Effects of Body Weight Uniformity and Pre-Peak Feeding Programs on Broiler Breeder Hen Performance

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Primary Audience: Breeder Managers, Nutritionists, Researchers

Summary

This study examined the effects of body weight (BW) uniformity on broiler breeder hen performance as well as the effects of post-lighting feeding programs on the uniformity and performance of nonuniform groups. Eight hundred Cobb-500 strain breeder females were housed in floor pens at 20 weeks of age. The HT treatment, which consisted of pullets that each weighed between 4.1 and 4.5 lb at housing, had high (H) uniformity and received typical (T) feed increases. Three other treatments contained 25 light (3.4 to 3.8 lb) and 25 heavy (4.8 to 5.2 lb) birds in each pen. These treatments had low (L) uniformity and were subject to either T (LT) or fast (F) (LF) increases in pre-peak feed allotments or skip-a-day (S) feeding (LS) until 25 weeks of age. Results indicated that H initial uniformity was associated with increased egg production, and F feed allotment increases stimulated early egg production. The onset of lay was delayed in birds on the LS treatment, causing a decline in cumulative egg production and an increase in mean egg weight; but weekly egg production levels had recovered by 30 weeks. Modifications to pre-peak feeding programs may be an effective method to improve uniformity of nonuniform flocks.

Key words: Broiler breeder, body weight uniformity, feeding programs, egg production, egg weight
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Description of Problem

Uniformity of BW in broiler breeder flocks is usually determined by individually weighing a sample of birds, calculating the average BW, determining the limits 15% above and below the average, and finally calculating the percentage of birds whose BW are within those limits [1]. *The Cobb Breeder Management Guide* [2] states that, in a "uniform" flock of pullets, 80% of pullets should be within ±15% of the average BW. Uniformity provides an estimate of the variability in a given flock at a given age, and, generally speaking, the more uniform the flock, the better the performance of that flock [1].

A highly uniform flock will reach peak egg production earlier and will peak higher than a nonuniform flock [3]. Nonuniform flocks generally do not attain high egg production peaks because of the varying degrees of maturity

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among the individual hens [3, 4]. Low peak production in nonuniform flocks is due to variability in sexual maturation, resulting in a delayed onset of production in light hens [5] and accelerated production in heavy hens [6]. Settable egg production is expected to be poor even if a nonuniform flock is at the target mean BW [7] because underweight hens may produce eggs that vary greatly in size and hens above target BW produce a greater percentage of double-yolked eggs [8]. Peak usually is not consistent, and egg size distribution is expected to be uneven in nonuniform flocks [4]. It has been reported that the lower the BW uniformity is at sexual maturity, the later and lower the peak egg production and the fewer eggs produced when the flock is liquidated [3]. Pettite *et al.* [7] reported that BW uniformity (80 vs. 89%) did not influence cumulative egg production, egg weight, fertility, or mortality; but the more uniform treatment had significantly higher egg production during the first 10 weeks of lay.

There are several factors that may contribute to low BW uniformity. It is estimated that >35% of the variation in mature BW in Leghorn flocks is due to variation in hatching egg size [9]. It has also been suggested that social dominance by larger birds prevents smaller birds from consuming their fair share of feed, which may result in a decrease in uniformity [3]. Other factors that may influence uniformity are feed distribution speed [4]; genetic variability in parent stock [5]; bird density; amount, or quality of feed, or both; availability of feeder and waterer space; diseases or parasites; house temperatures; and ventilation [1].

Low uniformity has been a problem associated with breeder flocks since the use of highly restrictive feeding programs was initiated. Overweight hens in nonuniform flocks represent a major economic loss because of their decreased production and overconsumption of feed [10]. The delayed onset of lay of lighter hens may also result in economic losses. The scale of these losses is difficult to assess but is likely significant. When poor uniformity occurs, birds may be separated by BW and managed differently to help regain uniformity [1, 2, 11, 12], but this task may be labor-intensive and costly. Relieving this problem entirely is impossible, but it may be alleviated significantly through alterations in feeding programs provided during the period immediately following photostimulation. With these observations in mind, this study was conducted to determine the effects of uniformity on hen performance, as well as the influences of different pre-peak feeding programs on performance and uniformity of nonuniform groups.

