

ENVIRONMENT, WELL-BEING, AND BEHAVIOR

Effect of feeder space during the growing and laying periods and the rate of feed increase at the onset of lay on broiler breeder female reproductive function^{1,2}

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ABSTRACT A study was conducted to examine how 2 feeder space allocations during the rearing period followed by 2 feeder space allocations after photostimulation and 2 female feeding to peak programs (fast or slow) affected female broiler breeder reproductive performance and mortality. Sixteen pens of 76 breeder females each were equipped with either 4 tube feeders with a 132 cm circumference pan (7.0 cm/female) or 6 feeders (10.4 cm/female) to 21 wk of age. Thereafter, 64 females were moved to breeding pens, photostimulated, and fed sex-separate from either 3 (6.2 cm/female) or 5 (10.3 cm/female) feeders with either fast or slow feeding to peak feeding programs applied to complete a 2 × 2 × 2 factorial design. Seven males that were separately reared in a similar manner were added per pen. Individual female BW was determined at 6, 20, and 32 wk of age and BW uniformity assessed. Greater feeder space during rearing increased BW at 32 wk of age, whereas greater feeder space during lay or slow feeding to peak decreased BW at 32 wk. There were no differences in BW uniformity. Hens from the 10.4 to 10.3 cm/female

combination produced a significantly greater number of eggs as compared with the 7.0 to 10.3 cm/female and 10.4 to 6.2 cm/female combinations with the 7.0 to 6.2 cm/female combination intermediate. Percentage hen-day egg production of the 10.4 to 10.3 cm/female combination hens was significantly greater than all other combinations. Livability was improved in the 10.4 to 10.3 cm/female combination relative to the 7.0 to 10.3 cm/female combination with the others intermediate. The fast feeding to peak program increased yolk weight as well as yolk:albumen ratio at 28 and 30 wk of age, but egg weight did not differ. These data indicated that increased or decreased feeder space between the growing and laying periods did not affect broiler breeder female BW, uniformity, egg weight, fertility, or hatchability. The 10.3 cm/female laying feeder space exhibited the best hen-day egg production in combination with 10.4 cm/pullet rearing but not with 7.0 cm/pullet rearing space. In a similar manner, hen mortality was greater in the 7.0 to 10.3 cm/female feeder space combination than the 10.4 to 10.3 cm/female combination.

Key words: broiler breeder, feeder space, uniformity, body weight, egg production

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INTRODUCTION

Historically, the brood-grow-lay housing system in which broiler breeders reside for 65 wk in a single facility has been popular internationally, whereas the brood-grow and lay housing system in which broiler breeders are moved from growing quarters to laying

quarters and photostimulated at about 21 wk of age has been popular in the United States. Even though the US system has economic advantages due to the fewer total houses required, production results have been generally acknowledged among industry personnel to favor the brood-grow-lay system. One difference between the brood-grow-lay and brood-grow and lay systems has been the difference in feeding systems and feeder space in the growing versus laying houses. Many of the primary breeder management guide programs have suggested that feeder space sufficient to ensure that all birds have access to the feed at the same time was a critical point and that feeder space should increase as the birds age (Hubbard Farms, 1986). Furthermore, inadequate feeder space has been generally associated with poor uniformity of flock BW (Hubbard Farms, 1997, 2009), but a controlled study found that significantly reduced feeder space had no effect

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²The use of trade names in this publication does not imply endorsement of the products mentioned nor criticism of similar products not mentioned.

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Table 1. Composition of starter (1 to 6 wk), grower (7 to 25 wk), and breeder (26 to 64 wk) diets

Item	Starter diet	Grower diet	Breeder diet
Ingredient (%)			
Corn	64.30	65.49	66.73
Soybean meal (48% CP)	22.17	16.53	19.17
Wheat bran	7.98	12.61	3.00
Dicalcium phosphate	2.04	1.99	1.70
Limestone	1.13	1.02	5.94
Mineral premix ¹	0.20	0.20	0.20
Vitamin premix ²	0.10	0.10	0.10
Salt	0.63	0.64	0.50
Coccidiostat (Amprol)	0.05	0.05	0.05
D,L-Methionine	0.07	0.04	0.06
Selenium premix	0.10	0.10	0.10
Lysine HCl	—	0.01	—
Choline chloride	0.20	0.20	0.20
Poultry fat	1.00	1.00	2.23
Antibiotic	0.03	0.03	0.03
Totals	100.00	100.00	100.00
Calculated analysis ³			
CP (%)	17.00	15.00	15.00
ME (kcal/g)	2.93	2.93	2.93
Lysine (%)	0.88	0.75	0.77
Methionine + cysteine (%)	0.71	0.63	0.63
Calcium (%)	0.95	0.90	2.70
Available phosphorus (%)	0.45	0.45	0.40

¹Mineral premix contained the following per kilogram of diet: manganese, 120 mg; zinc, 120 mg; iron, 80 mg; copper, 10 mg; iodine, 2.5 mg; and cobalt, 1.0 mg.

