreased than those of C at 8 and 12 weeks of age by 2.4, 1.8; 3.6, 3.5 and 1.8, 1.8%, respectively. The ABT of T2 significantly (P≤0.05) decreased than those of C, T1 and T3 by 2.2, 3.3 and 3.0% at 24 weeks of age, respectively.

It is well known that, adult birds are homeothermic and provided with physiological mechanisms by which they can maintain their deep body temperature constant within the thermoneutral zone. Most of the bird's heat load comes from digestion, absorption, assimilation of feed. Heat production peaks occur at 3 to 5 hrs after feeding cause almost 100% increase in heat production as compared to unfed birds. The increase in heat production associated with about +1°C rise in body temperature (Leeson and Summers, 2000, and Avila *et al.*, 2003a). The findings of many researchers as Kohne *et al.* (1973), Cave, (1981) and Wilson *et al.* (1989) found that the heat production, associated with feeding, is based on the early morning feeding of birds. This means if birds are fed at 0600 h, then the peak heat load will be at 0900-1100 h, which usually precedes the natural peak heat load in poultry facilities. Koh *et al.* (2000) found that heat production in fasted birds was much lower than that in fed birds at 26°C, changed little until 20°C and then increased steeply.

Wiernusz and Teeter (1993), observed that heat production and body temperature increased with feed intake at 24°C. They also showed that there were no differences in body temperature between feeding systems at 35°C, even though heat production increased with feed intake in broilers. Teeter *et al.* (1993) found that amount of feed intake did not consistently affect body temperature post feeding at 24°C or 35°C in broilers.

6- Mortality rate: The obtained results shown in Table (4), indicated that, the mortality rate of T1, T2 and T3 decreased than those of C by 3.0, 2.0, 2.0; 0.6, 1.6, 0.4 and 3.6, 3.6, 2.4 %, at 0-8, 8-24 and 0-24 weeks of age, respectively. Exposing birds to high temperature during midnight (more than three hours/day for 8 weeks during the summer in Egypt) increased the mortality rate (Zeidan *et al.*, 1997 and Marai *et al.*, 2002). These results disagree with observations of Avila *et al.* (2003b), who found that the mortality rate was similar among the tested treatments; Birds in the first treatment feeding was at 6:30 AM; In the second treatments, 50% feeding at 6:30 AM and 50% at 3:30 PM; In the third treatment, the feeding was at 11:00 AM; and 3:30 PM.

7- Egg production (EP): The data presented in Table (5) revealed significant differences ($P \leq 0.05$) in the average egg weight (EW), egg number (EN), hen day egg production (HDP) and egg mass (EM) among birds in the experimental four groups (C, L1, L2 and L3) at all ages studied during the experimental periods, except from 8-12, 12-16 and 16-20 weeks of age in the EW.

The averages of EN and HDP for T1 significantly ($P \leq 0.05$) exceeded those of C and T3, during the period from 8-12 weeks of age by 33.0 and 21.1%, respectively. The averages of EN and HDP for T1, T2 and T3 significantly ($P \leq 0.05$) exceeded those of C, during the period from 12-16 weeks of age by 19.3, 23.6 and 15.5%, respectively. The averages of EN and HDP for T2 significantly ($P \leq 0.05$) exceeded those of C, T1 and T3 during the period from 16-20 and 20-24 weeks of age by 11.3, 10.1; 29.6, 29.0 and 11.0, 19.5%, respectively. The overall mean of HDP for T2 exceeded significantly ($P \leq 0.05$) that of C by 28.3 %, while, the overall mean of HDP for T1 had an intermediate value. The total average of EN for T2 significantly ($P \leq 0.05$) surpassed those of C and T3 by 28.4 and 17.5 %, respectively.

The average EW for T2 significantly ($P \leq 0.05$) increased more than those of C, during the periods from 20-24 weeks of age by 8.0 %. The average EM for T2 significantly ($P \leq 0.05$) exceeded those of C from 8-12, 16-20 and 20-24 weeks of age by 36.8, 32.0 and 38.7%, respectively while, the overall mean of EM for T1 had an intermediate value. Also, the average EM for T1 and T2 significantly ($P \leq 0.05$) increased than that of C, from 12-16 weeks of age by 24.8 and 31.7%, respectively. The total average of EM for T2 significantly ($P \leq 0.05$) exceeded those of C and T3 by 9.2 and 21.0 %, respectively.

