

The Influence of a Twice-a-Day Feeding Regimen After Photostimulation on the Reproductive Performance of Broiler Breeder Hens¹

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ABSTRACT Broiler breeder hens are typically provided a restricted amount of feed once a day. This feed is rapidly consumed; therefore, the hens fast for an extended period of time before their next feeding. In the current research, the effects on reproductive performance of implementing a twice-a-day vs. a once-a-day feeding program after photostimulation were investigated. Pullets and cockerels were reared on a skip-a-day feeding program. Pullets were weighed at 20 wk of age and then distributed into 30 laying pens such that each pen had a similar BW distribution. Each individual laying pen consisted of 35 hens and 4 roosters. At 21 wk of age, the birds were photostimulated for reproduction and 15 of the laying pens were placed on a once-a-day feeding schedule, whereas the other 15 pens were placed on a twice-a-day feeding schedule. The total amount of feed provided per day to all the

laying pens was the same. Birds fed once a day received all their feed at 0630 h, whereas birds fed twice a day received 60% of their total feed allotment at 0630 h and the other 40% at 1500 h. Even though both treatment groups began egg production at the end of wk 23, birds fed twice a day laid more ($P \leq 0.05$) eggs through 42 wk of age than those fed once a day. Additionally, the average egg weight for the entire production period, which lasted until the birds were 60 wk of age, was greater for hens fed twice a day. Overall BW uniformity for the entire experiment was significantly better for hens fed twice a day vs. once a day. However, cumulative mortality was significantly higher for hens fed twice a day than for those fed once a day. The results indicate that feeding broiler breeder hens twice a day after photostimulation may enhance reproductive performance during the early lay period.

Key words: broiler breeder hen, twice-a-day feeding, egg production

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INTRODUCTION

The typical poultry industry practice of feed-restricting broiler breeder hens decreases BW gain (Robbins et al., 1986; Katanbaf et al., 1989; Bruggeman et al., 1999, 2005; Onagbesan et al., 2006), delays the onset of sexual maturity (Robbins et al., 1986; Yu et al., 1992; Heck et al., 2004; Bruggeman et al., 2005; Hocking and Robertson, 2005; Onagbesan et al., 2006), and decreases mortality (Robbins et al., 1986; Katanbaf et al., 1989; Heck et al., 2004; Bruggeman et al., 2005). In addition, feed restriction during the rearing and laying periods reduces the number of large follicles on the ovary of broiler breeder hens (Hocking et al., 1987, 1989; Heck et al., 2004; Hocking and Robertson, 2005). More important, broiler breeder hens that have been feed restricted produce more eggs (Yu et al., 1992; Heck et al., 2004; Bruggeman et al., 2005; Onagbesan et al., 2006),

lay longer sequences (Robinson et al., 1991), persist in lay longer (Fattori et al., 1991), lay fewer abnormal eggs, and have fewer multiple ovulations in a single day (Fattori et al., 1991; Yu et al., 1992; Heck et al., 2004) compared with fully fed broiler breeder hens.

Despite the improvement in egg production of broiler breeder hens resulting from feed-restriction programs, these hens still have inferior total egg production compared with commercial laying hens. Interestingly, total egg production in broiler breeder hens may be depressed as a result of poultry industry feed-restriction practices. Broiler breeder hens are typically provided feed once a day during reproduction. This feed is quickly consumed by the hens, and as a result, they will fast for a significant portion of each day. Morris and Nalbandov (1961) suggested that the lack of gonadotropin secretion from the pituitary is responsible for the loss of egg production in fasted birds. Subsequently, Scanes et al. (1976) reported that plasma luteinizing hormone concentrations were significantly depressed in 6-wk-old male chicks fasted for 12 h compared with control-fed cockerels. In addition, fasted laying hens had lower plasma concentrations of luteinizing hormone after 48 h of fasting and lower estradiol and progesterone concentrations after 24 h of fasting compared with ad libi-

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tum-fed control hens (Tanabe et al., 1981). On the basis of these previous reports, the reproductive capability of chickens may be compromised by even short-term fasting. Therefore, the goal of the current research was to determine whether the reproductive performance of broiler breeder hens could be improved by splitting the feed allotment offered each day during the entire breeding period into 2 feeding periods separated by 8.5 h instead of offering the feed allotment once a day, as is typically done in a commercial setting.

MATERIALS AND METHODS

At 1 d of age 1,300 Cobb 500 slow-feathering pullets were randomly divided among 4 rooms, and 500 Cobb cockerels were divided among 2 rooms. The rooms measured 7.32 × 9.14 m and had pine shavings for litter. The rooms were environmentally controlled, with the temperature maintained at 32.2°C for the first week, and then decreased by approximately 2.8°C every week thereafter until a target temperature of 21°C was reached. From 1 to 3 d of age, the chicks were given 24 h of light per day, and then from 4 to 14 d of age, the amount of light was decreased from 24 to 8 h per day. The 8 h per day lighting schedule was then maintained until the birds reached 21 wk of age. All birds were fed a standard corn and soy diet (Table 1) ad libitum from 0 to 2 wk of age, and then fed a developer diet (Table 1) from 2 to 23 wk of age. From 2 to 21 wk of age, the birds were feed restricted and fed on a skip-a-day basis. Feed was distributed by automatic chain feeders, and the birds were given ad libitum access to water from nipple drinkers. A random selection of 10% of the birds from each room was weighed every week to determine feed allocations so that BW gain of the pullets and cockerels matched the recommended guidelines of the primary breeder. All pullets were wing-banded for identification purposes. All animal procedures were approved by the Animal Care and Use Committee of the University of Georgia.