TABLE 1. Contents of feeds provided to broiler breeder hens. (Ingredients and nutrients appear in subtitles)

INGREDIENT (%)	PREBREEDER	BREEDER
Corn	70.18	66.88
Soybean meal	21.25	22.05
Rice mill feed	2.75	—
Limestone	2.75	6.70
Dicalcium phosphate	1.80	1.85
Salt	0.38	0.38
DL-Met	0.05	0.10
Poultry oil	0.10	1.30
Vitamin premix	0.50	0.50
Mineral premix	0.25	0.25
NUTRIENTS[A]		
CP (%)	16.00	16.00
ME (kcal/lb)	2,922	2,922
Fat (%)	3.01	3.93
Ca (%)	1.50	3.01
Met + Cys (%)	0.58	0.63
Met (%)	0.33	0.38
Lys (%)	0.81	0.82

[A]Calculated values.

Materials and Methods

Eight hundred Cobb-500 broiler breeder pullets were obtained from a commercial pullet house at 20 weeks of age. They were wing-banded and then moved to and housed in floor pens at the Auburn University Poultry Research Unit. Treatments were based on uniformity of BW at 20 weeks as well as pre-peak feeding programs. In each of four replicate floor pens (82.5 ft^2 per pen) were placed 50 pullets that each weighed between 4.1 and 4.5 lb at housing. This was called the H BW uniformity treatment. In each of the 12 remaining replicate pens were placed 50 pullets, 25 of which weighed between 3.4 and 3.8 lb (light), and 25 of which weighed between 4.8 and 5.2 lb (heavy). These pens had L uniformity. All pens had similar BW means at initiation of the trial. Common prebreeder and breeder diets were provided for all treatments from 20 to 23 weeks and 23 to 35 weeks, respectively (Table 1). The H uniformity pens and four of the L uniformity pens received T pre-peak feed allotment increases that increased to a peak of 34.0 lb/100 birds per day during Week 29 (Table 2). Four of the remaining L pens were subject to increases in pre-peak feed allotments (LF), which reached the same peak allotments during Week 27 (Table 2). The final four L pens were provided weekly intakes similar to those of the T treatments, but feed was provided on 4 of 7 days per week until 25 weeks. This treatment will be referred to as the LS treatment. All other treatments were fed daily from 20 weeks until the end of the trial. Treatment S feed allotments were increased more rapidly relative to the T treatments, from 24 to 27 weeks, because of poor feed efficiency and delayed onset of lay. Skip-a-day feeding was practiced until 20 weeks for the other three treatments. Therefore, the four treatments were HT, LT, LF, and LS (which was fed 4 of 7 days/wk until 25 weeks).

All pullets were subjected to 8 hr of light and 16 hr of darkness with an intensity between 0.5 and 1.0 fc at floor level from 3 to 20 weeks of age. They were photostimulated at 21 weeks with 15 hr of light and 9 hr of darkness, providing an intensity of >2 fc. Individual BW and pen uniformity were determined weekly from 20 to 35 weeks. Birds on treatment LS were weighed on "off feed" days. In each nonuniform pen, average BW was determined for both the light and heavy groups of birds to monitor the progression of each of these subpopulations. Eggs were picked up four times daily, and the total production of normal (single-yolked and intact), cracked, double-yolked, very small, misshapen, thin-shelled, and soft-shelled eggs by each pen were recorded daily. Weights of all normal eggs produced were determined daily. Egg weight uniformity was determined weekly by first calculating the average egg weight for each treatment, then calculating the percentage of eggs that weighed within ±5% of the average weight. Double-yolked eggs were not included in egg weight or uniformity determinations. Four birds per pen were killed at 21, 25, and 30 weeks of age. In the L uniformity pens, two heavy and two light birds were killed at each sampling time. In an effort to not alter uniformity of the pens, birds weighing about 2.5% above and below their pen (HT treatment) or BW group (LT, LF, and LS treatments) mean were killed. Ovary, oviduct, breast, and abdominal fat pad weights

