Effect of Feeding Time on the Reproductive Performance of Japanese Quail *(Coturnix coturnix japonica)*

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ABSTRACT Several feeding regimens are applied to improve performance of fertile egg production during times of heat stress. During a period of heat stress (34 to 36°C), two feeding periods were used to measure the impact of feeding time on reproductive performance of Japanese quail (*Coturnix coturnix japonica*) between 44 and 60 wk of age. Each feeding time treatment had 25 individually caged male and female pairs. Quail were fed ad libitum between 0600 to 1400 or 1400 to 2200 h daily. Results indicated that feeding between 0600 to 1400 h reduced BW, fertility, hatchability, egg production, and egg specific gravity when compared with the effects of feeding between 1400 to 2200 h. Feeding time had no effect on total embryonic mortality, egg weight, or the period between subsequent ovipositions. The different feeding times affected the distribution curve of oviposition over time. An instrument designed to record oviposition time is described. Results showed that selection of the time of day for application of an 8-h restricted feeding regimen affected BW, fertility, hatchability, egg production, egg specific gravity, and oviposition time in Japanese quail.

(*Key words*: feeding time, fertility, hatchability, heat stress, oviposition time)

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INTRODUCTION

Feeding a limited amount of feed each morning to broiler breeder hens is a common practice. Changing the time of feeding from morning to afternoon was among many experimental alternatives used to improve eggshell quality of broiler breeder hens maintained under optimal environmental conditions (Balnave, 1977; Bootwalla et al., 1983; Wilson and Keeling, 1991). However, poultry industry management practices do not normally allow broiler breeders to consume feed in the afternoon or evening when eggshell calcification normally occurs, especially under heat stress conditions. Some researchers suggest that this temporal nutrition discordance can be corrected by providing calcium later in the day as the obvious method to improve shell quality (Roland and Farmer, 1984). Broiler breeders that receive limited feed early in the day do not maintain sufficient quantities of calcium in the digestive tract for maximum eggshell calcification (Farmer et al., 1983a). Whether feeding late in the day can be used as a means to improve the fertility, hatchability, eggshell quality, and embryonic mortality is unknown. Also, the effect of feeding period during periods of heat stress on the performance of quail is undocumented. Therefore, the effect of feeding time on fertility and other parameters of reproductive performance in Japanese quail during a period of heat stress were studied.

MATERIALS AND METHODS

Experimental Design

One hundred 44-wk-old Japanese quail (*Coturnix coturnix japonica*) were obtained from the colony maintained by the Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. They were housed in quail brooding batteries with 86 × 50 × 25 cm pens from hatch until 5 wk of age. Subsequently the quail were transferred into breeding battery individual cages (21 × 20 × 27 cm) throughout the laying period. Continuous lighting exposure was provided to 5 wk of age. After 5 wk quail were subjected to a 16L:8D cycle until the end of the study. They received a quail starter ration (24.8% CP; 2,826 kcal/kg ME) and water ad libitum until 5 wk of age, after which they received a quail breeder ration (20.2% CP; 2,809 kcal/kg ME) and water ad libitum to the end of the study (Table 1).

Fifty female and fifty male Japanese quail at 37 wk of egg production were randomly distributed between two treatments. Each female-male pair was individually caged. Each treatment was fed ad libitum one time daily either between 0600 to 1400 or between 1400 to 2200 h. The temperature within the house during the time of this study in Ismalia, Egypt, ranged between a high of 34 to

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TABLE 1. Composition of quail starter and breeder diets

Ingredient	Ration	
	Starter	Breeder
Maize (%)	54	62
Soybean meal, 44% CP (%)	33	22
Concentrate,[1] (%)	10	10
Wheat bran (%)	3	–
Limestone (%)	–	5.7
Sodium chloride (%)	–	0.3
Calculated nutrient content		
Metabolizable energy (kcal/kg)	2,825	2,809
Crude protein (%)	24.8	20.2
Methionine (%)	0.460	0.648
Cysteine (%)	0.325	0.257
Methionine + cysteine (%)	0.211	0.211
Crude fiber (%)	3.99	3.061
Crude fat (%)	3.02	3.15
Linoleic acid (%)	1.37	1.45
Calcium (%)	0.84	2.95
Available phosphorus (%)	0.49	0.46