The obtained results of egg production are coincided with observations of Wilson *et al.* (1989), who reported that the feeding time during hottest part of day is a factor that may lead to heat stress, due to the heat increment that happen during feed metabolism. The findings of Duncan and Hughes (1975), and Roland *et al.* (1972) suggest that the higher egg production rate increased feed intake in quail fed from 1400 to 2200 h. Also, Hassan *et al.* (2003) found that Japanese quail fed from 1400 to 2200 h increased the egg production as compared to quail fed during 0600 to 1400. Moreover, the herein results agree with observations of Balnave (1977) and Farghly (2008) who found that the afternoon feeding resulted in a higher rate of egg production. Avila *et al.* (2003b) found that total EP of birds fed at 6:30 AM, as well as birds fed 50% of the feeding at 0630 and 50% at 1530 h was higher than that of other treatments. The average total egg production of birds fed at 11:00 AM had the smallest EP.

The results obtained by Brake and Peebles (1986) in chickens, indicated that changing the time of feeding of hens from morning to afternoon resulted in a reduction in egg production. Also, Harms (1991), found lower egg production in birds fed late in the day. However, Brake (1988), Wilson and Keeling (1991), and Samara *et al.* (1996) noted that afternoon feeding had no effect on egg production. The observations of Ndubuisi *et al.* (2008), revealed that the highest egg production could be achieved, when the ambient temperatures are within the neutrality range. However, Under high ambient temperature, core blood supply to the egg synthesizing rate is reduced through the endocrine mechanism, consequently a drop in egg number and egg weight.

These results of egg weight are in agreement with the findings of Farmer *et al.* (1983); Bootwalla *et al.* (1983); Brake and Peebles, (1986) who, found that afternoon feeding in chickens increased the egg weight. However, the average of egg weight from quail fed from 0200 to 1400 h was not different from egg weight produced from quail birds, fed from 1400 to 2200 h. Also, Harms, (1991), Wilson and Keeling, (1991), and Samara *et al.* (1996) found that egg weight was not affected by changing the feeding time from morning to afternoon.

8- Egg quality traits: The recorded data in Table (6), showed that, insignificant differences ($P \leq 0.05$) were found in average of egg weight (AEW) and egg components (Albumen%, Yolk%, Shell%) as well as in the overall mean among all groups at all ages studied, while, there were significant differences ($P \leq 0.05$) in the egg shape index (ESI), egg yolk index (EYI), shell thickness (ST) and Haugh units (HU) values among the birds in the experimental four groups (C, T1, T2 and T3) during the experimental periods, except at 20 weeks of age for ESI, EYI and HU as well as at 12 weeks of age for ESI and at 16 weeks of age for EYI, respectively.

The ESI of T2 had significantly ($P \leq 0.05$) higher values by 5.9 and 4.7 % at 16 and 24 weeks of age than those of C, respectively. The average EYI of T1 and T2 had significantly higher ($P \leq 0.05$) than those of C at 12 weeks of age by 2.7 and 2.7 %, respectively. Also, The average EYI of T2 had significantly higher ($P \leq 0.05$) than those of C at 24 weeks of age by 2.7 and 8.9 %.

Concerning, the average Haugh units (HU) of T1 and T2 significantly ($P \leq 0.05$) increased than those of C and T3 at 12 weeks of age by 2.8, 2.7 and 3.7, 3.5, respectively. At 16 weeks of age the AHU of T1 and T2 significantly ($P \leq 0.05$) exceeded that of C by 2.9 and 4.7%, respectively. At 24 weeks of age, the HU for T2 had significantly ($P \leq 0.05$) higher value than those of C and T1 by 3.9 and 4.0%, respectively.

With regard to shell thickness (ST), the average ST of T2 was significantly ($P \leq 0.05$) higher values than those of C, T1 and T3 at 12 and 24 weeks of age by 9.7, 8.9; 10.8, 11.5 and 7.9, 9.5 %, respectively. Also, the average ST of T1 and T2 was significantly ($P \leq 0.05$) higher values than those of C and T3 at 16 weeks of age by 8.6, 5.2 and 12.4. 8.9%, respectively. At 20 weeks of age, the average ST of T2 was significantly ($P \leq 0.05$) higher value than those of C by 5.2%, while, the average ST of T1 and T3 had an intermediate values.

These obtained results are in agreement with numerous observations of Lennards *et al.* (1981), who reported that commercial laying hens utilize more calcium for eggshell quality from afternoon consumption than from morning consumption and added that the time of calcium intake has an important role in the ability of laying hens to calcify eggshells. Also, Balnave, (1977), Bootwalla *et al.* (1983), Brake and Peebles (1986), Brake (1988), Harms, (1991) reported that egg shell thickness increased after changing feeding time from morning to afternoon. High temperatures are well known to increase respiratory rate resulting in respiratory alkalosis which alters the acid-base balance and blood pH. A reduced bicarbonate concentration in a lumen of the shell gland during panting adversely affects egg shell quality. On the other hand, Wilson and Keeling (1991) and Samara *et al.* (1996) found no effect of feeding time on egg quality.