²Vitamin premix contained the following per kilogram of diet: vitamin A, 13,200 IU; cholecalciferol, 4,000 IU; vitamin E, 66 IU; vitamin B₁₂, 34.6 µg; riboflavin, 13.2 mg; niacin, 110 mg; pantothenic acid, 22 mg; vitamin K, 4 mg; folic acid, 2.2 mg; thiamine, 4 mg; pyridoxine, 8 mg; and biotin, 252 µg.

³Data presented on an as-is basis.

on BW uniformity (Van Krey and Weaver, 1988). Furthermore, our preliminary studies with 24-wk-old males with an increased feeder space produced a poorer CV for feed consumption when compared with males with less feeder space (40.58 and 20.45% CV, respectively; unpublished data). This was interpreted to mean that an increase in feeder space at moving and photostimulation was not necessarily good because it could reduce the uniformity of feed consumption that might lead to poorer hen performance.

The ovary and oviduct develop rapidly during the time of sexual maturation that follows movement to the laying quarters and photostimulation. The increment of the ovary and oviduct was reported to be several thousand percent in only a few weeks at sexual maturity (Breneman, 1956). Both the ovary and oviduct organs have been shown to be sensitive to the feed allocation program at the time of photostimulation during sexual maturation. According to Zuidhof et al. (2007), the growth and development of the oviduct can be very responsive to feed allocation during sexual maturation. Overfeeding during reproductive development has been found to increase the formation of large yellow ovarian follicles, which are more likely to be arranged in multiple hierarchies of large follicles (Hocking et al., 1987; Katanbaf et al., 1989; Yu et al., 1992). Overfeeding for as little as 2 wk between photostimulation and

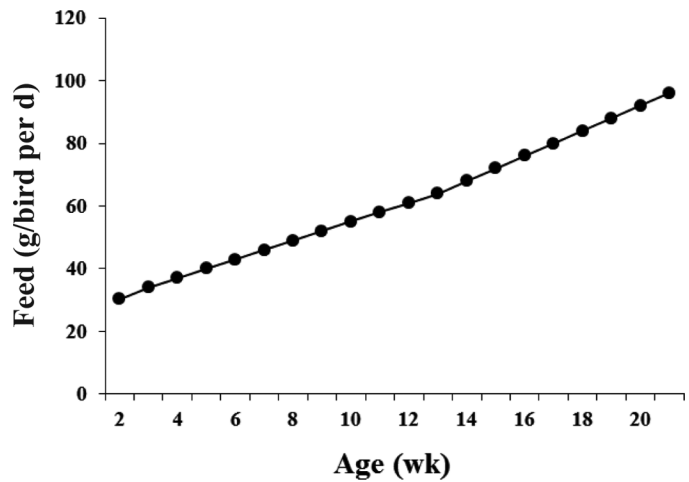


Figure 1. Ross 708SF pullets received feed according to this feeding program from placement to 21 wk of age. The figure shows the daily feeding amounts from which the 4/3 restricted feeding amounts were calculated. Pullets were fed from 3 wk of age on Monday, Wednesday, Friday, and Saturday each week until 21 wk of age when they were moved to the laying house.

peak egg production has been reported to permanently decrease fertility and hatchability (Ingram and Wilson, 1987). This study was conducted to examine how 2 feeder space allocations during rearing and 2 feeder space allocations during laying in combination with 2 feed increase rates from photostimulation to peak egg production affected broiler breeder female performance.

MATERIALS AND METHODS

Broiler Breeder Rearing Period

Broiler breeder males (Ross 344) and females (Ross 708SF) were placed in an enclosed fan-ventilated 32-pen litter floor rearing house with 16 (14.3 m² area)

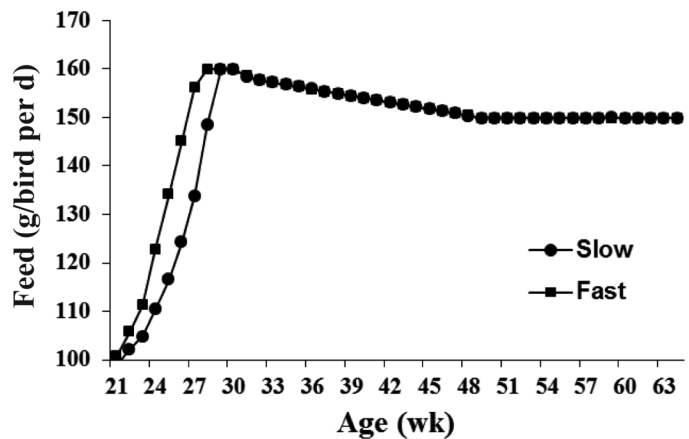


Figure 2. Ross 708SF hens received restricted feed amounts daily according to these 2 feeding to peak programs. Either a fast feed to peak program from 21 to 28 wk of age or a slow feed to peak program from 21 to 29 wk of age was employed. All the hens received the same feed rate previously (Figure 1) and thereafter as shown above. Squares represent the fast feeding to peak program, and circles represent the slow feeding to peak program.

pens for females and 16 (4.56 m² area) pens for males. At placement, there were 76 females and 25 males in each female and male pen, respectively. There were either 4 or 6 tube feeders (Kuhl DH-4) per female rearing pen as well as 1 tube feeder per male rearing pen. Each feeder pan had a circumference of 132 cm. Pens were equally divided among feeder space treatments. After 23 h of light per day for 1 wk all birds were reared to 21 wk of age with 8 h of light per day at an average light intensity of 15 lx using 12 W fluorescent lamps. Access to water was limited by a time clock and solenoid system sufficient to control litter moisture and allow the birds to have unlimited access to water until at least 2 h after all feed was consumed and a similar amount on nonfeed days during rearing. This was typically 6 h daily. Individual female and male BW was taken at 6 and 20 wk of age.