At 20 wk of age, all the pullets were weighed. Pullets were selected and assigned to 30 laying pens to ensure that the weight profile in each pen was similar. Each laying pen contained 35 pullets and 4 roosters. Each pen measured 3.65 × 2.75 m, and the floor space of each pen consisted of two-thirds pine shavings litter and one-third elevated slats. Each pen had one 6-hole nest box located on the slat area and was equipped with 10 nipple drinkers. In the laying pens, the hens and roosters were hand-fed by using plastic feeder pans. Each pen contained 3 hen feeder pans, which were fitted with rooster exclusion grills. The feeding system provided 9.14 cm of feeder space per hen. Males were given their own feeder pan, which was elevated in height to prevent females from consuming their feed. Each rooster had 25.9 cm of feeder space. The male-to-female ratio was kept between 10 and 11% throughout the experiment by replacing male mortalities from a pool of extra males. When the hens were 50 wk of age, 26-wk-old males from another flock were added to the pens to stimulate mating and

Table 1. Composition of the experimental diets

Item	Diet		
	Starter ¹	Developer ²	Layer ³
	% of diet		
Ingredient			
Corn	62.95	65.88	70.80
Soybean meal, 48% CP	22.24	15.00	18.11
Poultry fat	0.00	0.00	0.91
Wheat middlings	10.53	14.83	0.00
Limestone	1.16	1.28	7.33
Dicalcium phosphate	1.75	1.57	1.49
Sodium chloride	0.54	0.60	0.51
Vitamin premix ⁴	0.50	0.50	0.50
DL-Met	0.15	0.13	0.15
L-Lys·HCl	0.10	0.13	0.12
Trace mineral premix ⁵	0.08	0.08	0.08
Calculated analysis ⁶			
ME (kcal/kg)	2,865.00	2,920.00	2,920.00
CP (%)	18.00	15.00	15.00
Lys (%)	1.00	0.83	0.83
Calcium (%)	0.91	0.92	3.22
Met and Cys (%)	0.73	0.64	0.64
Available phosphorus (%)	0.45	0.42	0.38

¹Starter diet was fed from 0 to 2 wk of age.

²Developer diet was fed from 2 to 23 wk of age.

³Layer diet was fed from 23 to 60 wk of age. To add more bulk to the layer diet, 100 g of rice hulls was added per kilogram of layer diet before pelleting. The rice hulls were considered not to add any significant nutrient value to the diet for purposes of calculating daily nutrient intake; therefore, the contribution of the rice hulls was not included in the calculated analysis of the layer diet. If the contribution of the rice hulls was included in the calculated analysis, the values for ME, CP, Lys, calcium, Met, and Cys and available phosphorus would decrease to 2,657 kcal/kg, 13.65%, 0.76%, 2.90%, 0.58%, and 0.34%, respectively.

⁴Vitamin premix provided the following per kilogram of diet: vitamin A, 5,510 IU; vitamin D₃, 1,100 IU; vitamin E, 11 IU; vitamin B₁₂, 0.01 mg; riboflavin, 4.4 mg; niacin, 44.1 mg; D-pantothenic acid, 11.2 mg; choline, 191.3 mg; menadione sodium bisulfate, 3.3 mg; folic acid, 5.5 mg; pyridoxine HCl, 4.7 mg; thiamin, 2.2 mg; D-biotin, 0.11 mg; and ethoxyquin, 125 mg.

⁵Trace mineral premix provided the following in milligrams per kilogram of diet: Mn, 60; Zn, 50; Fe, 30; I, 1.5; and Se, 0.5.

⁶Calculated analysis was based on Dale (2001).

ensure continued fertility. Subsequent male mortality replacements came from this younger male flock.

Photostimulation occurred at 21 wk of age by providing 14 h of light (lights on at 0600 h), and this photoperiod was maintained until the hens reached 60 wk of age when the experiment ended. At 21 wk of age, the birds in half of the 30 replicate pens were switched from skip-a-day feeding to once-a-day feeding, whereas the remaining pullets in the other 15 pens were switched to twice-a-day feeding. The birds for the once-a-day feeding treatment received all their feed at 0630 h, whereas the birds for the twice-a-day feeding treatment received 60% of their total daily feed allotment at 0630 h and 40% at 1500 h. The birds in both treatments received the same total amount of daily feed. Roosters were fed their daily allotment of feed at 0630 h. At 23 wk of age, all the hens and roosters were switched to a broiler breeder layer diet (Table 1). Before the layer diet was pelleted, 100 g of rice hulls/kg of diet was added to increase feed volume to ensure that all the birds fed twice a day had access to feed at the 1500 h feeding. The rice hulls were considered not to add any

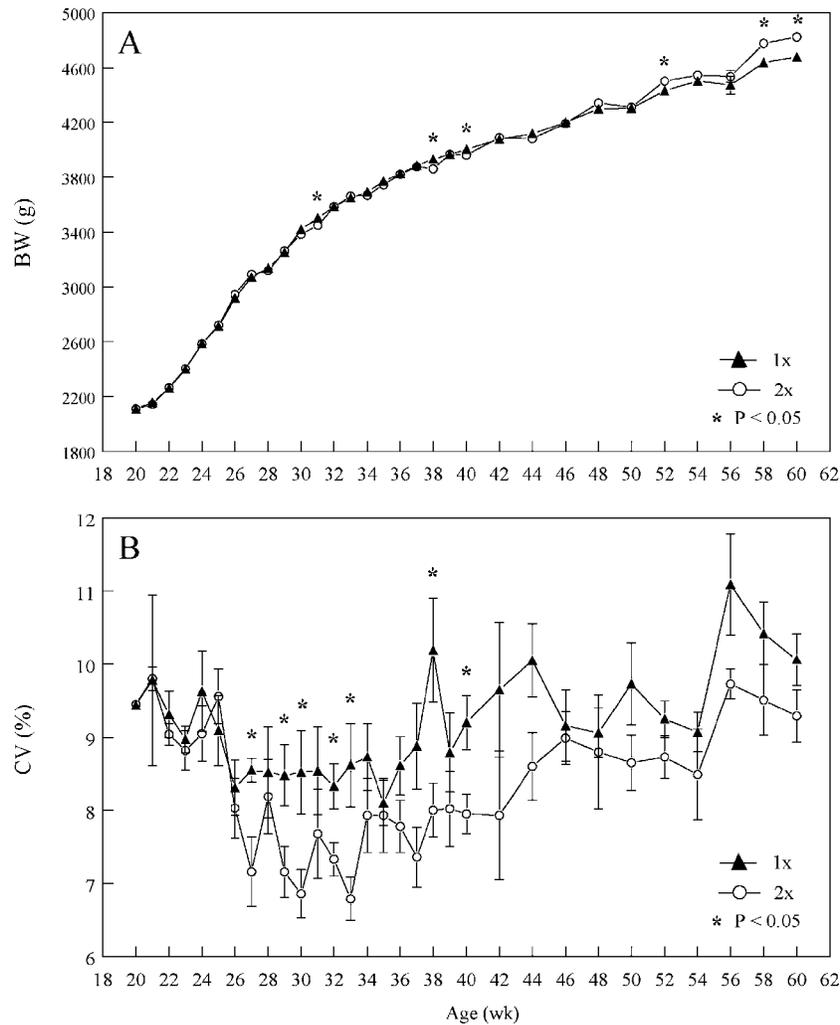


Figure 1. Weekly BW (A) and CV of BW (B) of broiler breeder hens fed either once a day (1x) or twice a day (2x) after photostimulation for reproduction at 21 wk of age. Values are means \pm SEM, $n = 15$ (wk 20, 21, 32, 40, 52, and 60) or 5 (all other weeks) replicate pens of 35 hens each for both feeding treatments. Body weight values are calculated on a per-bird basis. Because of the significant labor involved in weighing all the birds, only one-third of the replicate pens were weighed on a rotating basis for most weeks. *Means differ ($P < 0.05$) from the corresponding mean for the other feeding treatment.