TABLE 2. Limited feed allotments provided to broiler breeder hens with either high or low uniformity. Hens were provided different prepeak feeding programs

WEEK	TREATMENT[A] HT	LT	LF	LS
	(lb/100 bird/day)			
20	19.25[B]	19.25[B]	19.25[B]	19.25[B]
21	20.50	20.50	21.00	20.50[B]
22	22.00	22.00	23.00	22.00[B]
23	23.00	23.00	24.50	23.00[B]
24	24.75	24.75	27.00	25.50[B]
25	26.75	26.75	30.00	28.50[B]
26	29.00	29.00	33.50	30.00
27	31.00	31.00	34.00	31.50
28	33.00	33.00	34.00	33.00
29	34.00	34.00	34.00	34.00
30	34.00	34.00	34.00	34.00
31	34.00	34.00	34.00	34.00
32	33.00	33.00	33.00	33.00
33	32.00	32.00	32.00	32.00
34	31.80	31.80	31.80	31.80
35	31.60	31.60	31.60	31.60

[A]Indicates uniformity and prepeak feeding program (Uniformity: H = high, L = low; feeding program: T = typical, F = fast increase, and S = skip-a- day).
[B]Indicates S feeding. Otherwise, allotments were provided daily.

TABLE 3. Breast, abdominal fat, and body weights of broiler breeder hens with high or low uniformities. Hens were provided different prepeak feeding programs

WEEK	TREATMENT[A] HT	LT	LF	LS	p	SEM
	BODY WEIGHT (lb)					
20	4.27	4.30	4.28	4.33	0.4551	0.03
21	4.72[a]	4.75[a]	4.79[a]	4.59[b]	0.0001	0.02
22	5.14[b]	5.14[b]	5.26[a]	4.82[c]	0.0001	0.03
23	5.47[b]	5.48[b]	5.59[a]	5.11[c]	0.0001	0.02
24	5.78[b]	5.83[b]	5.99[a]	5.34[c]	0.0001	0.02
25	6.09[b]	6.14[b]	6.39[a]	5.74[c]	0.0001	0.02
26	6.59[b]	6.61[b]	6.93[a]	6.61[b]	0.0001	0.02
27	6.85[c]	6.86[c]	7.23[a]	7.00[b]	0.0001	0.03
28	7.02[b]	7.07[b]	7.36[a]	7.29[a]	0.0001	0.04
29	7.13[b]	7.13[b]	7.43[a]	7.39[a]	0.0007	0.05
30	7.30[b]	7.33[b]	7.56[a]	7.51[a]	0.0028	0.04
31	7.45[b]	7.46[b]	7.67[a]	7.66[a]	0.0259	0.06
32	7.50	7.52	7.74	7.69	0.0917	0.07
33	7.49[b]	7.56[ab]	7.73[a]	7.71[ab]	0.0586	0.07
34	7.56	7.59	7.73	7.69	0.2116	0.06
35	7.63	7.61	7.77	7.75	0.2129	0.06
	BREAST WEIGHT (g)					
21	409.0[b]	407.3[b]	420.0[ab]	441.9[a]	0.0469	8.4
25	588.1	596.4	607.8	574.4	0.2800	11.7
30	649.2	652.0	670.4	682.6	0.5128	77.5
	ABDOMINAL FAT WEIGHT (g)					
21	11.3	15.8	12.5	15.3	0.6184	2.7
25	49.3[b]	53.0[ab]	61.8[a]	54.1[ab]	0.0812	3.1
30	63.9[b]	67.0[b]	74.2[ab]	95.9[a]	0.0154	6.3

[A]Indicates uniformity and prepeak feeding program (Uniformity: H = high, L = low; feeding program: T = typical, F = fast increase, and S = skip-a-day to 25 weeks).
[a–c]Means within a row without a common superscript differ significantly ($p < 0.10$).

as well as number of large yellow follicles (>0.40 in.) were determined.

Data were analyzed using the General Linear Models procedure of SAS® [13]; pens served as the experimental unit (n = 4 per treatment). Data were analyzed separately for each age, and data were also analyzed on a cumulative basis when applicable. When p values of <0.10 occurred, means were separated using the Tukey's Studentized Range Test.