Broiler Breeder Production Period

There were 64 females and 7 males moved as groups from each rearing pen to each of 16 slat-litter floor laying pens (17.52 m² total area/pen, 4.60 m² litter area/

pen) at 21 wk of age and photostimulated with 14 h of light at movement to the breeder house. The day length was subsequently increased to 15 h 7 d later, and then to 15.5 h and 16 h at 5 and 50% rate of lay, respectively. Natural light entered the slat-litter house through open or translucent curtains during normal daylight hours. Supplemental light provided an average intensity of 35 lx at bird head level using 18 W fluorescent lamps when natural light was not present. There were either 3 or 5 feeders for females and a single feeder for males in each laying pen. Pens were equally divided among female feeder space treatments. Water was provided for 8 h per day during the laying period using 2 bell-type drinkers in each of the 16 breeding pens. One 6-hole (50.8 cm double-wide nest spaces) conventional nest was provided in each breeding pen. Separation of sexes was ensured by special grills (sixteen 48 × 58 mm holes per pan) on each female feeder that prevented the non-dubbed males from accessing the feed, which allowed all males to be fed in a similar and female-independent manner during the laying period as had been the case during the growing period. Individual female BW was taken at 32 wk of age. At 28 and 30 wk of age, 458 and

Table 2. Broiler breeder female BW as affected by broiler breeder female feeder space allocation during growing and laying periods, and feed increase rate from photostimulation to peak egg production, as well as interactions among these factors

Feeder space/female		Peak feed increase ¹	BW (kg)		
Growing ² (cm)	Laying ³ (cm)		6 wk of age	20 wk of age	32 wk of age
7.0			0.789	2.263	3.463
10.4			0.800	2.263	3.507
<i>P</i> -value			0.525	0.981	0.072
	6.2		0.791	2.277	3.512 ^a
	10.3		0.798	2.250	3.458 ^b
<i>P</i> -value			0.685	0.128	0.033
		Fast	0.794	2.258	3.539 ^A
		Slow	0.796	2.269	3.432 ^B
SEM			0.035 ⁴	0.024 ⁴	0.021 ⁵
<i>P</i> -value			0.920	0.505	0.009
7.0	6.2		0.803	2.279	3.483
7.0	10.3		0.776	2.247	3.444
10.4	6.2		0.793	2.274	3.542
10.4	10.3		0.807	2.253	3.472
<i>P</i> -value			0.231	0.754	0.486
7.0		Fast	0.786	2.255	3.531
7.0		Slow	0.794	2.271	3.395
10.4		Fast	0.803	2.261	3.546
10.4		Slow	0.798	2.266	3.468
<i>P</i> -value			0.690	0.725	0.200
	6.2	Fast	0.795	2.272	3.575
	6.2	Slow	0.802	2.281	3.449
	10.3	Fast	0.794	2.244	3.502
	10.3	Slow	0.790	2.256	3.414
SEM			0.046 ⁶	0.031 ⁶	0.029 ⁷
<i>P</i> -value			0.749	0.942	0.397

^{a,b}Means in a column that possess different superscripts differ significantly ($P \leq 0.05$).

^{A,B}Means in a column that possess different superscripts differ significantly ($P \leq 0.01$).

¹Feed increase rates (see Figure 2) from photostimulation to peak egg production.

²Feeder space allocations of 7.0 or 10.4 cm per each of 76 pullets during growing.

³Feeder space allocations of 6.2 or 10.3 cm per each of 64 hens during laying.

⁴SEM for $n = 8$ pens with 76 pullets weighed individually per pen.

⁵SEM for $n = 8$ pens with 64 hens weighed individually per pen.

⁶SEM for $n = 4$ pens with 76 pullets weighed individually per pen.

⁷SEM for $n = 4$ pens with 64 hens weighed individually per pen.