significant nutrient value to the diet for purposes of calculating daily nutrient intake.

All mortalities were recorded, and necropsies were performed on all hen mortalities from 23 to 60 wk of age. Roosters and hens were weighed weekly from 21 to 40 wk of age and every other wk from 42 to 60 wk of age. A rotating sample of 5 of the 15 pens per treatment was weighed during each weigh period, which allowed for individual pens to be weighed every third weigh period. All birds were weighed at 21, 32, 40, 52, and 59 wk of age to accurately determine whole-flock BW uniformity. Birds were weighed before their morning feeding, which delayed feeding by 1 h on each weigh day. For the week that all the birds were weighed, multiple weigh teams were used to keep the delay in feeding consistent. Eggs were manually collected 3 to 4 times per day. Hen-housed and hen-day egg production were calculated weekly from daily egg counts and the numbers of hatchable, abnormally shaped, cracked, double-yolked, dirty, membrane, and total eggs were recorded daily for each pen.

Ninety hatching eggs from each pen were saved (and stored at 18.3 to 19.9°C for no more than 7 d) every other week when the hens were between 26 and 41 wk of age and then every 4 wk thereafter. Eggs were incubated at 37.8°C with 53% RH from d 0 to 18, and then at 37.2°C with 70% RH from d 19 to 21. Eggs were candled on d 12 of incubation and transferred for hatching on d 19 of incubation. During candling, transfer, and after hatching, eggs were characterized as being infertile, cracked, contaminated, or containing early dead embryos (less than 7 d), mid dead embryos (7 to 14 d), or late dead embryos (15 to 21 d). Eggs cracked during transfer to the hatchery were removed from the data set as lost eggs. After hatching, the numbers of live and dead pips and live and dead chicks were determined.

Beginning when the birds were 26 wk of age, all hatching eggs from 2 d of production were weighed every other week for each pen. Specific gravities were determined by using the saline flotation method (Phillips and Williams, 1943) on 20 eggs per pen from 1 production day every

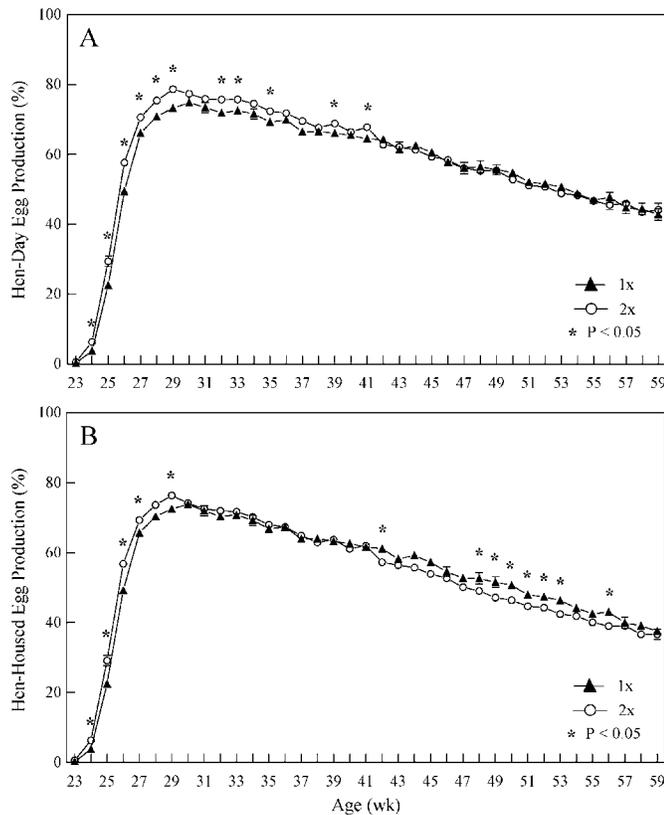


Figure 2. Weekly hen-day egg production (A) and hen-housed egg production (B) through 59 wk of age for broiler breeder hens fed either once a day (1x) or twice a day (2x) after photostimulation for reproduction at 21 wk of age. Values are means \pm SEM, $n = 15$ replicate pens of 35 hens for both feeding treatments. Weekly hen-day egg production equals the percentage of hens in lay corrected for mortality, whereas hen-housed egg production equals the percentage of hens in lay based on the original number of hens placed in each replicate pen. *Means differ ($P < 0.05$) from the corresponding mean for the other feeding treatment.

other week when the hens were 30 to 40 wk of age, and then once every 4 wk thereafter. In addition, when the hens were 46 wk of age, all hatching eggs produced by the hens of each pen over a 2-d period were individually weighed. Each individual egg was then opened and the shell (including shell membranes), albumen, and yolk were separated and immediately weighed to allow the weight of each component to be calculated as a percentage of the total egg weight.

Statistical Analyses

One-way ANOVA was used to detect significant weekly or overall experimental period differences between the once-a-day and twice-a-day feeding treatments (Neter et al., 1990). All statistical procedures were done with the Minitab Statistical Software package (Release 13, State College, PA). Differences were considered significant when P -values were < 0.05 .