[1]Protein mineral-vitamin premix provided the following per kilogram of diet: crude protein, 520 g; vitamin A, 120,000 UI; vitamin E, 100 mg; vitamin K_3, 21 mg; vitamin B_1, 10 mg; vitamin B_2, 40 mg; vitamin B_6, 15 mg; pantothenic acid, 100 mg; vitamin B_{12}, 0.1 mg; niacin, 200 mg; folic acid, 10 mg; biotin, 0.5 mg; choline chloride, 5,000 mg; Fe, 0.3 mg; Mn, 600 mg; Cu, 50 mg; Co, 2 mg; Se, 1 mg; and Zn, 450 mg.

36°C during the day and a low of 24 to 26°C during the night as determined using a high-low temperature thermometer. Quail were housed in open-sided houses so that the outside environmental temperature rapidly equilibrates with the internal house environment. The warmest part of the day occurred at 1100 to 1400 h, during the 0600 to 1400 feeding time.

Measurements

Individual BW were recorded weekly from 44 to 60 wk of age for both sexes. Individual egg production was recorded for 100 d. Egg specific gravity, fertility, hatchability, and embryo mortality were determined.

Egg samples were taken the first 3 consecutive d of every 5-wk period. Samples were weighed to the nearest 0.01 g. Collected eggs were stored overnight in the same room before specific gravity was determined. Egg specific gravity was determined using the floating method (Harms et al., 1990), where solutions of specific gravity 1.060 to 1.090 g/mL were used to determine specific gravity in increments of 0.005. Eggs were stored (18°C, 65 to 70% RH), set, and incubated (37.5°C, 65 to 80% RH) every week of the 15-wk experimental period. At 14 d of incubation, eggs were transferred into hatching baskets. Unhatched eggs were examined to determine time and type of embryonic mortality. Unhatched eggs were classified as infertile, early dead, late dead, or dead pipped. Hatchability and fertility were determined weekly.

Oviposition time and the time interval between consecutive ovipositions were recorded daily for 10 consecutive d for each experimental group. An instrument designed by Mady (1996) was used to accurately detect oviposition time (Figure 1). The number of eggs laid was recorded hourly for each replication for 10 d to determine the effect of feeding time on oviposition time.

Statistical Analysis

Two-way analysis of variance was conducted. All proportional data were transformed to arcsine before analysis. When treatment effects were noted, differences among treatments were separated by Duncan's new multiple-range test (Duncan, 1955). The threshold for significance was $P \leq 0.05$.

RESULTS AND DISCUSSSION

These results may be the first to show that during heat stress, feeding time affects fertility and other parameters of the productive and reproductive performance of Japanese quail.

BW

The initial BW of quail distributed between the two time treatment groups were different at the start of the experiment (Table 2). Prior to treatment, the BW of birds allocated to the 0600 to 1400 feeding regime were higher than those of birds fed between 1400 to 2200 h. However, the final BW of quail fed from 1400 to 2200 h was higher than for quail fed from 0600 to 1400 h. These results disagree with observations of Harms (1991) and Samara et al. (1996) who found a decrease in chicken BW when time of feeding was changed from morning to afternoon. However, Harms and Waldroup (1963) suggested that hens did not utilize energy from the feed as efficiently when fed at 0600 h as they did when fed at 1800 h. Duncan and Hughes (1975) noted that the pattern of feed intake is influenced by the egg formation cycle. Fraps et al. (1947), Snetsinger et al. (1971), and Roland et al. (1972) noted that hens ate more on egg-forming days than on days when eggs were not formed. These observations suggest that higher egg production increased feed intake in quail fed during1400 to 2200 h, which in turn increased the BW above those of quail fed during 0600 to 1400 h. This species difference in BW response to the feeding time treatment could reflect the species difference in oviposition time (Tanabe and Nakamura, 1980).