Table 3. Coefficient of variation of broiler breeder female BW as affected by broiler breeder female feeder space allocation during growing and laying periods, and feed increase rate from photostimulation to peak egg production, as well as interactions among these factors

Feeder space/female			CV (%)		
Growing ² (cm)	Laying ³ (cm)	Peak feed increase ¹	6 wk of age	20 wk of age	32 wk of age
7.0			13.40	13.39	9.57
10.4			14.36	14.57	9.41
<i>P</i> -value			0.249	0.292	0.853
	6.2		13.80	14.24	9.60
	10.3		13.95	13.72	9.39
<i>P</i> -value			0.878	0.684	0.805
		Fast	13.58	13.98	9.31
		Slow	14.17	13.98	9.68
SEM			0.58 ⁴	0.74 ⁴	0.59 ⁵
<i>P</i> -value			0.449	0.999	0.665
7.0	6.2		13.02	13.73	9.81
7.0	10.3		13.77	13.06	9.33
10.4	6.2		14.58	14.75	9.39
10.4	10.3		14.13	14.39	9.44
<i>P</i> -value			0.559	0.885	0.755
7.0		Fast	13.10	13.65	9.20
7.0		Slow	13.69	13.14	9.95
10.4		Fast	14.06	14.31	9.41
10.4		Slow	14.65	14.82	9.42
<i>P</i> -value			0.962	0.638	0.666
	6.2	Fast	13.39	14.53	9.19
	6.2	Slow	14.21	13.95	10.01
	10.3	Fast	13.77	13.43	9.42
	10.3	Slow	14.13	14.01	9.35
SEM			0.82 ⁶	1.04 ⁶	0.83 ⁷
<i>P</i> -value			0.824	0.595	0.608

¹Feed increase rates (see Figure 2) from photostimulation to peak egg production.

²Feeder space allocations of 7.0 or 10.4 cm per each of 76 pullets during growing.

³Feeder space allocations of 6.2 or 10.3 cm per each of 64 hens during laying.

⁴SEM for n = 8 pens with 76 pullets per pen weighed and CV calculated on a pen basis.

⁵SEM for n = 8 pens with 64 pullets per pen weighed and CV calculated on a pen basis.

⁶SEM for n = 4 pens with 76 pullets per pen weighed and CV calculated on a pen basis.

⁷SEM for n = 4 pens with 64 pullets per pen weighed and CV calculated on a pen basis.

635 individual eggs, respectively, were collected and egg weight (**EW**) as well as yolk and albumen weight were determined gravimetrically. The contents were then removed and shells dried to constant weight, which indicated that all moisture had been removed, before cooling to room temperature. The shells were then weighed.

Fertility and Hatchability

Eggs were collected twice daily from the nests and stored in an egg cooler at 16 to 18°C and 60% RH until incubated. Analysis of percentage fertility, hatchability, and embryo mortality was conducted from 26 to 63 wk of age by macroscopic examination of all unhatched eggs from weekly sets of 60 eggs per pen. All unhatched eggs were opened and examined macroscopically to determine fertility or infertility, and if fertile, to determine the stage of embryonic mortality. Embryos that died from 1 to 7 d of incubation were termed early dead, and embryos that died after 7 d were termed late dead because very few mortalities between 8 and 14 d were observed. Eggs were set in a Jamesway model 252B incubator (Butler Manufacturing Co., Ft. Atkinson, WI).

Experimental Diets and Feeding Programs

Feed was provided daily during the first 3 wk of age and then a 4/3 restricted feed allocation program (feed Monday, Wednesday, Friday, and Saturday only) was used until 21 wk of age (Figure 1) after which a daily feeding program was employed. Diets are shown in Table 1. A common starter diet (17% CP) was fed to all pens for 6 wk followed by a common grower diet (15% CP) from 7 to 25 wk (approximately 15% rate of lay). Females received a calculated 25.1 Mcal of ME and 1,349 g of CP cumulative nutrient intake, and males received approximately 30 Mcal of ME and 1,600 g of CP cumulative nutrient intake to photostimulation at 21 wk (147 d) of age. Two daily feed increase rates (fast or slow) were then used from photostimulation to peak egg production (Figure 2). The females that received the fast feed increase rate reached the peak feed rate of 160 g per female per day at 83% rate of lay (28 wk of age), whereas the slow feed increase rate reached the same peak feed rate 7 d later at 84% rate of lay. The feed allocation was then reduced once egg production across both treatments was similar for 5 d. The daily feed allocation was the same for all females thereafter.

Table 4. Egg weight (EW), percentage egg components, and yolk:albumen ratio at 28 wk of age as affected by broiler breeder female feeder space allocation during growing and laying periods, and feed increase rate from photostimulation to peak egg production, as well as interactions among these factors