RESULTS

The hens fed twice a day weighed significantly less than the hens fed once a day at 31, 38, and 40 wk of age; however,

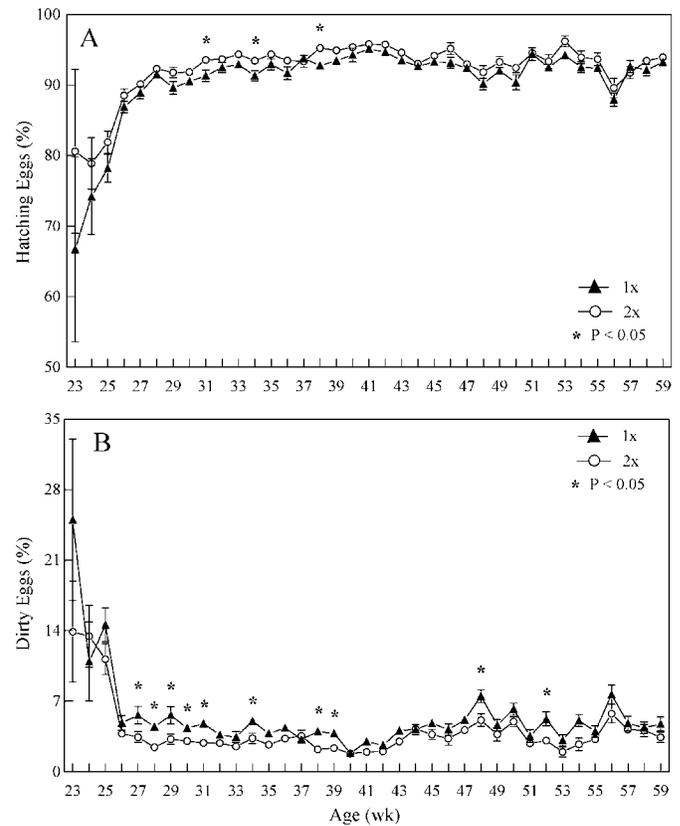


Figure 3. The percentages of hatching (A) and dirty (B) eggs out of the total number of eggs produced per week. Values are means \pm SEM, $n = 15$ replicate pens of 35 hens for each feeding treatment. Hatching eggs excluded membrane eggs or eggs that were abnormal in shape, cracked, double-yolked, or dirty. Dirty eggs were contaminated with feces, blood, or both. *Means differ ($P < 0.05$) from the corresponding mean for the other feeding treatment.

at 52, 58, and 60 wk of age, the hens fed twice a day weighed significantly more than the hens fed once a day (Figure 1). After 25 wk of age, the CV of BW was always numerically lower for the hens fed twice a day vs. those fed once a day (Figure 1). The mean \pm SEM CV for BW for the entire experimental period were 9.22 ± 0.08 and 8.49 ± 0.09 for the birds fed once a day and twice a day, respectively, and the difference between these means was highly significant ($P = 0.0001$).

The hens from both feeding treatments began producing eggs during wk 23 of age, reached 25% egg production during wk 25 of age, and reached 50% production during wk 26 of age (Figure 2). For the hens fed twice a day, hen-day egg production peaked at 78.64% at 29 wk of age, whereas the hens fed once a day peaked at 74.84% at wk 30 of age. Weekly hen-day egg production was generally higher in the hens fed twice a day compared with the hens fed once a day in the first half of the experimental period (Figure 2); however, this trend did not continue during the last half of the experimental period, in which hen-day egg production was similar between treatments. Nonetheless, for the entire production period the overall percentage of hen-day egg production was significantly greater (58 vs. 56%) for the hens fed twice a day compared with the hens fed once a day. Through 41 wk of age, total hen-day egg

Table 2. Cumulative mortality of broiler breeder hens from 23 through 59 wk of age fed either once a day or twice a day after photostimulation at 21 wk of age¹

Age (wk)	Feeding treatment	
	Once a day	Twice a day
	(%)	
23	0.00 ± 0.00	0.20 ± 0.20
24	0.19 ± 0.19	0.77 ± 0.34
25	0.38 ± 0.26	0.77 ± 0.34
26	0.57 ± 0.31	1.53 ± 0.55
27	0.57 ± 0.31	2.10 ± 0.71
28	0.95 ± 0.46	2.29 ± 0.70
29	1.14 ± 0.47	3.44 ± 0.85*
30	1.52 ± 0.47	4.01 ± 0.88*
31	2.10 ± 0.65	4.39 ± 0.78*
32	2.10 ± 0.65	4.96 ± 0.90*
33	3.05 ± 0.65	5.54 ± 0.94*
34	3.43 ± 0.75	5.73 ± 0.93
35	3.62 ± 0.76	5.73 ± 0.93
36	3.62 ± 0.76	6.11 ± 0.83*
37	3.81 ± 0.87	6.68 ± 0.91*
38	4.19 ± 0.88	6.87 ± 0.87*
39	4.38 ± 0.88	7.25 ± 0.88*
40	4.38 ± 0.88	8.02 ± 0.98*
41	4.76 ± 0.77	8.40 ± 1.06*
42	4.95 ± 0.76	8.78 ± 1.23*
43	5.33 ± 0.73	8.78 ± 1.23*
44	5.52 ± 0.76	8.78 ± 1.23*
45	5.52 ± 0.76	8.97 ± 1.25*
46	5.91 ± 0.90	9.93 ± 1.50*
47	6.48 ± 0.81	10.50 ± 1.62*
48	7.24 ± 0.88	11.26 ± 1.56*
49	7.43 ± 0.87	11.45 ± 1.63*
50	8.00 ± 0.85	12.03 ± 1.59*
51	8.00 ± 0.85	12.03 ± 1.59*
52	8.38 ± 0.94	12.61 ± 1.60*
53	8.95 ± 1.00	12.80 ± 1.61*
54	9.14 ± 1.09	13.56 ± 1.64*
55	9.71 ± 1.14	13.75 ± 1.71
56	10.48 ± 1.24	13.94 ± 1.65
57	10.86 ± 1.16	14.32 ± 1.83
58	12.00 ± 1.09	16.04 ± 1.87
59	12.00 ± 1.09	17.56 ± 1.95*

¹Before wk 23, pullets that died were replaced with spare pullets to maintain all breeder pens at 35 pullets per pen. Values are means ± SEM, n = 15 replicate pens of 35 hens for each feeding schedule.

*Different from the corresponding value for the hens fed once a day ($P \leq 0.05$).

production was also significantly ($P < 0.01$) higher (83 vs. 78 eggs/bird) for the hens fed twice a day compared with those fed once a day. By the end of the experiment (through 59 wk of age), the hens fed twice a day had produced 149 eggs/hen compared with 145 eggs/hen for the hens fed once a day, and this difference in egg production was not statistically significant.