9- Fertility and hatchability (%): The results presented in Table (7) revealed significant differences ($P \leq 0.05$) in the average of fertility and hatchability percentage among the birds in the experimental four groups (C, T1, T2 and T3) at all hatches studied. At 12 weeks of age, the birds of T2 had significantly ($P \leq 0.05$) higher fertility percentages (F%) as compared to the C, T1 and T3 by 13.9, 8.1 and 12.1 %, respectively. The T2 had significantly ($P \leq 0.05$) higher F% by 12.5, 13.9 and 15.11 % than those of C, while, T1 and T3 had an intermediate values. The overall mean of F% for T2 exceeded significantly ($P \leq 0.05$) that of C by 13.9 %, respectively, while, T1 and T3 had an intermediate values. The birds of T2 had significantly ($P \leq 0.05$) higher hatchability percentages (H%) as compared to the C and T3 by 9.2, 4.8 and 26.4, 6.5 % at 12 and 24 weeks of age, respectively. While, T1 had an intermediate values. At 16 and 20 weeks of age, the T2 had significantly ($P \leq 0.05$) higher H% by 31.4, 13.5 and 10.8, 4.6 % than those of C and T1, respectively. The overall mean of H% for T2 exceeded significantly ($P \leq 0.05$) that of C, T1 and T3 by 19.5, 5.6 and 6.9 %, respectively.

These results are in agreement with the findings of Hassan *et al.* (2003), who found that the average fertility was higher, when quails were fed during the period from 1400 to 2200 h than from 0600 to 1400 h. Also, Brake (1988) and Farghly *et al.* (2008) found that feeding hens in the afternoon resulted in higher fertility than those fed in the morning, whereas Bootwalla *et al.* (1983) found no effect of feeding time on fertility.

McDaniel *et al.* (1979), showed that the hatchability percentage was higher in quail fed from 1400 to 2200 h than that of birds fed from 0600 to 1400 h. These results agree with the observations of Brake (1988) and Farghly *et al.* (2008), who postulated that afternoon feeding improves hatchability in broiler breeder. Conversely, the findings of Farmer *et al.* (1983) found that the afternoon feeding decreased the hatchability percentage.

The improvement in fertility and hatchability of quail birds fed from 2100 to 0300 h may attributed to increase of the Haugh units, egg shell thickness and egg production. The previous results agree with McDaniel *et al.* (1981) and North and Bell (1990) who, found positive correlations between fertility and hatchability with egg production.

10- Economical efficiency: The data presented in Table (8), showed that. birds fed from 2100 to 0300 h (T2) had higher economical efficiency than those of birds fed at 0900 to 1500, 1500 to 2100, and

0300 to 0900 h (C, T1 and T3) during growing and laying periods, since, it amounted 100, 122.6, 137.9 and 101.6 for growing period as well as100, 132.0, 170.3 and 116.7 for laying period, respectively. The obtained results are also in harmony with the findings of Farghly *et al.* (2008), who found remarkable increase in economical efficiency of JQ fed at 2100 to 0300 h followed by birds fed at 1500 to 2100 than those of birds fed at 0900 to 1500, and 0300 to 0900 h. Also, Abd El-Hakim and Abd-Elsamee, (2003), evaluated the effect of four different feeding systems (skip a day and skip a half day i.e.12 hr feed + 12 hr fast) during summer season for the Arbor Acres broiler chicks significantly improved the performance parameters and economical efficiency.

It could be concluded that the feeding birds at 2100 to 0300 h (T2) was more economical efficient than those of birds fed at 0900 to 1500 (C) and 0300 to 0900 h (T3). This could be attributed to the superiority of T2 in body weight performance, egg production, egg quality and lower mortality percentages, as well as having adequate percentages fertility and hatchability. In addition, T2 decreased the body temperature of birds, which positively reflected on the health condition of the birds, while the T1 had an intermediate value. The feeding at 2100 to 0300 h for growing and laying Japanese quail is highly recommended.

Table 1: The overall means of indoor temperature and relative humidity values of during the experimental period.