Feeder space/female		Peak feed increase ¹	Egg weight (EW; g)	Yolk weight (% of EW)	Egg shell (% of EW)	Albumen (% of EW)	Yolk:albumen ratio (g:g)
Growing ² (cm)	Laying ³ (cm)						
7.0			51.79	26.75	9.48	63.77	0.42
10.4			51.71	26.73	9.52	63.74	0.42
<i>P</i> -value			0.805	0.930	0.275	0.884	0.99
	6.2		51.90	26.79	9.40 ^B	63.80	0.42
	10.3		51.60	26.69	9.61 ^A	63.71	0.42
<i>P</i> -value			0.350	0.559	0.001	0.565	0.811
		Fast	51.80	26.99 ^a	9.51	63.49 ^b	0.43 ^a
		Slow	51.70	26.49 ^b	9.50	64.02 ^a	0.41 ^b
<i>P</i> -value			0.745	0.019	0.642	0.013	0.017
SEM ⁴			0.22	0.12	0.02	0.12	0.01
7.0	6.2		51.62	26.98	9.40	63.62 ^{ab}	0.43
7.0	10.3		51.96	26.52	9.56	63.92 ^{ab}	0.42
10.4	6.2		52.19	26.61	9.40	63.99 ^a	0.42
10.4	10.3		51.23	26.85	9.65	63.50 ^b	0.43
<i>P</i> -value			0.067	0.078	0.216	0.044	0.074
7.0		Fast	52.04	26.91	9.53 ^{ab}	63.55	0.43
7.0		Slow	51.54	26.58	9.43 ^b	63.98	0.42
10.4		Fast	51.57	27.07	9.49 ^b	63.44	0.43
10.4		Slow	51.86	26.39	9.56 ^a	64.05	0.41
<i>P</i> -value			0.237	0.340	0.041	0.598	0.436
	6.2	Fast	52.17	27.02	9.39	63.59	0.43
	6.2	Slow	51.63	26.56	9.42	64.02	0.42
	10.3	Fast	51.43	26.96	9.64	63.40	0.43
	10.3	Slow	51.77	26.41	9.58	64.01	0.41
<i>P</i> -value			0.193	0.802	0.234	0.603	0.764
SEM ⁵			0.31	0.17	0.03	0.17	0.02

^{a,b}Means in a column that possess different superscripts differ significantly ($P \leq 0.05$).

^{A,B}Means in a column that possess different superscripts differ significantly ($P \leq 0.01$).

¹Feed increase rates (see Figure 2) from photostimulation to peak egg production.

²Feeder space allocations of 7.0 or 10.4 cm per each of 76 pullets during growing.

³Feeder space allocations of 6.2 or 10.3 cm per each of 64 hens during laying.

⁴SEM for $n = 8$ pens with mean of approximately 30 eggs weighed per pen.

⁵SEM for $n = 4$ pens with mean of approximately 30 eggs weighed per pen.

Male and female mortality was recorded daily and feed allocation adjusted accordingly.

Statistical Analyses

A completely randomized design with a factorial ($2 \times 2 \times 2$) arrangement of treatments was used. The main factors were feeder space allocation during rearing (7.0 or 10.4 cm/female), feeder space allocation during production (6.2 or 10.3 cm/female), and feed increase rate (fast or slow) from photostimulation to peak. The treatment combinations were randomly distributed among 16 pens with 2 replicate pens per interaction cell. The GLM procedure of SAS Institute (2001) was used to analyze the continuous variables. Percentage data were subjected to arcsin transformation before analysis. The fertility data were analyzed as categorical data, where each individual egg was taken as a binomial event, either fertile or infertile, using the general model (GENMOD) procedure of SAS Institute (2001). Means were partitioned using LS MEANS, and statements of statistical significance were based upon $P \leq 0.05$ unless otherwise stated.

RESULTS

Female BW at 32 wk of age was affected by laying feeder space, and peak feed increase rate where females from the 6.2 cm/hen laying allocation and fast feed increase rate ($P < 0.01$) were significantly heavier, respectively. There were no significant interactions found (Table 2). There were no significant main effects or interactions found with respect to broiler breeder female CV of individual BW at 6, 20, and 32 wk of age (Table 3). At 28 wk of age, percentage shell was increased ($P < 0.01$) by 10.3 cm/hen of laying feeder space. Percentage yolk, percentage albumen, and yolk:albumen ratio were significantly affected by feed increase rate as the yolk and yolk:albumen ratio from hens subject to the fast feed increase rate were significantly greater, but percentage albumen was significantly reduced. Percentage albumen was affected by the growing feeder space by laying feeder space interaction where percentage albumen from the 10.4 to 6.2 cm/female combination hens was significantly greater than from the 10.4 to 10.3 cm/female combination, whereas the 7.0 to 6.2 cm/female and the 7.0 to 10.3 cm/female combinations

Table 5. Egg weight (EW) percentage egg components and yolk:albumen ratio at 30 wk of age as affected by broiler breeder female feeder space allocation during growing and laying periods, and feed increase rate from photostimulation to peak egg production, as well as interactions among these factors

Feeder space/female		Peak feed increase ¹	EW (g)	Yolk weight (% of EW)	Egg shell (% of EW)	Albumen (% of EW)	Yolk:albumen ratio (g:g)
Growing ² (cm)	Laying ³ (cm)						
7.0			54.84	28.03	9.24	62.73	0.45
10.4			54.98	27.86	9.16	62.98	0.44
<i>P</i> -value			0.761	0.350	0.127	0.202	0.38
	6.2		55.01	27.91	9.19	62.90	0.45
	10.3		54.80	27.97	9.22	62.81	0.45
<i>P</i> -value			0.638	0.714	0.585	0.624	0.787
		Fast	55.10	28.24 ^A	9.16	62.60 ^b	0.45 ^A
		Slow	54.72	27.64 ^B	9.25	63.11 ^a	0.44 ^B
SEM ⁴			0.30	0.12	0.03	0.12	0.01
<i>P</i> -value			0.404	0.007	0.084	0.020	0.005
7.0	6.2		54.60	28.23 ^a	9.25	62.52 ^b	0.45 ^a
7.0	10.3		55.08	27.82 ^{ab}	9.23	62.94 ^{ab}	0.44 ^{ab}
10.4	6.2		55.43	27.60 ^b	9.13	63.28 ^a	0.44 ^b
10.4	10.3		54.52	28.13 ^{ab}	9.20	62.68 ^b	0.45 ^{ab}
<i>P</i> -value			0.143	0.022	0.394	0.020	0.022
7.0		Fast	55.13	28.36	9.17	62.47	0.46
7.0		Slow	54.55	27.69	9.31	63.00	0.44
10.4		Fast	55.06	28.13	9.14	62.73	0.45
10.4		Slow	54.89	27.59	9.19	63.22	0.44
<i>P</i> -value			0.638	0.716	0.368	0.920	0.928
	6.2	Fast	55.35	28.20	9.19	62.61	0.45
	6.2	Slow	54.68	27.63	9.18	63.19	0.44
	10.3	Fast	54.85	28.29	9.12	62.59	0.45
	10.3	Slow	54.76	27.66	9.31	63.03	0.44
SEM ⁵			0.43	0.17	0.05	0.18	0.02
<i>P</i> -value			0.522	0.716	0.064	0.687	0.703