Cumulative mortality at the end of the experiment was significantly higher in the birds fed twice a day compared with those fed once a day (Table 2). Necropsy records indicated that 75% of the hens that died in the once-a-day treatment were either out of lay (regressed ovary) or going out of lay (multiple-regressing hierarchical follicles). In contrast, of the total number of hens that died in the twice-a-day treatment, 63% were in active lay (normal ovarian hierarchy, egg in oviduct, or both), whereas 37% were out of lay or going out of lay. Given the higher mortality of the hens fed twice a day, it is not surprising that hen-

Table 3. Classification of all the eggs produced through 59 wk of age by broiler breeder hens fed either once a day or twice a day after photostimulation for reproduction at 21 wk of age¹

Egg type	Feeding treatment	
	Once a day	Twice a day
	(%)	
Hatching	91.14 ± 0.31	92.47 ± 0.28*
Dirty	5.08 ± 0.21	3.95 ± 0.24*
Cracked	2.30 ± 0.12	2.21 ± 0.10
Abnormally shaped	0.73 ± 0.04	0.77 ± 0.04
Double-yolked	0.69 ± 0.09	0.55 ± 0.05
Membrane	0.06 ± 0.02	0.05 ± 0.01

¹Values are means ± SEM, n = 15 replicate pens of 35 hens each for both feeding treatments.

*Different from the corresponding value for the hens fed once a day ($P \leq 0.001$).

housed egg production was sometimes significantly higher for the hens fed once a day vs. twice a day for some of the individual weeks of production during the last half of the experiment (Figure 2). However, total hen-housed egg production was not significantly different through 41 wk of age (78 vs. 79 eggs per hen on the once- and twice-a-day treatments, respectively) or through 59 wk of age (140 vs. 137 eggs per hen on the once- and twice-a-day treatments, respectively).

The percentage of hatching eggs (excluding membrane eggs or eggs that were abnormal in shape, cracked, double-yolked, or dirty) out of the total number of eggs produced each week by the hens fed twice a day was at times significantly greater than the percentage of hatching eggs produced by the hens fed once a day (Figure 3). For the entire production period, the hens fed twice a day produced a significantly greater percentage of hatching eggs of total eggs produced than the hens fed once a day (Table 3). The increased production of hatching eggs by the hens fed twice a day, compared with those fed once a day, was due in large part to the difference in the production of dirty eggs by the hens in the 2 feeding treatments (Figure 3 and Table 3). The overall proportion of cracked, abnormally shaped, double-yolked, and membrane eggs did not differ between the 2 feeding treatments (Table 3).

Biweekly egg weights were significantly greater for the hens fed twice a day compared with those fed once a day except on wk 28, 56, and 58 (Table 4). For the entire experimental period, the mean ± SEM egg weights were 67.87 ± 0.33 and 68.84 ± 0.34 g for the hens fed once and twice a day, respectively. This overall difference in egg weight between the 2 treatments was significant ($P < 0.001$). Hatching eggs produced over a 2-d period by the hens fed once a day when they were 46 wk of age did not differ in their percentage of total egg weight for albumen (55.29 ± 0.04 vs. 55.45 ± 0.04), yolk (32.29 ± 0.13 vs. 32.22 ± 0.12), or shell plus shell membranes (12.42 ± 0.10 vs. 12.33 ± 0.09), compared with those produced by the hens fed twice a day. The specific gravities of the eggs produced by the hens from the 2 feeding treatments also did not differ (Table 5).

Table 4. Biweekly egg weights for eggs produced by broiler breeder hens fed either once a day or twice a day after photostimulation for reproduction¹

Age (wk)	Feeding treatment	
	Once a day	Twice a day
	(g)	
26	54.17 ± 0.29	54.98 ± 0.17*
28	58.20 ± 0.20	58.74 ± 0.20
30	61.22 ± 0.15	62.10 ± 0.20*
32	62.95 ± 0.19	63.91 ± 0.19*
34	64.98 ± 0.27	65.87 ± 0.21*
36	66.89 ± 0.21	67.50 ± 0.24*
38	68.26 ± 0.20	69.09 ± 0.27*
40	68.91 ± 0.31	69.74 ± 0.27*
42	69.52 ± 0.19	70.49 ± 0.31*
44	70.46 ± 0.15	71.47 ± 0.22*
46	71.10 ± 0.19	72.48 ± 0.22*
48	71.23 ± 0.24	72.40 ± 0.29*
50	71.85 ± 0.21	73.11 ± 0.24*
52	72.10 ± 0.32	73.01 ± 0.24*
54	72.43 ± 0.27	73.51 ± 0.30*
56	72.99 ± 0.22	73.77 ± 0.35
58	72.72 ± 0.28	73.27 ± 0.39
60	72.56 ± 0.25	74.28 ± 0.30*

¹Values are means ± SEM, n = 15 replicate pens of 35 hens each for both feeding treatments. All the hatching eggs produced over a 2-d period for every pen were weighed for a given week of age.

*Different from the corresponding value for the hens fed once a day ($P \leq 0.05$).

The fertility and hatchability of eggs produced by the hens fed either once a day or twice a day were not significantly different (Table 6). The only significant difference in the hatchability of fertile eggs between the 2 treatments occurred at wk 59 (Table 6), but the overall hatchability of fertile eggs did not differ between the 2 treatments (Table 6). Although there was a significant difference between the treatments in the incidence of pips at wk 41 and the incidence of late dead embryos at wk 59, the overall incidence of early dead, mid dead, and late dead embryos, as well as the incidence of live and dead pips in the eggs incubated during the entire experiment, was equivalent for the 2 feeding treatments (Table 7).

Table 5. Specific gravities of eggs produced by broiler breeder hens fed either once a day or twice a day after photostimulation for reproduction¹

Age (wk)	Feeding schedule	
	Once a day	Twice a day
30	1.0874 ± 0.0003	1.0874 ± 0.0002
32	1.0886 ± 0.0003	1.0884 ± 0.0004
34	1.0824 ± 0.0004	1.0815 ± 0.0003
36	1.0854 ± 0.0004	1.0860 ± 0.0003
38	1.0845 ± 0.0003	1.0844 ± 0.0002
42	1.0829 ± 0.0003	1.0830 ± 0.0003
46	1.0828 ± 0.0003	1.0828 ± 0.0004
50	1.0841 ± 0.0003	1.0846 ± 0.0003
54	1.0820 ± 0.0003	1.0815 ± 0.0004
58	1.0830 ± 0.0005	1.0834 ± 0.0005

¹Values are means ± SEM, n = 15 replicate pens of 35 hens each for both feeding treatments. Specific gravities were determined for all hatching eggs collected over a 1-d period for each pen at a given week of age.