Intervals (month)	Temperature (C°)			Humidity (%)		
	Max.	Min	Av.	Max.	Min.	Av.
Jun	32.6	23.6	28.1	62.1	41.8	52.0
Jul	33.5	25.6	29.6	60.6	39.6	50.1
Aug	35.8	26.8	31.3	59.8	40.4	50.1
Sep	35.6	26.3	31.0	60.3	42.1	51.2
Oct	34.5	24.7	29.6	62.5	44.4	53.5
Nov	32.8	22.9	27.9	64.8	42.8	53.8
Overall mean	33.5	24.2	28.9	61.9	42.1	52.0

Max = Maximum Min= Minimum Av. = Average

Table 2: Composition and calculation analysis of the experimental diets.

Ingredients	Starter (%)	Layer (%)
Yellow corn	53.0	52.3
Soybean meal (44%)	34.6	31.7
Concentrate	12.0*	10.0**
Salt	0.25	0.50
Dicalcium phosphate	0.15	1.50
Limestone	---	4.00
Total	100	100
Calculated analysis***		
Protein (%)	26.0	23.6
ME (KCal/ Kg diet)	2850	2775
Calcium (%)	0.90	2.75
Available phosphorus (%)	0.45	0.75

* **Broiler concentrate contains:**

52% crude protein 1.6% crude fiber 6.1% ether extract 7% calcium 3.5% available phosphorus 1.5% methionine 2.1% methionine and cystine 3.0% lysine 2416 kcal/ kg metabolizable energy.

Each Kilogram of broiler concentrate contains the following levels of vitamins and minerals: vit. A 130,000 IU; D3 26,000 IU; vit. E 120 IU: vit B12 150 ug; vit. K3 MSB 16 mg; vit B2 50 mg; capantothenate B3 120 mg; nicotinic acid PP 250 mg ; thiamine B1 25 mg; folic acid 15 mg; pyridoxine B6 15 mg; betain-Choline- HCl 5000 mg; Mn 700 mg;Zn 600 mg; Fe 400 mg;Cu 40 mg; Iodine 7 mg; Co 2 mg; Se 1.5 mg; B.H.T. 1250 mg; Zinc baciteracin 150 mg.

* * **The layer concentrate contains:**

- Crude protein	51.00%	- Lysine	3.30%
- Crude fiber	2.00 %	- Calcium	8.00%
- Crude fat	6.40 %	- Available phosphorus	3.00%
- Methionine	1.67 %	- Salt	3.19%
- Methionine + Cystine	2.25%	- Metabolizable energy	2400 kcal/ diet

Each Kilogram of layer concentrate contains the following levels of vitamins and minerals:

- Vit. A	10000 IU	- Folic acid	10 mg
- Vit. E	100 mg	- Biotin	500 mg
- Vit. D3	2500 IU	- Chorine chloride	5000 mg
- Vit. K	25 mg	- Iron	400 mg
- Vit. B1	100 mg	- Zinc	560 mg
- Vit. B2	40 mg	- Copper	5 mg
- Vit. B6	15 mg	- Iodine	3 mg
- Vit. B12	200 mg	- Selenium	1 mg
- Pantothenic acid	100 mg	- Manganese	620 mg
- Niacin	400 mg	- Antioxidant	75 mg

*** **Calculated according to NRC (1994).**

Table 3: Means ±SE of body weight, body weight gain, feed consumption and feed conversion traits of growing and laying Japanese quail as affected by feeding time.