Results and Discussion

The mean BW of birds on the HT and LT treatments were similar throughout the trial, but those of birds on the LF treatment were consistently higher because of their faster feed allotment increases (Tables 2 and 3). The mean BW of birds on treatment LS was lowest through

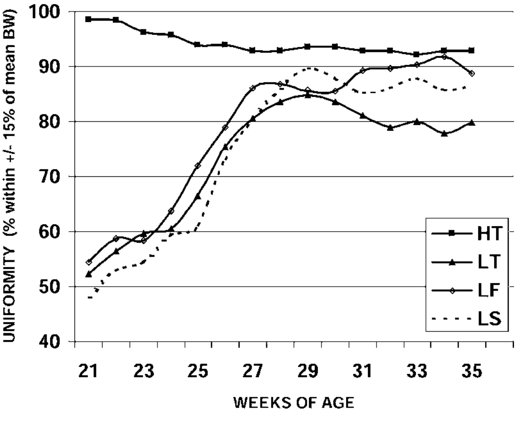

FIGURE 1. Uniformity of broiler breeder hens with high (H) or low (L) uniformity. Hens were provided different prepeak feeding programs. Acronyms inside legend represent uniformity and feeding program (T = typical, F = fast increases, and S = skip-a-day to 25 weeks). BW = body weight.

TABLE 4. Body weight gain from 20 to 30 weeks of birds with light and heavy body weights on low uniformity treatments

	WEIGHT GAIN (lb)
TREATMENT[A]	
LT	3.02[b]
LF	3.29[a]
LS	3.18[ab]
p	0.0600
SEM	0.07
BODY WEIGHT GROUP	
Light	3.52[a]
Heavy	2.81[b]
p	0.0001
SEM	0.06

[A]Indicates uniformity and prepeak feeding program (Uniformity: L = low feeding program, T = typical, F = fast increase, and S = skip-a-day to 25 weeks).
[a–b]Means within a treatment or body weight group without a common superscript differ significantly ($p < 0.10$).

25 weeks but increased when allotments were increased relative to the T treatments during weeks 24 to 27; daily allotments were provided after 25 weeks (Table 3). The lower initial BW and rapid increase in BW when treatment LS was switched to daily feeding may be attributed to poor feed efficiency associated with S feeding [14, 15] and the fact that these birds were being weighed on "off-feed" days. More feed was provided to birds on the LS treatment than to birds on the T treatments during weeks 24 to 27 to increase BW gains and stimulate the onset of lay (Table 2). It has been stipulated that providing large quantities of feed when using an S program may lead to a higher incidence of choking [1], but there were no treatment effects on mortality (data not provided).

Body weight uniformity remained above 90% during the entire trial for birds on treatment HT but decreased slightly with age (Figure 1). After 30 weeks, uniformity was similar among birds on treatments HT, LF, and LS but remained low for birds on treatment LT (Figure 1). Uniformity increased up to 28 weeks for birds on all L uniformity treatments. However, from 28 to 35 weeks, uniformity seemed to decrease slightly for birds on the LT treatment and remained relatively constant for birds on the LS treatment. Birds on the LF treatment had higher BW means and continually increasing uniformity up to 35 weeks. It should be taken into consideration that, as actual mean BW of a flock varies increasingly from the target BW, the uniformity becomes less of a concern. For example, a flock with a high percentage of overweight hens may have high uniformity but will probably perform poorly because of excessive BW. Increases in BW uniformity prior to peak egg production may be due to decreased growth rate of heavy hens, which have begun to produce eggs; lighter hens, which have not yet initiated production, continue to grow at a rapid rate. A significant amount of BW gain occurs just prior to the initiation of production because of the rapid development of the ovary and oviduct. Prolonged S feeding also resulted in significant in-

TABLE 5. Influence of uniformity and prepeak feeding program on egg production of broiler breeders to 35 weeks