DISCUSSION

The present study indicated that feeding broiler breeder hens twice a day rather than once a day improves egg production from the initiation of lay through peak egg production. Cave (1981) reported that feeding broiler breeder hens 3 times a day increased the percentage of hen-day egg production for the first 10 wk of production when compared with hens fed once or twice a day. However, for the 3 subsequent 10-wk periods and for the entire experimental period, there was no difference in the percentage of hen-day egg production between the hens fed once, twice, or 3 times a day (Cave, 1981). Similarly, de Avila et al. (2003a,b) did not observe a difference in total egg production through 66 wk of age between broiler breeder hens fed either once or twice a day. de Avila et al. (2003b) did report that the time to 5% egg production was shorter for the flock fed twice a day, but the age at first egg and the age to reach 50% production did not vary between the hens fed once and twice a day (de Avila et al., 2003a).

An even greater difference in overall egg production between the hens fed once a day and twice a day in the present research may have been achieved if mortality had not been different between the 2 treatments. Mortality was high for both treatments, based on breeder guidelines (Cobb-Vantress Inc., 2005a,b), but was comparable to the 17.1% mortality reported for commercial practice in the United States during the breeding period (Agri Stats Inc., 2007) and was actually lower than we have experienced in previous experiments with caged Cobb slow-feathering hens (Hudson et al., 2004). However, by the end of the experiment the birds fed twice a day had experienced a significantly higher level of mortality than those fed once a day. More important, 67% of the hens that died in the twice-a-day treatment were still producing eggs, compared with only 25% of the hens that died in the once-a-day feeding treatment. Possibly the stress associated with producing more eggs caused the greater loss of egg-producing hens in the twice-a-day feeding treatment, but the loss of these hens was very detrimental to overall egg production. Further research is needed to determine whether feeding hens twice a day is detrimental to livability or whether this finding was peculiar to the specific strain of hens used for this experiment. Cave (1981) and de Avila (2003a), using different strains of broiler breeder hens than were used in the present research, did not report an increase in mortality when feeding broiler breeder hens twice a day.

The decision to split the daily feed allotment into a 60:40 ratio was based on ensuring that there was a sufficient volume of feed at both feeding times to minimize competition among the hens. Furthermore, because the start of the experiment was occurring in the summer, a slightly lower proportion of the feed was provided for the afternoon feeding (1500 h) than the morning feeding (0630 h) to have slightly less heat generated in the hottest part of the day associated with increased feeding and metabolic activity. For their research, de Avila et al. (2003a,b) split the daily feed allotment equally and fed half of the feed allotment at 0630 h and the other half at 1530 h. Cave (1981) took a

Table 6. Fertility, hatchability, and hatchability of fertile eggs¹ produced by broiler breeder hens fed either once a day or twice a day after photostimulation for reproduction

Age (wk)	Feeding schedule					
	Fertility		Hatchability		Hatch of fertile	
	Once a day	Twice a day	Once a day	Twice a day	Once a day	Twice a day
	(%)					
26	94.44 ± 1.40	95.89 ± 0.90	84.26 ± 1.95	84.88 ± 1.49	88.86 ± 1.33	87.64 ± 1.16
28	97.69 ± 0.44	98.14 ± 0.26	89.48 ± 0.86	89.14 ± 0.95	91.13 ± 0.96	90.62 ± 0.92
30	97.09 ± 0.82	97.62 ± 0.64	85.26 ± 0.90	87.62 ± 1.12	87.45 ± 0.93	89.07 ± 0.99
32	97.09 ± 1.21	97.98 ± 0.55	86.96 ± 1.32	87.31 ± 1.02	89.22 ± 0.77	88.59 ± 1.06
34	95.15 ± 1.35	96.80 ± 0.72	83.89 ± 1.86	87.79 ± 1.22	87.61 ± 1.50	90.09 ± 0.77
36	91.15 ± 2.34	92.30 ± 1.88	82.52 ± 2.79	83.29 ± 1.99	89.78 ± 1.08	89.64 ± 0.83
39	88.70 ± 3.60	94.04 ± 1.71	80.62 ± 3.68	85.00 ± 1.93	89.79 ± 1.01	89.58 ± 1.07
41	89.28 ± 2.53	93.69 ± 1.74	79.22 ± 2.51	84.28 ± 1.51	89.09 ± 1.02	90.04 ± 0.96
44	93.05 ± 1.79	92.18 ± 2.03	83.26 ± 1.60	80.69 ± 2.26	88.92 ± 1.09	87.30 ± 1.50
48	93.73 ± 0.99	92.34 ± 1.02	80.86 ± 1.56	77.27 ± 1.82	85.76 ± 1.21	83.62 ± 1.21
52	89.52 ± 2.20	90.50 ± 1.89	87.94 ± 0.85	84.94 ± 1.11	82.89 ± 1.42	83.24 ± 1.43
56	90.46 ± 2.08	90.04 ± 2.13	75.71 ± 2.03	76.39 ± 2.31	84.50 ± 1.46	82.80 ± 1.18
59	90.10 ± 2.55	90.58 ± 1.63	78.66 ± 2.72	74.99 ± 1.91	85.43 ± 1.11	81.91 ± 1.24*
Overall	92.94 ± 0.94	94.04 ± 0.49	83.02 ± 0.85	83.39 ± 0.51	87.72 ± 0.43	87.21 ± 0.42

¹Values are means ± SEM, n = 15 replicate pens of 35 hens for each feeding schedule. Ninety eggs from each replicate pen were incubated for each age period. Hatchability is hatch of set eggs.

*Different from the corresponding value for the hens fed once a day (*P* ≤ 0.05).

different approach and fed 34% of the daily feed allotment at 0500 h and the remainder of the feed allotment at 4 h before the lights went out. Surprisingly, despite the concern in the present research that flock BW uniformity might be difficult to control by splitting the daily feed allotment into 2 feeding periods compared with 1 feeding period, the birds fed twice a day actually had better BW uniformity than the birds fed once a day. Neither Cave (1981) nor de Avila et al. (2003a,b) reported findings on BW uniformity.