^{a,b}Means in a column that possess different superscripts differ significantly ($P \leq 0.05$).

^{A,B}Means in a column that possess different superscripts differ significantly ($P \leq 0.01$).

¹Feed increase rates (see Figure 2) from photostimulation to peak egg production.

²Feeder space allocations 7.0 or 10.4 cm per each of 76 pullets during growing.

³Feeder space allocations 6.2 or 10.3 cm per each of 64 hens during laying.

⁴SEM for $n = 8$ pens with mean of approximately 40 eggs weighed per pen.

⁵SEM for $n = 4$ pens with mean of approximately 40 eggs weighed per pen.

were intermediate. Percentage shell was affected by the growing feeder space by feed increase rate interaction where percentage shell from the 10.4 cm/pullet by slow feed increase rate combination hens was significantly greater than those of the 7.0 cm/pullet by slow feed increase rate and the 10.4 cm/pullet by fast feed increase rate combination, whereas the 7.0 cm/pullet by fast feed increase rate combination was intermediate. No significant effects due to the growing feeder space or laying feeder space by feed increase rate interaction were found (Table 4). At 30 wk of age, the percentage yolk and the yolk:albumen ratio from fast feed increase rate hens were significantly ($P < 0.01$) greater, but percentage albumen was significantly less due to feed increase rate. Percentage yolk and the yolk:albumen ratio from the 7.0 to 6.2 cm/female combination hens were both significantly greater than that of the 10.4 to 6.2 cm/female combination with the 7.0 to 10.3 cm/female, and the 10.4 to 10.3 cm/female combination hens were intermediate. Percentage albumen from the 10.4 to 6.2 cm/female combination hens was significantly greater than from the 7.0 to 6.2 cm/female and 10.4 to 10.3 cm/female combination hens with the 7.0 to 10.3 group intermediate. There were no significant effects due to growing feeder space, laying feeder space, the growing

feeder space by feed increase rate interaction, and the laying feeder space by feed increase rate interaction (Table 5). Hen-day egg production was increased by the 10.3 cm/hen laying feeder space compared with the 6.2 cm/hen feeder space. Eggs per hen housed, hen-day egg production, and female mortality were affected by the growing feeder space by laying feeder space interaction. Hens from the 10.4 to 10.3 cm/female combination produced a significantly greater number of eggs compared with the 7.0 to 10.3 cm/female and 10.4 to 6.2 cm/female combinations with the 7.0 to 6.2 cm/female combination intermediate. Percentage hen-day egg production of the 10.4 to 10.3 cm/female combination hens was significantly ($P < 0.01$) greater than that of all other feeder space combinations. Female mortality of the 7.0 to 10.3 cm/female feeder space combination hens was significantly greater than of the 10.4 to 10.3 cm/female combination hens, whereas the 7.0 to 6.2 cm/female and the 10.4 to 6.2 cm/female combination hens were intermediate. There were no significant effects found due to growing feeder space, feed increase rate, the growing feeder space by feed increase rate interaction, or the laying feeder space by feed increase rate interaction (Table 6). There were no significant main effects or interactions found concerning broiler

Table 6. Broiler breeder egg production and female mortality from 24 to 64 wk as affected by broiler breeder female feeder space allocation during growing and laying periods, and feed increase rate from photostimulation to peak egg production, as well as interactions among these factors