Traits	Age (wks)	Treatments			
		C	T1	T2	T3
Body weight (g)	0	7.52±0.88	7.81±0.96	7.42±1.11	7.61±0.67
	2	51.0±3.32	52.6±2.83	55.3±1.82	53.1±4.11
	4	115.2^{b}±3.93	124.6^{a}±4.68	129.6^{a}±3.35	121.1^{ab}±5.94
	6	161.7^{c}±4.21	177.4^{ab}±5.90	184.4^{a}±3.56	170.1^{bc}±6.12
	8	185.6^{c}±6.92	205.1^{ab}±5.31	214.2^{a}±4.12	194.3^{bc}±5.91
	12	187.4^{c}±8.83	205.5^{ab}±6.22	216.2^{a}±3.92	201.6^{b}±3.93
	16	193.6^{b}±6.25	206.6^{a}±7.36	215.7^{a}±5.56	203.2^{ab}±5.94
	20	200.0^{b}±5.92	208.8^{b}±3.01	218.9^{a}±4.91	204.1^{b}±3.95
	24	202.0^{c}±4.84	210.8^{b}±4.56	219.8^{a}±2.52	208.9^{c}±4.75
	Overallmean	144.9^{c}±5.32	155.4^{ab}±6.23	162.4^{a}±3.85	151.5^{bc}±4.15
Body weight gain (g/bird/day)	0 - 2	3.11±1.22	3.20±0.66	3.42±0.55	3.25 ±0.86
	2 - 4	4.59^{c}±1.31	5.14^{a}±1.10	5.31^{a}±0.75	4.86^{b}±1.21
	4 - 6	3.32^{c}±1.02	3.78^{b}±1.16	3.91^{a}±1.02	3.50^{b}±1.22
	6 - 8	1.70^{c}±0.32	1.98^{b}±0.22	2.13^{a}±0.25	1.73^{c}±0.18
	Overallmean	3.18^{c}±1.08	3.52^{b}±0.92	3.69^{a}±0.78	3.33^{c}±1.03
Average feed consumption (g/bird/day)	0 - 2	7.89±0.90	8.11±0.67	7.72±0.75	8.02±0.88
	2 - 4	11.98±0.85	12.22±1.11	12.11±0.62	12.13±1.11
	4 - 6	13.82±1.20	13.81±0.92	14.01±0.74	13.86±0.98
	6 - 8	16.23±0.88	16.41±0.98	16.81±1. 11	16.22±1.21
	8 - 12	16.22±1.31	16.14±1. 22	17.47±1.03	16.26±1.22
	12 - 16	17.96±2.12	18.24±1.63	18.91±1.21	18.33±1.61
	16 - 20	19.62±1.81	19.91±1.61	20.92±1.12	20.20±1.43
	20 - 24	19.88±1.51	19.94±1.32	21.20±0.92	20.30±1.59
	Overallmean	15.41±1.24	15.58±1.19	16.14±0.93	15.68±1.02
Feed conversion (g feed/g gain)	0 - 2	2.51^{ab}±0.22	2.53^{ab}±0.33	2.23^{b}±0.12	2.56^{a}±0.43
	2 - 4	2.60^{a}±0.38	2.37^{ab}±0.41	2.32^{b}±0.18	2.49^{ab}±0.52
	4 - 6	4.15^{a}±0.61	3.66^{bc}±0.37	3.58^{c}±0.22	3.94^{ab}±0.42
	6 - 8	9.51^{a}±0.53	8.28^{b}±0.54	7.88^{bc}±0.38	9.38^{ab}±0.63
	Overallmean	4.69^{a}±0.38	4.21^{b}±0.35	3.92^{bc}±0.20	4.59^{a}±0.51
Feed conversion (g feed/g egg mass)	8 - 12	3.93^{a}±0.02	3.30^{b}±0.12	3.08^{c}±0.05	3.51^{b}±0.08
	12- 16	2.91^{a}±0.22	2.37^{b}±0.12	2.33^{b}±0.04	2.55^{b}±0.10
	16 – 20	2.70^{a}±0.03	2.33^{b}±0.06	2.18^{b}±0.10	2.64^{a}±0.12
	20 - 24	3.07^{a}±0.05	2.50^{b}±0.21	2.36^{b}±0.08	2.82^{ab}±0.18
	Overallmean	3.15^{a}±0.11	2.63^{b}±0.12	2.49^{b}±0.05	2.88^{ab}±0.23

$^{a,\ b\ and\ c}$ Means within each row for each division (C,T1, T2 and T3) with no common superscripts are significantly different (P≤0.05).

C= Control group (birds were fed at 0900 and 1500 h)

T1= Treatment group (birds were fed at 1500 and 2100 h)

T2= Treatment group (birds were fed at 2100 and 0300 h)

T3= Treatment group (birds were fed at 0300 and 0900 h)

Table 4: Means ±SE of Body temperature and mortality rate of growing and laying Japanese quail as affected by feeding time.

Traits	Age (wks)	Treatments			
		C	T1	T2	T3
Body temp. (C°)	0	40.02±0.48	39.75±0.46	39.64±0.11	40.01±0.67
	2	40.42±0.32	40.61±0.43	40.38±0.52	40.41±0.11
	4	40.89^{a}±0.53	40.62^{ab}±0.28	40.11^{b}±0.15	40.92^{ab}±0.54
	6	41.22^{a}±0.21	40.66^{bc}±0.40	40.32^{c}±0.26	40.92^{ab}±0.12
	8	41.86^{a}±0.32	40.88^{b}±0.11	40.42^{c}±0.12	41.12^{b}±0.41
	12	41.95^{a}±0.23	41.22^{b}±0.22	40.52^{c}±0.32	41.22^{b}±0.33
	16	42.11^{a}±0.25	41.66^{ab}±0.16	41.02^{c}±0.26	41.56^{bc}±0.34
	20	41.86^{a}±0.32	41.42^{a}±0.01	40.65^{b}±0.31	41.62^{a}±0.35
	24	42.01^{a}±0.24	41.56^{a}±0.26	40.66^{b}±0.22	41.89^{a}±0.25
Mortality rate (%)	0 - 8	4.2	1.2	2.2	6.2
	8 - 24	1.8	1.2	2.6	4.4
	0 - 24	6.0	2.4	4.8	10.6

$^{a, b \text{ and } c}$ Means within each row for each division (C,T1, T2 and T3) with no common superscripts are significantly different ($P \le 0.05$).