The observed increase in egg size for hens fed twice a day compared with those fed once a day in the current research is consistent with an earlier report by Cave (1981). The increase in egg size may be related to providing feed

later in the day rather than feeding the hens twice a day. Broiler breeder hens provided feed once a day in the afternoon produced larger eggs than those provided feed once a day in the morning (Farmer et al., 1983; Brake and Peebles, 1986). In the current research, the increase in egg size resulted from an increase in all the major individual components of the egg, because the percentage of egg components did not differ between the 2 treatments. Based on specific gravity measurements, eggshell quality was not compromised in the larger sized eggs produced by the hens fed twice a day.

Feeding the hens twice a day significantly reduced the production of dirty eggs. Possibly the increased physical

Table 7. The incidence of early dead, mid dead, and late dead embryo mortality¹ as well as the incidence of pips in eggs incubated from broiler breeder hens fed either once a day or twice a day after photostimulation for reproduction

Age (wk)	Feeding schedule							
	Early dead		Mid dead		Late dead		Pips	
	Once a day	Twice a day	Once a day	Twice a day	Once a day	Twice a day	Once a day	Twice a day
	(%)							
26	6.00 ± 0.53	7.02 ± 0.98	0.08 ± 0.08	0.00 ± 0.00	2.83 ± 0.64	2.87 ± 0.57	0.87 ± 0.31	0.83 ± 0.32
28	4.48 ± 0.67	5.13 ± 0.65	0.08 ± 0.08	0.15 ± 0.10	2.84 ± 0.49	2.31 ± 0.49	0.45 ± 0.15	0.89 ± 0.27
30	4.24 ± 0.58	3.50 ± 0.54	0.07 ± 0.07	0.00 ± 0.00	4.32 ± 0.46	3.66 ± 0.70	1.93 ± 0.43	1.72 ± 0.37
32	4.24 ± 0.57	4.49 ± 0.63	0.00 ± 0.00	0.00 ± 0.00	3.51 ± 0.62	3.66 ± 0.54	1.72 ± 0.36	1.79 ± 0.40
34	5.29 ± 0.86	3.36 ± 0.47	0.00 ± 0.00	0.00 ± 0.00	3.21 ± 0.33	3.35 ± 0.56	1.79 ± 0.40	1.78 ± 0.43
36	4.24 ± 0.58	4.92 ± 0.53	0.00 ± 0.00	0.00 ± 0.00	2.31 ± 0.44	2.38 ± 0.55	1.19 ± 0.30	0.97 ± 0.21
39	3.62 ± 0.59	3.47 ± 0.44	0.00 ± 0.00	0.00 ± 0.00	2.33 ± 0.39	2.70 ± 0.47	0.75 ± 0.24	1.29 ± 0.27
41	4.02 ± 0.61	3.94 ± 0.73	0.00 ± 0.00	0.00 ± 0.00	3.29 ± 0.57	2.31 ± 0.48	0.74 ± 0.26	1.64 ± 0.26*
44	3.51 ± 0.54	3.95 ± 0.57	0.00 ± 0.00	0.00 ± 0.00	3.59 ± 0.62	3.58 ± 0.76	1.12 ± 0.33	2.98 ± 0.92
48	4.27 ± 0.72	5.75 ± 0.62	0.00 ± 0.00	0.00 ± 0.00	5.53 ± 0.72	4.56 ± 0.78	1.72 ± 0.42	1.12 ± 0.22
52	4.55 ± 0.60	5.65 ± 0.58	0.00 ± 0.00	0.00 ± 0.00	5.74 ± 0.80	4.96 ± 0.67	2.60 ± 0.83	1.92 ± 0.39
56	6.50 ± 0.81	5.43 ± 0.70	0.15 ± 0.10	0.00 ± 0.00	4.66 ± 0.51	4.48 ± 0.56	1.91 ± 0.38	1.95 ± 0.47
59	5.05 ± 0.58	5.83 ± 0.83	0.00 ± 0.00	0.08 ± 0.08	3.46 ± 0.59	5.29 ± 0.50*	1.28 ± 0.31	2.14 ± 0.36
Overall	4.62 ± 0.18	4.80 ± 0.23	0.03 ± 0.01	0.01 ± 0.01	3.66 ± 0.21	3.55 ± 0.19	1.39 ± 0.15	1.62 ± 0.16

*Significantly different from the corresponding value for the hens fed once a day (*P* ≤ 0.05).

¹Values are means ± SEM, n = 15 replicate pens of 35 hens each for both feeding treatments. Ninety eggs from each replicate pen were incubated for each age period. Embryo mortality was classified as early dead (less than 7 d), mid dead (7 to 14 d), or late dead (15 to 21 d of incubation). Pips included both live and dead pips at the time of hatch.

activity associated with receiving feed twice a day promoted the production of fewer floor eggs, which are also typically more prone to becoming dirty. Both the female feeder pans and nest boxes were located in the slat area of our pens; thus, the hens on the twice-a-day feeding treatment may have spent more time on the slats than the hens on the once-a-day feeding treatment. Providing feed in the afternoon did not appear to interfere with mating behavior because egg fertility was not different between the hens fed once or twice a day. Finally, the proportion of total eggs produced before and after 1500 h was equivalent for both treatments (data not shown), so the additional afternoon feeding did not dramatically shift the timing of oviposition.

In summary, feeding broiler breeder hens twice a day improved the total number of eggs produced per hen through 42 wk of age and the overall percentage of hen-day egg production through 59 wk of age. However, these gains in egg production were lost on a hen-housed basis because of the significantly higher level of mortality associated with feeding broiler breeder hens twice a day after photostimulation for reproduction through 59 wk of age. Feeding broiler breeder hens twice a day increased egg weight without compromising shell quality, increased the production of hatching eggs, decreased the production of dirty eggs, and had no effect on fertility. However, in light of the increased mortality observed in hens fed twice a day, further research with different strains of broiler breeder hens is needed before a definitive recommendation on the utility of feeding broiler breeder hens twice a day can be made.