Feeder space/female			Egg production		
Growing ² (cm)	Laying ³ (cm)	Peak feed increase ¹	Eggs per hen housed (n)	Hen-day production (%)	Female mortality (%)
7.0			172	62.3	8.8
10.4			175	63.2	7.8
<i>P</i> -value			0.326	0.077	0.525
	6.2		172	62.2 ^b	8.2
	10.3		175	63.3 ^a	8.4
<i>P</i> -value			0.195	0.037	0.525
		Fast	173	62.7	9.0
		Slow	174	62.8	7.6
SEM ⁴			2.4	0.7	1.3
<i>P</i> -value			0.922	0.741	0.382
7.0	6.2		175 ^{AB}	62.9 ^B	6.6 ^{ab}
7.0	10.3		169 ^B	61.7 ^B	10.9 ^a
10.4	6.2		168 ^B	61.5 ^B	9.8 ^{ab}
10.4	10.3		181 ^A	65.0 ^A	5.9 ^b
<i>P</i> -value			0.004	0.001	0.024
7.0		Fast	171	62.2	10.9
7.0		Slow	173	62.4	6.6
10.4		Fast	176	63.1	7.0
10.4		Slow	174	63.3	8.6
<i>P</i> -value			0.440	0.951	0.083
	6.2	Fast	172	62.6	9.8
	6.2	Slow	171	61.8	6.6
	10.3	Fast	174	62.8	8.2
	10.3	Slow	176	63.9	8.6
SEM ⁵			3.4	0.9	1.8
<i>P</i> -value			0.583	0.070	0.270

^{a,b}Means in columns that possess different superscripts differ significantly ($P \leq 0.05$).

^{A,B}Means in columns that possess different superscripts differ significantly ($P \leq 0.01$).

¹Feed increase rates (see Figure 2) from photostimulation to peak egg production.

²Feeder space allocations of 7.0 or 10.4 cm per each of 76 pullets during growing.

³Feeder space allocations of 6.2 or 10.3 cm per each of 64 hens during laying.

⁴SEM for $n = 8$ pens of 64 hens per pen.

⁵SEM for $n = 4$ pens of 64 hens per pen.

breeder fertility, hatchability of fertile eggs, hatchability of total eggs, and embryonic mortality from 26 to 63 wk of age (Table 7).

DISCUSSION

It was interesting that broiler breeder hens from the less crowded feeder space during laying and fast feeding to peak program were heavier at 32 wk (Table 2). However, there were no differences in BW uniformity due to feeder space during either rearing or laying periods. This was in agreement with previous data (Van Krey and Weaver, 1988). The feed increase from photostimulation to peak egg production and feeder space program also had no effect on BW uniformity. This may be because all birds were ready to respond to photostimulation when moved to the laying house at the end of the 21 wk on the adequate cumulative rearing program employed in this study. As Renema et al. (2007) stated, delaying photostimulation from 18 to 22 wk of age, regardless of the strain, improved the uniformity of sexual maturation and was a good breeder management tool to achieve uniform onset of lay. This may simply be related to cumulative feed in rearing (Bruggeman et al., 2005). Adequate amounts of feed during the rear-

ing period supplied minimum recommended cumulative nutrient intakes as previously suggested (Peak, 1996; Walsh and Brake, 1997; Peak, 2001). Breeder hens that were given the most similar feeder space (10.4 to 10.3 cm/female) between the rearing and laying periods produced the most eggs as well as exhibited the greatest hen-day egg production with the least mortality. Hens from the small decrease in feeder space (7.0 to 6.2 cm/female) between the rearing and laying periods were the next best egg production group, whereas hens from the increased (7.0 to 10.3 cm/female) or decreased (10.4 to 6.2 cm/female) feeder space combinations produced equally poor egg production. It was noteworthy that the increased feeder space combination, as would normally be employed in much of the US industry, exhibited the highest percentage mortality (Table 6). As seen in Figure 3, the mortality in the decrease in feeder space combination group occurred early in the production period. The most deaths in the group with the most increase in feeder space coincided with summer weather during the second half of the laying period. As Ross 708 hens have the characteristic of increased breast muscle (Renema et al., 2007), the loss of relatively uniform control of feed intake due to an increase in feeder space at photostimulation may have

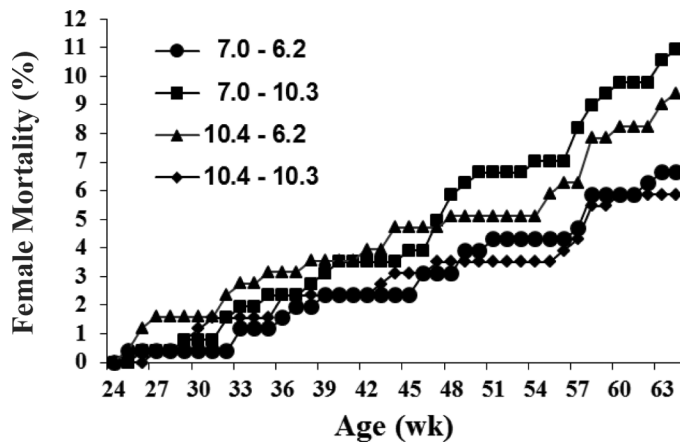


Figure 3. Percentage female mortality during the laying period as affected by female feeding space. Circles represent a small decrease in feeder space (7.0–6.2 cm/female); squares represent an increase in feeder space (7.0–10.3 cm/female); triangles represent a decrease in feeder space (10.4–6.2 cm/female); and diamonds represent a small decrease in feeder space (10.4–10.3 cm/female) at photostimulation.

allowed more aggressive pullets to consume more feed, thus adding slightly more breast meat without causing significant changes in BW or increasing variability among hens. Queiroz and Cromberg (2006) discussed

that changes in feeder space may alter flock social order and increase competition for feed, altering either BW uniformity or hen development, and Renema et al. (2008) reported previously that hens that received an aggressive feed increase carried a slightly increased proportion of breast muscle at sexual maturity. Further, by 58 wk of age, the same high feeding profile hens still had the most breast muscle as well as a smaller ovary and less abdominal fat, which reflected lower ovarian activity (Renema et al., 2008). This could be one of the reasons why hens that were exposed to the increase in feeder space combination produced fewer eggs than hens with no change in feeder space because hens with excess feed have been reported to direct nutrients toward breast muscle rather than reproductive system development during the time of sexual maturity (Hudson et al., 2000; Reddish and Lilburn, 2004).