C= Control group (birds were fed at 0900 and 1500 h)   T1= Treatment group (birds were fed at 1500 and 2100 h)

T2= Treatment group (birds were fed at 2100 and 0300 h)   T3= Treatment group (birds were fed at 0300 and 0900 h)

Table 5: Means ±SE of egg number, hen day egg production, egg weight and egg mass for Japanese quail as affected by feeding time.

Traits	Periods	Treatments			
		C	T1	T2	T3
Egg number (egg/hen/28 days)	P1 (8 -12 w)	11.2^{b}±1.1	13.0^{ab}±1.89	14.9^{a}±0.86	12.3^{b}±1.2
	P2 (12 -16 w)	16.1^{b}±0.5	19.2^{a}±1.2	19.9^{a}±1.0	18.6^{a}± 1.3
	P3 (16- 20 w)	18.2^{c}±0.72	21.2^{b}±0.82	23.6^{a}±0.66	19.1^{c}±0.91
	P4 (20- 24 w)	16.2^{c}±1.2	18.9^{b}±1.1	20.8^{a}±0.71	17.4^{bc}±0.83
	Total	61.7^{c}±1.1	72.3^{ab}±1.2	79.2^{a}±0.51	67.4^{bc}±0.72
Egg weight (g)	P1 (8 -12 w)	10.3±0.31	10.5 ±0.21	10.6 ±0.12	10.5 ±0.23
	P2 (12 -16 w)	10.7 ±0.42	11.2±0.33	11.4 ±0.22	10.8 ±0.42
	P3 (16- 20 w)	11.2±0.51	11.3 ±0.32	11.4 ±0.15	11.2 ±0.41
	P4 (20- 24 w)	11.2^{b}±0.66	11.8^{ab}±0.21	12.1^{a}±0.22	11.6^{ab}±0.36
	Overallmean	10.9 ±0.48	11.2±0.31	11.4 ±0.20	11.0 ±0.41
HDP (%)	P1 (8 -12 w)	40.0^{b}±0.41	46.4^{ab}±0.36	53.2^{a}±0.22	43.9^{ab}±0.33
	P2 (12 -16 w)	57.5^{b}±0.31	68.6^{a}±0.31	71.1^{a}±0.36	66.4^{a}±0.32
	P3 (16- 20 w)	65.0^{c}±0.45	75.7^{b}±0.41	81.3^{a}±0.29	68.2^{c}±0.28
	P4 (20- 24 w)	57.9^{c}±0.55	67.5^{b}±0.22	74.3^{a}±0.28	62.1^{bc}±0.41
	Overallmean	55.1^{c}±0.46	64.6^{ab}±0.38	70.7^{a}±0.25	60.2^{bc}±0.38
Egg mass (g/hen/28 days)	P1 (8 -12 w)	115.4^{b}±4.2	136.5^{ab}±5.2	157.9^{a}±4.1	129.2^{ab}±5.1
	P2 (12 -16 w)	172.3^{b}±3.6	215.0^{a}±4.1	226.9^{a}±3.9	200.9^{ab}±4.2
	P3 (16- 20 w)	203.8^{c}±4.8	239.6^{ab}±3.8	269.0^{a}±3.5	213.9^{bc}±3.5
	P4 (20- 24 w)	181.4^{c}±4.2	223.0^{ab}±3.2	251.7^{a}±2.6	201.8^{bc}±4.2
	Total	745.8^{c}±5.2	905.5^{ab}±4.7	814.1^{a}±3.2	672.9^{c}±4.4

$^{a, b \text{ and } c}$ Means within each row for each division (C,T1, T2 and T3) with no common superscripts are significantly different ($P \le 0.05$).

C= Control group (birds were fed at 0900 and 1500 h)   T1= Treatment group (birds were fed at 1500 and 2100 h)

T2= Treatment group (birds were fed at 2100 and 0300 h)   T3= Treatment group (birds were fed at 0300 and 0900 h)

Table 6: Means ±SE of egg quality parameters and egg components for Japanese quail as affected by feeding time.