REFERENCES

- Agri Stats Inc. 2007. Live Production Analysis Manual. Agri Stats Inc., Fort Wayne, IN.
- Brake, J., and E. D. Peebles. 1986. Effect of strain and time of day of feeding on reproductive performance and shell quality of broiler breeders. *Poult. Sci.* 65:156. (Abstract)
- Bruggeman, V., O. Onagbesan, E. D'Hondt, N. Buys, M. Safi, D. Vanmontfort, L. Berghman, F. Vandesande, and E. Decuyper. 1999. Effects of timing and duration of feed restriction during rearing on reproductive characteristics in broiler breeder females. *Poult. Sci.* 78:1424–1434.
- Bruggeman, V., O. Onagbesan, O. Ragot, S. Metayer, S. Cassy, F. Favreau, Y. Jego, J. J. Trevidy, K. Tona, J. Williams, E. Decuyper, and M. Picard. 2005. Feed allowance-genotype interactions in broiler breeder hens. *Poult. Sci.* 84:298–306.
- Cave, N. A. 1981. Effect of diurnal programs of nutrient intake on the performance of broiler breeder hens. *Poult. Sci.* 60:1287–1292.
- Cobb-Vantress Inc. 2005a. Cobb 500 slow feather breeder management supplement. Cobb-Vantress Inc., Siloam Springs, AR.
- Cobb-Vantress Inc. 2005b. Cobb breeder management guide. Cobb-Vantress Inc., Siloam Springs, AR.
- Dale, N. M. 2001. Feedstuffs ingredient analysis table. *Feedstuffs* 73:28–37.
- de Avila, V. S., A. M. Penz Jr., P. A. R. de Brum, P. S. Rosa, A. L. Guidoni, and E. A. P. de Figueiredo. 2003a. Performance of female broiler breeders submitted to different feeding schedules. *Braz. J. Poult. Sci.* 5:197–202.
- de Avila, V. S., A. M. Penz Jr., P. S. Rosa, P. A. R. de Brum, A. L. Guidoni, and M. C. Ledur. 2003b. Influence of feeding time on sexual maturity and carcass composition in female broiler breeders. *Braz. J. Poult. Sci.* 5:189–196.
- Farmer, M., D. A. Roland Sr., and M. K. Eckman. 1983. Calcium metabolism in broiler breeder hens. 2. The influence of the time of feeding on calcium status of the digestive system and egg shell quality in broiler breeders. *Poult. Sci.* 62:465–471.
- Fattori, T. R., H. R. Wilson, R. H. Harms, and R. D. Miles. 1991. Response of broiler breeder females to feed restriction below recommended levels. 1. Growth and reproductive performance. *Poult. Sci.* 70:26–36.
- Heck, A., O. Onagbesan, K. Tona, S. Metayer, J. Putterflam, Y. Jego, J. J. Trevidy, E. Decuyper, J. Williams, M. Picard, and V. Bruggeman. 2004. Effects of ad libitum feeding on performance of different strains of broiler breeders. *Br. Poult. Sci.* 45:695–703.
- Hocking, P. M., A. B. Gilbert, M. Walker, and D. Waddington. 1987. Ovarian follicular structure of White Leghorns fed ad libitum and dwarf and normal broiler breeders fed ad libitum or restricted until point of lay. *Br. Poult. Sci.* 28:493–506.
- Hocking, P. M., and G. W. Robertson. 2005. Limited effect of intense genetic selection for broiler traits on ovarian function and follicular sensitivity in broiler breeders at the onset of lay. *Br. Poult. Sci.* 46:354–360.
- Hocking, P. M., D. Waddington, M. A. Walker, and A. B. Gilbert. 1989. Control of the development of the ovarian follicular hierarchy in broiler breeder pullets by food restriction during rearing. *Br. Poult. Sci.* 30:161–173.
- Hudson, B. P., W. A. Dozier III, J. L. Wilson, J. E. Sander, and T. L. Ward. 2004. Reproductive performance and immune status of caged broiler breeder hens provided diets supplemented with either inorganic or organic sources of zinc from hatching to 65 wk of age. *J. Appl. Poult. Res.* 13:349–359.
- Katanbaf, M. N., E. A. Dunnington, and P. B. Siegel. 1989. Restricted feeding in early and late-feathering chickens. 1. Growth and physiological responses. *Poult. Sci.* 68:344–351.
- Morris, T. R., and A. V. Nalbandov. 1961. The induction of ovulation in starving pullets using mammalian and avian gonadotropins. *Endocrinology* 68:687–697.
- Neter, J., W. Wassermann, and M. H. Kutner. 1990. Pages 519–561 in *Applied Linear Statistical Models*. 3rd ed. Richard D. Irwin Inc., Boston, MA.
- Onagbesan, O. M., S. Metayer, K. Tona, J. Williams, E. Decuyper, and V. Bruggeman. 2006. Effects of genotype and feed allowance on plasma luteinizing hormones, follicle-stimulating hormones, progesterone, estradiol levels, follicle differentiation, and egg production rates of broiler breeder hens. *Poult. Sci.* 85:1245–1258.
- Phillips, R. E., and C. S. Williams. 1943. Relationship of specific gravity and shell appearance to the hatchability of fertile turkey eggs. *Poult. Sci.* 23:110–113.
- Robbins, K. R., G. C. McGhee, P. Osei, and R. E. Beauchene. 1986. Effect of feed restriction on growth, body composition, and egg production of broiler females through 68 weeks of age. *Poult. Sci.* 65:2226–2231.
- Robinson, F. E., N. E. Robinson, and T. A. Scott. 1991. Reproductive performance, growth rate and body composition of full-fed versus feed-restricted broiler breeder hens. *Can. J. Anim. Sci.* 71:549–556.
- Scanes, C. G., S. Harvey, and A. Chadwick. 1976. Plasma luteinizing hormone and follicle stimulating hormone concentration in fasted immature male chickens. *IRCS Med. Sci.* 4:371.
- Tanabe, Y., T. Ogawa, and T. Nakamura. 1981. The effect of short-term starvation on pituitary and plasma LH, plasma estradiol and progesterone, and on pituitary response to LH-RH in the laying hen (*Gallus domesticus*). *Gen. Comp. Endocrinol.* 43:392–398.
- Yu, M. W., F. E. Robinson, R. G. Charles, and R. Weingardt. 1992. Effect of feed allowance during rearing and breeding on female broiler breeders. 2. Ovarian morphology and production. *Poult. Sci.* 71:1750–1761.