Egg Production

Japanese quail fed from 1400 to 2200 h increased egg production as compared to quail fed during 0600 to 1400 h (Table 3). These results agree with observations of Balnave (1977) who found that afternoon feeding resulted in a higher rate of egg production. Contradictory results were obtained in chickens according to Brake and Peebles (1986) and Harms (1991) who observed that changing the time of feeding of hens from morning to afternoon resulted in a reduction in egg production. However, Brake (1988), Wilson and Keeling (1991), and Samara et al. (1996) noted that afternoon feeding had no effect on egg production.

TABLE 2. Initial and final mean BW ± SEM of male and female Japanese quail breeders at 44 and 60 wk of age as affected by daily feeding between 0600 to 1400 or 1400 to 2200 h during a period of daily heat stress[1]

	Feeding period			
	0600 to 1400 h		1400 to 2200 h	
Sex[2]	Initial (g)	Final (g)	Initial (g)	Final (g)
Male[3]	174.3 ± 2.2[a]	170.3 ± 2.2[a]	160.0 ± 1.7[c]	166.3 ± 1.6[b]
Female	196.6 ± 3.2[b]	186.6 ± 3.1[c]	189.5 ± 2.7[c]	203.5 ± 2.9[a]
Mean	185.5 ± 3.2[a]	178.4 ± 2.8[b]	174.7 ± 2.8[b]	184.9 ± 3.4[a]

[a–c]Means within a row that do not share a common superscript are different ($P \leq 0.05$).

[1]Mean temperatures during 0600 to 1400 and 1400 to 2200 h were between 34 to 36 and 24 to 26°C, respectively.

[2]No interaction was found among treatments and sex at any age.

[3]Each feeding treatment was allotted 25 male and 25 female Japanese quail.

Egg weights from quail fed from 0600 to 1400 h were not different from egg weights from quail fed from 1400 to 2200 h (Table 3). This result agrees with observations in chickens where egg weight was not affected by changing the feeding time from morning to afternoon (Harms, 1991; Wilson and Keeling, 1991; Samara et al., 1996). However, others report that afternoon feeding in chickens increases egg weight (Cave, 1981; Daniel and Balnave, 1981; Farmer et al., 1983a; Bootwalla et al., 1983; Brake and Peebles, 1986).

Egg specific gravity was increased ($P < 0.05$) in quail fed from 1400 to 2200 h in comparison to quail fed from 0600 to 1400 h (Table 3). Farmer et al. (1986) reported that hens utilize more calcium for eggshell quality from afternoon consumption than from morning consumption. These results agree with numerous observations that report increased egg specific gravity after changing feeding time from morning to afternoon (Balnave, 1977; Bootwalla et al., 1983; Farmer and Roland, 1986; Brake and Peebles, 1986; Brake, 1988; Harms, 1991). On the other hand, Wilson and Keeling (1991) and Samara et al. (1996) found no effect of feeding time on egg specific gravity.

Reproductive Performance

Fertility was higher when quail were fed during 1400 to 2200 h than from 0600 to 1400 h (Table 3). These results agree with observations of Brake (1988) who found that feeding at afternoon resulted in higher fertility, whereas Bootwella et al. (1983) found no effect of feeding time on fertility. Improvement of fertility observed in the present experiment on quail fed at 1400 to 2200 h may be due to increased egg specific gravity and egg production. Bilgili and Renden (1984) reported a correlation between egg specific gravity and fertility. McDaniel et al. (1981) noted positive correlations between fertility and hen-day pro-