Traits	Treatments			
	C	T1	T2	T3
At 12 wks of age				
Egg weight (g)	10.8 ±0.21	10.9 ±0.18	11.0 ±0.32	10.8 ±0.36
Egg shape index (%)	72.8±0.56	73.3±0.82	74.2±0.811	73.4±0.56
Egg yolk index (%)	56.6^{b}±0.44	58.2^{a}±0.68	58.1^{a} ± 0.82	57.6^{ab}±0.47
Haugh units	90.1^{b}±0.59	92.6^{a}±1.21	93.4^{a} ± 1.01	90.2^{b}±0.55
Egg shell thickness (x 0.01 mm)	18.6^{b}±0.38	19.3^{b}±0.41	20.6^{a} ±0.41	19.1^{b}±0.39
Albumen (%)	55.62±1.65	55.71±1.95	55.40±1.95	55.41±1.85
Yolk (%)	35.61±2.85	35.50±1.85	35.71±2.77	35.81±1.52
Shell (%)	8.81^{c} ±0.57	8.86^{b} ±0.55	8.96^{c} ±0.57	8.82^{b} ±0.56
At 16 wks of age				
Egg weight (g)	10.8 ±0.22	11.0 ±0.43	11.3 ±0.18	10.9 ±0.45
Egg shape index (%)	74.2^{b}±0.56	77.8^{ab}±1.15	78.6^{a}±1.53	76.4^{ab}±0.76
Egg yolk index (%)	57.8 ±0.48	58.6±1.67	58.5 ± 0.82	56.9 ±0.49
Haugh units	88.6^{b}±0.59	91.2^{a}±1.43	92.8^{a} ± 1.11	91.1^{ab}±1.51
Egg shell thickness (x 0.01 mm)	18.5^{b}±0.31	20.1^{a}±0.33	20.8^{a} ±0.42	19.1^{b}±0.33
Albumen (%)	55.22±2.45	55.10±1.51	55.11±1.51	55.41±1.56
Yolk (%)	35.88±1.57	35.76±1.58	35.91±1.45	35.88±1.05
Shell (%)	8.88 ±0.72	9.11±0.56	9.34 ±0.63	9.12±0.78
At 20 wks of age				
Egg weight (g)	11.1±0.41	11.3 ±0.38	11.6 ± 0.15	11.4 ±0.22
Egg shape index (%)	76.4±1.82	76.2±1.49	77.6±1.74	75.9±0.86
Egg yolk index (%)	60.2 ±2.42	61.4±1.62	62.5 ± 1.82	61.6±0.43
Haugh units	90.4±0.57	91.6±1.33	91.0 ± 1.1	90.2±0.53
Egg shell thickness (x 0.01 mm)	19.0^{b}±0.34	19.2^{ab}±0.68	20.0^{a}±0.44	19.1^{ab}±0.32
Albumen (%)	54.90±1.82	55.21±0.31	55.01±1.82	55.20±1.56
Yolk (%)	36.58±0.38	35.76±1.52	36.02±1.54	35.81±1.82
Shell (%)	8.47 ±0.51	9.03 ±0.63	9.28 ±0.88	9.08 ±0.55
At 24 wks of age				
Egg weight (g)	11.3 ±0.56	11.6 ±0.71	11.7 ±0.85	11.5 ±0.66
Egg shape index (%)	76.2^{b}±1.24	78.8^{ab}±1.15	79.8^{a} ±1.33	78.6^{ab}±1.56
Egg yolk index (%)	58.6^{c}±1.42	60.6^{bc}±1.65	63.8^{a} ± 1.71	62.6^{ab}±1.22
Haugh units	90.4^{b}±1.55	90.2^{b}±1.42	93.9^{a} ± 1.41	91.2^{ab}±1.53
Egg shell thickness (x 0.01 mm)	18.4^{b}±0.38	19.1^{b}±0.45	20.8^{a} ±0.52	19.0^{b}±0.61
Albumen (%)	55.22±1.51	55.30±1.57	55.18±1.83	55.31±1.68
Yolk (%)	36.03±1.61	35.68±0.81	35.91±1.31	35.71±1.41
Shell (%)	8.65 ±0.58	9.01 ±0.53	9.18 ±0.23	8.97 ±0.51

$^{a,\ b,\ c\ \mathrm{and}\ d}$ Means within each row for each division (C,T1, T2 and T3) with no common superscripts are significantly different ($P \leq 0.05$).