	TREATMENT[A]					
	HT	LT	LF	LS	*p*	SEM
Total eggs per hen	52.0[a]	49.4[ab]	50.4[ab]	46.8[b]	0.0371	1.1
Settable eggs per hen	45.0[a]	42.3[ab]	42.9[ab]	40.6[b]	0.0283	0.9
DY[B] (eggs per hen)	0.9	0.9	1.3	0.9	0.1126	0.1
Small eggs per hen	4.6	4.5	4.2	3.4	0.2131	0.4
Days to 20% HDP[C]	176.8[b]	175.5[b]	176.3[b]	184.8[a]	0.0002	1.1
Days to 50% HDP	184.3[b]	186.0[b]	183.3[b]	190.3[a]	0.0005	0.9
Days to 80% HDP	196.8[b]	204.3[a]	198.5[ab]	204.8[a]	0.0324	2.0
HDP (24 to 35 weeks)	61.9[a]	58.8[ab]	60.0[ab]	55.7[b]	0.0368	1.3
Egg weight (g)	56.9[ab]	56.4[b]	56.9[ab]	57.5[a]	0.0399	0.2

[A]Indicates body weight uniformity and prepeak feeding program (Uniformity: H = high, L = low; feeding program: T = typical, F = fast increase, and S = skip-a-day to 25 weeks).
[B]DY = double-yolked eggs.
[C]HDP = .
[a–c]Means within a row without a common superscript differ significantly ($p < 0.10$).

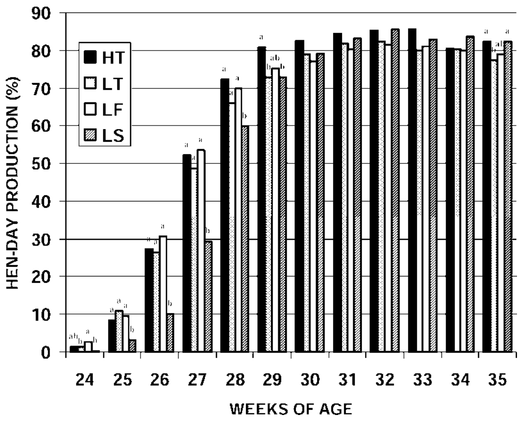

FIGURE 2. Effects of uniformity and prepeak feeding program on egg production by broiler breeder hens. Acronyms inside legend represent uniformity (H = high; L = low) and feeding program (T = typical, F = fast increases, and S = skip-a-day to 25 weeks).

creases in uniformity, perhaps because of its effect on eating habits; Lilburn [15] proposed that birds ate less aggressively after prolonged S feeding. Because feed is available for longer periods of time when provided on an S program, the larger and more aggressive birds may be consuming feed immediately after it is provided, allowing smaller and less aggressive birds to eat adequate amounts of feed afterward. Researchers have stipulated that heavy birds in nonuniform flocks consume more than their share of feed, and light birds do not consume enough feed [3]. Our results indicate that light birds in nonuniform flocks may, in fact, be consuming adequate amounts of feed because they gained more weight than the heavy birds from 20 to 30 weeks of age (Table 4). Light hens might have gained more weight because they likely produced fewer eggs than heavy hens during this period and had more nutrients available for growth. If the trial would have been carried through the entire production period, heavy hens might have gained more weight late in lay because of earlier cessation of egg production.

Higher feed intakes led to increased abdominal fat weights in birds on the LF and LS treatments at 30 weeks (Table 3). Breast weights were similar among all treatments at both 25 and 30 weeks (Table 3). Heavy birds on nonuniform treatments consistently had greater abdominal fat and breast weight averages than did light birds (data not provided). There were no treatment effects on follicle number, oviduct, or ovary weights at 21, 25, or 30 weeks (data not provided).