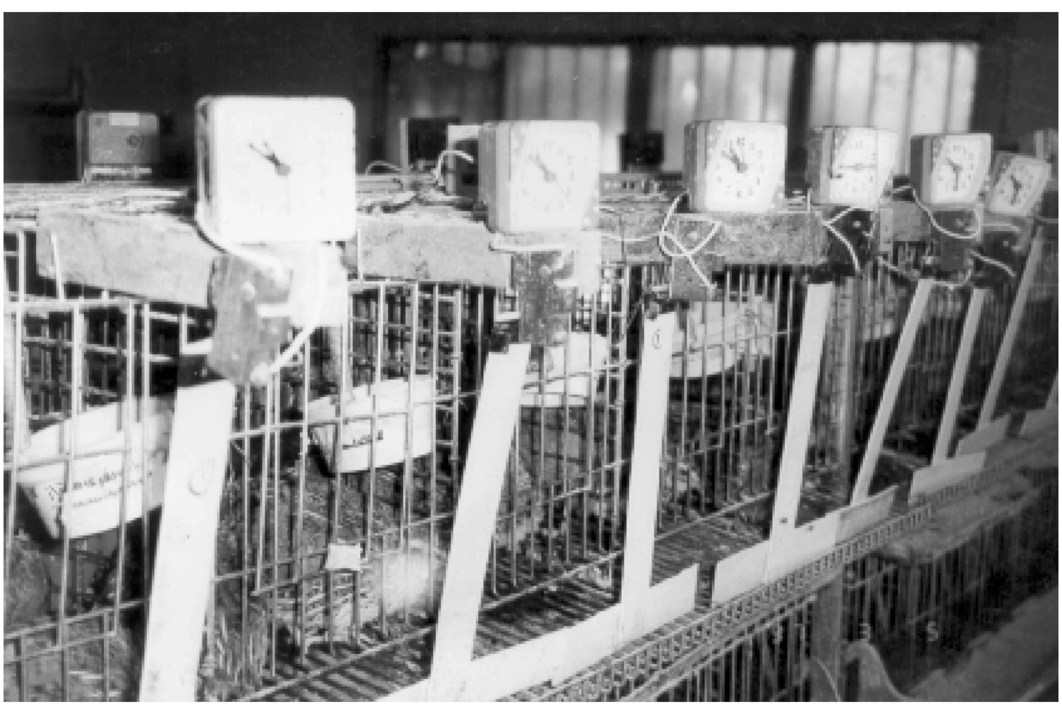

FIGURE 1. Quail breeding battery cages with oviposition detection apparatus designed to accurately detect oviposition time (Mady, 1996).

TABLE 3. Means ± SEM of measures of 100 d egg production and reproductive performance in Japanese quail from 44 to 60 wk of age as affected by daily feeding between 0600 to 1400 or 1400 to 2200 h during a period of daily heat stress[1]

	Feeding time (h)	
Parameter[2]	0600 to 1400	1400 to 2200
Egg production		
Oviposition interval (h)	23.4 ± 1.1	24.2 ± 0.9
100 d production (n)	46.9 ± 1.9[b]	57.1 ± 1.8[a]
Weight (g)	10.7 ± 0.1	10.5 ± 0.1
Specific gravity (g/mL)	1.066 ± 0.013[b]	1.078 ± 0.021[a]
Reproductive performance		
Fertility (%)	72.1 ± 1.6[b]	77.3 ± 1.4[a]
Hatchability (%)	36.8 ± 2.6[b]	55.5 ± 7.1[a]
Embryo mortality		
Early dead (%)	21.1 ± 1.8	16.2 ± 2.1
Late dead (%)	24.3 ± 2.5	21.7 ± 1.9
Pipped (%)	1.1 ± 0.4	2.5 ± 0.8
Total dead embryos (%)	43.5 ± 2.2	38.4 ± 2.2

[a–b]Means within a row that do not share a common superscript are different ($P \leq 0.05$).

[1]Mean temperatures during 0600 to 1400 and 1400 to 2200 h were between 34 to 36 and 24 to 26°C, respectively.

[2]Parameters measured from oviposition and eggs produced from 25 male-female pairs.

duction. Upp (1928) and Parker et al. (1940) described an important interaction between feeding time and natural peak of mating frequency, which reportedly occurs in late afternoon, or following lay.