C= Control group (birds were fed at 0900 and 1500 h)

T1= Treatment group (birds were fed at 1500 and 2100 h)

T2= Treatment group (birds were fed at 2100 and 0300 h)

T3= Treatment group (birds were fed at 0300 and 0900 h)

Table 7: Means ±SE of fertility and hatchability in Japanese quail as affected by feeding time.

Age (wks)	Fertility (%)				Hatchability (%)			
	C	T1	T2	T3	C	T1	T2	T3
12	80.5^{b}±2.53	84.8^{b}±5.31	91.7^{a}±2.63	81.8^{b}±4.51	60.3^{c}±2.53	63.6^{ab}±2.31	65.9^{a}±3.72	62.9^{b}±5.81
16	82.1^{b}±3.58	87.7^{ab}±3.85	92.4^{a}±3.52	86.8^{ab}±5.81	53.8^{c}±4.55	63.8^{b}±6.56	70.7^{a}±2.89	64.3^{b}±3.37
20	83.3^{b}±5.36	89.8^{ab}±2.75	94.9^{a}±4.63	88.3^{ab}±4.52	58.5^{c}±5.71	63.5^{b}±4.72	66.4^{a}±1.65	62.2^{ab}±4.58
24	81.3^{b}±6.73	86.6^{ab}±5.52	93.6^{a}±2.59	89.6^{ab}±5.65	48.9^{b}±3.32	59.7^{ab}±3.91	61.8^{a}±0.98	58.^{b}±2.63
Overall mean	81.8^{b}±4.88	87.2^{ab}±4.52	93.2^{a}±3.66	86.6^{ab}±5.75	55.4^{c}±4.52	62.7^{b}±5.58	66.2^{a}±2.81	61.9^{b}±3.72

a, b and c Means within each row for each division (C,T1, T2 and T3) with no common superscripts are significantly different (P≤0.05).

C= Control group (birds were fed at 0900 and 1500 h)
T1= Treatment group (birds were fed at 1500 and 2100 h)
T2= Treatment group (birds were fed at 2100 and 0300 h)
T3= Treatment group (birds were fed at 0300 and 0900 h)

Table 8: Economical efficiency for growing and laying Japanese quail as affected by feeding time.

Items		Treatment			
		C	T1	T2	T3
Growing period:					
Total costs/ bird/L.E	Price of chick at one day of age (L.E)	0.5	0.5	0.5	0.5
	Total feed consumption (kg/bird)	0.70	0.71	0.70	0.73
	Total feed costs (L.E)	1.28	1.30	1.28	1.34
Total revenue/ bird/L.E	Selling price of bird at 8 weeks of age (L.E)	2.97	3.28	3.43	3.11
Net revenue/ bird/L.E (without *constant costs=25%)		1.19	1.48	1.64	1.27
Economical efficiency/bird (EE)		0.93	1.14	1.28	0.94
Relative economical efficiency/bird (REE)		100.0	122.6	137.9	101.6
Laying period:					
Total costs/ bird/L.E	Price of chick at 8 weeks of age (L.E)	2.97	3.28	3.43	3.11
	Total feed consumption (kg/bird)	2.10	2.11	2.02	2.16
	Total feed costs (L.E)	3.86	3.88	3.72	3.98
Total revenue/ bird/L.E	Selling price of bird at 24 weeks of age (L.E)	3.23	3.37	3.52	3.34
	Fertile egg number/hen	81.8	87.2	93.2	86.6
	Selling price for fertile eggs/hen/L.E	12.62	15.77	18.44	14.60
Net revenue/ bird/L.E (without *constant costs=25%)		9.02	11.98	14.81	10.85
Economical efficiency/bird (EE)		2.34	3.09	3.98	2.73
Relative economical efficiency/bird (REE)		100.0	132.0	170.3	116.7

Cost of 1 kg of live body weight = 16.00 L.E.	Price of 1 fertile egg = 0.25 L.E.
Price of 1 kg litter = 0.04 L.E.	Price of 1 kg manure = 0.05 L.E.
Price of 1 kg of growing ration = 1.84 L.E.	Price of 1 kg of laying ration = 1.68 L.E.
L.E = Egyptian pound.	EE/bird=Net revenue per unit of total costs

a, b, c and d Means within each row for each division (C,T1, T2 and T3) with no common superscripts are significantly different (P≤0.05).

C= Control group (birds were fed at 0900 and 1500 h)
T1= Treatment group (birds were fed at 1500 and 2100 h)
T2= Treatment group (birds were fed at 2100 and 0300 h)
T3= Treatment group (birds were fed at 0300 and 0900 h)
*Constant costs include: housing, labour, heating, cooling, lighting and treatment regimens.

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