Increased percentage mortality was another reason why hens with the greatest increase in feeder space combination produced the fewest eggs on an eggs per hen housed basis. As mentioned earlier, there were no differences in the BW among hens in all the feeder space combinations (Table 2), but their body composition may have changed with regards to breast muscle as it has been previously demonstrated in experiments

Table 7. Broiler breeder fertility, hatchability, and embryonic mortality from 26 to 63 wk of age from weekly set of 60 eggs as affected by broiler breeder female feeder space allocation during growing and laying periods, and feed increase rate from photostimulation to peak egg production, as well as interactions among these factors

Feeder space/female			Incubation variable ² (%)				
Growing ³ (cm)	Laying ⁴ (cm)	Peak feed increase ¹	Fertility	Hatchability of			
				Fertile eggs	Total eggs	Early dead ⁵	Late dead ⁶
7.0			95.79	94.74	90.75	3.40	1.98
10.4			95.38	95.05	90.67	3.15	1.69
<i>P</i> -value			0.621	0.212	0.919	0.181	0.408
	6.2		95.17	94.86	90.29	3.43	1.72
	10.3		96.00	94.92	91.13	3.12	1.89
<i>P</i> -value			0.334	0.684	0.383	0.120	0.712
		Fast	95.46	94.87	90.63	3.30	1.83
		Slow	95.71	94.91	90.80	3.25	1.84
<i>P</i> -value			0.873	0.976	0.880	0.802	0.973
7.0	6.2		95.73	94.87	90.83	2.65	1.88
7.0	10.3		95.85	94.60	90.68	3.15	1.89
10.4	6.2		94.61	94.85	89.75	2.77	1.56
10.4	10.3		96.16	95.24	91.59	2.48	1.88
<i>P</i> -value			0.364	0.455	0.322	0.071	0.815
7.0		Fast	95.59	94.87	90.69	2.91	1.80
7.0		Slow	95.99	94.61	90.81	2.88	1.96
10.4		Fast	95.34	94.98	90.56	2.46	1.62
10.4		Slow	95.43	95.12	90.78	2.79	1.82
<i>P</i> -value			0.658	0.589	0.956	0.253	0.987
	6.2	Fast	94.89	94.73	89.90	2.58	1.80
	6.2	Slow	95.46	95.00	90.68	2.84	1.64
	10.3	Fast	96.04	95.12	91.35	2.79	1.63
	10.3	Slow	95.96	94.73	90.91	2.83	2.15
<i>P</i> -value			0.904	0.338	0.604	0.575	0.373

¹Feed increase rates (see Figure 2) from photostimulation to peak egg production.

²Categorical analysis does not generate SEM.

³Feeder space allocations of 7.0 or 10.4 cm per each of 76 pullets during growing.

⁴Feeder space allocations of 6.2 or 10.3 cm per each of 64 hens during laying.

⁵Embryos that died from 1 to 7 d.

⁶Embryos that died after 7 d.

that have evaluated changes in feed availability after photostimulation (Wilson et al., 1995; Melnychuk et al., 2004; Leksrisonpong et al., 2007). Therefore, the most likely explanation for increased mortality due to an increase in feeder space was greater breast muscle that would contribute to higher body temperature during the summer weather that was present after 45 wk of age (Figure 3). Further, we did not observe very many double-yolk eggs, which would be indicative of ovary dysfunction, as well as no differences in fertility or hatchability. This suggested that these birds did not have enough excess feed to overstimulate ovarian follicle development during the initial phase of lay as shown in other experiments (Van Middelkoop, 1971; Hocking et al., 1987; Yu et al., 1992; Melnychuk et al., 2004). These broiler breeders were certainly not overfed as it has been the case in other studies (Renema et al., 2007, 2008) that employed ad libitum feeding. In contrast, in this study the feed allocations followed typical commercial scenarios and addressed a relevant commercial management issue.

Increased or decreased feeder space may have upset the delicate developmental balance between breast muscle and oviduct as has been discussed extensively (Melnychuk et al., 2004; Renema et al., 2007, 2008). This could lead to the difference in the number of eggs produced as well as slightly increased mortality of broiler breeder hens during periods of summer temperatures. Maintaining slightly reduced feeder space during the change between rearing and laying quarters resulted in greater egg production and better livability. There were no significant effects due to the feed increase rate from photostimulation to peak egg production, which suggested that control of feeder space change between rearing and laying periods was the more important factor to consider under the conditions of this study.

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