Hatchability was higher in quail fed from 1400 to 2200 h than those fed from 0600 to 1400 h (Table 3). These results agree with observations of McDaniel et al. (1979) and Brake (1988) who postulated that afternoon feeding improves hatchability. Conversely, the findings of Farmer et al. (1983b) revealed that afternoon feeding decreased hatchability. The improvement in hatchability of quail fed from 1400 to 2200 h may be due to increased egg specific gravity, egg production, and fertility. McDaniel et al. (1979) reported a positive correlation between egg specific gravity and hatchability. North and Bell (1990) noted that eggs from higher producing hens usually have better hatchability than eggs from lower producing hens. No differences in embryonic mortality were observed between quail fed from 0600 to 1400 h or 1400 to 2200 h. Therefore, differences in hatchability appeared to result from differences in fertility that have been correlated with improvements in egg specific gravity (Table 3).

Oviposition Time

Length of time between ovipositions in quail fed from 1400 to 2200 h and 0600 to 1400 h was not different. Japanese quail in the present study showed that oviposition increased from 16.10 to 31.36% during 1400 to 1600 h versus 19.1 to 42.7% after which oviposition decreased reaching 0.85 vs. 0.0% at 1900 h in quail fed from 0600 to 1400 h and 1400 to 2200 h, respectively. These results agree with Tanabe and Nakamura (1980) who state that oviposition in Japanese quail mostly occurs in the last 5 h of daylight as opposed to during morning activity of the chicken (Table 4). Quail fed in the morning laid 92.3% of their eggs between 1300 to 1700 h, whereas the afternoon fed quail laid 98.5% of their eggs during the same period. However, quail fed in the morning laid 7.5% of their eggs from 1800 to 2000 h versus 1.5% of the eggs from afternoon fed quail (Table 4). These results agree with observations of Daniel and Balnave (1981) and Harms (1991) who found that feeding in the afternoon changed oviposition time. Brake (1985) and Wilson and Keeling (1991) indicated that feeding in the afternoon did not change oviposition time in chickens.

The oviposition time of Japanese quail is different than the oviposition time of the chicken. Because the time of egg formation is confounded with feed intake and shell synthesis and impacts egg specific gravity, the observed differences between the impact of morning and afternoon feeding between quail and chickens are reasonable. Oviposition time is also confounded with the period of heat stress encountered in Egypt, which occurs between 0600 to 1400 h. Higher BW increases occurred during the study in the afternoon fed quail even though they had lighter

TABLE 4. Effect of daily feeding between 0600 to 1400 or 1400 to 2200 h during a period of daily heat stress[1] on oviposition time by hourly intervals in Japanese quail[2]

	Feeding period			
	0600 to 1400 h		1400 to 2200 h	
Oviposition time[3] (h)	n	%	n	%
1300	3	2.54	1	0.74
1400	19	16.10	26	19.12
1500	28	23.73	29	21.32
1600	37	31.36	58	42.65
1700	22	18.64	20	14.71
1800	8	6.68	2	1.47
1900	1	0.85	0	0
Cumulative total	118	99.90	136	100.01
1300 to 1700	109	92.3	134	98.5
1700 to 2200	9	7.7	2	1.5

[1]Mean temperatures during 0600 to 1400 and 1400 to 2200 h were between 34 to 36 and 24 to 26°C, respectively.

[2]Oviposition time was recorded over 10 d in 20 Japanese quail (50 to 52 wk of age) per feeding period treatment.

[3]No eggs were produced before 1300 h or after 1900 h.

BW at the beginning of the study. Afternoon feeding increased egg production and advanced oviposition time relative to the morning fed quail. The environmental conditions in the afternoon were more amenable to feed consumption than the hotter morning conditions. This situation could result in better nutrition during the period of shell formation, thereby yielding better egg production measures including egg number and egg specific gravity. Male activity also could be impacted contributing to increased fertility and hatchability in the eggs produced from afternoon fed quail. Because oviposition peaks at 1600 h in these quail, feeding that occurs in the afternoon at the time nutrients are needed for egg formation could benefit egg production and decrease immature eggs.

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