Age at 20% and 50% hen-day production was approximately 7 days greater in hens on the LS treatment (Table 5). The onset of lay lagged for birds on the LS treatment (Figure 2), probably because that group included more pullets that had not yet reached adequate BW for maturity (Table 3). Egg production of hens on the LS treatment was similar to that of birds on the LT and LF treatments during Weeks 29 through 34

TABLE 6. Influence of body weight uniformity and prepeak feeding program on egg weight uniformity[A]

	TREATMENT[B]					
WEEK	HT	LT	LF	LS	*p*	SEM
24	20.0[a]	15.0[b]	35.0[a]	—	0.0179	4.1
25	22.8	26.1	20.1	8.2	0.1449	5.3
26	32.5[a]	29.6[a]	30.6[a]	14.0[b]	0.0226	4.0
27	33.6[a]	38.3[a]	35.3[a]	18.7[b]	0.0012	2.7
28	47.0[a]	42.2[ab]	44.1[a]	30.4[b]	0.0218	3.4
29	52.9[a]	47.3[ab]	47.9[ab]	40.2[b]	0.0619	2.9
30	50.9	46.8	49.1	44.3	0.5200	3.2
31	48.7	49.2	51.3	48.9	0.9339	3.3
32	52.5	47.4	52.2	49.0	0.5398	2.8
33	53.9	49.6	51.2	47.4	0.4972	3.0
34	49.8	48.6	52.3	49.8	0.8401	3.0
35	52.7	46.6	51.8	51.7	0.6146	3.5

[A]Percentage of eggs with ± 5% of mean egg weight.
[B]Indicates body weight uniformity and prepeak feeding program (Uniformity: H = high, L = low; feeding program: T = typical, F = fast increase, and S = skip-a-day to 25 weeks).
[a–b]Means within a row without a common superscript differ significantly ($p < 0.10$).

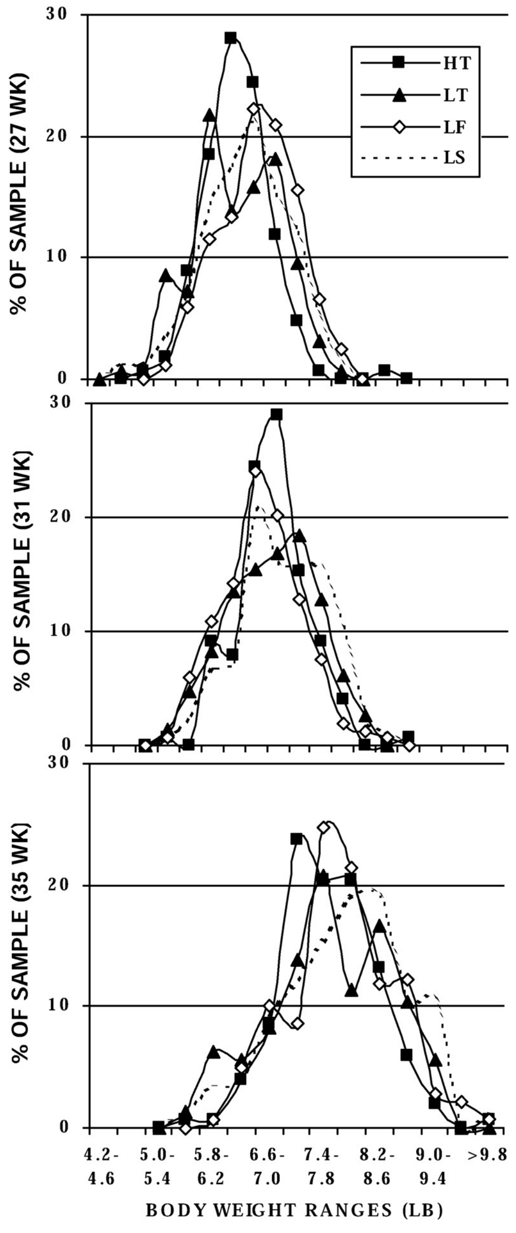

FIGURE 3. Effects of uniformity and prepeak feeding program on body weight distribution of broiler breeder hens at 27, 31, and 35 weeks. Acronyms inside legend represent uniformity (H = high; L = low) and feeding program (T = typical, F = fast increases, and S = skip-a-day to 25 weeks).

and was greater than that of birds on the LF treatment during Week 35, but lower initial production levels caused cumulative production to be lower (Table 5). In a previous report, when feed restriction delayed the onset of lay, delayed birds that experienced decreased egg production early in the production period had greater production later [16]. This trend appeared to be occurring for birds on the LS treatment in this study and, had it been continued to a normal

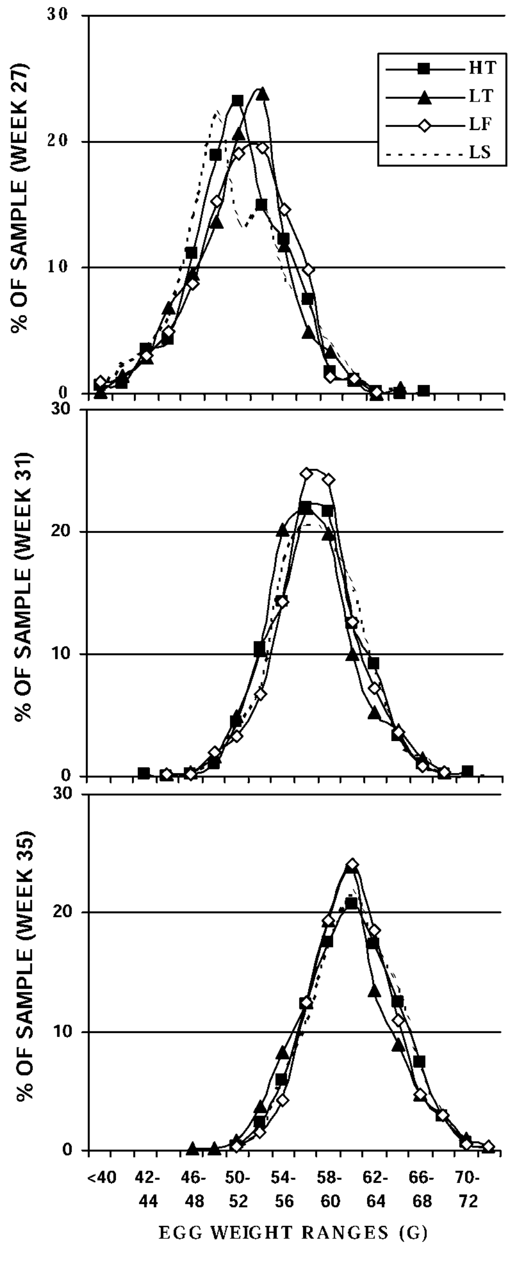

FIGURE 4. Effects of uniformity and prepeak feeding program on egg weight distribution of broiler breeder hens during 27, 31, and 35 weeks. Acronyms inside legend represent uniformity (H = high; L = low) and feeding program (T = typical, F = fast increases, and S = skip-a-day to 25 weeks).

cycle length, might have resulted in LS birds having the best performance of all birds on treatments with L uniformity. Cumulative egg production up to 35 weeks was higher for birds on treatment HT when compared with birds on treatment LS; hens on treatments LT and LF produced intermediate numbers of eggs (Table 5). Increased uniformity of sexual maturation among hens on the HT treatment might have contributed to increased production. Our data indicate that peak egg production was numerically higher in the H uniformity treatment (Figure 2), and this treatment generally reached 20, 50, and 80% hen-day production at earlier ages relative to L uniformity treatments (Table 5). Although nonsignificant, double-yolked egg production was numerically higher for birds on the LF treatment (Table 5). It was expected that rapidly increasing feed allotments would increase the production of multiple follicular hierarchies and, hence, increase the incidence of double-yolked egg production [17]. However, the more rapid increase in feed allotments for birds on the LF treatment was apparently not great enough to increase double-yolked egg production significantly. In addition, follicle numbers for birds on the LF treatment at 30 weeks of age were numerically, but not significantly, higher than those for birds on the other treatments (data not provided).

When analyzed at different ages, there were significant treatment effects on egg weight only at 33 weeks of age, but when analyzed for cumulative egg weight to 35 weeks, there were significant treatment effects (Table 5). Hens on treatment LS had the highest overall egg weight, probably because of their delayed onset of lay and greater initial egg weights. Hens on treatment LT had the lowest overall egg weight, possibly because of the decreased weight of eggs laid initially by heavy hens. Significant treatment effects on egg weight uniformity during the first few weeks of production may be partly due to differences in the numbers of eggs produced by hens on each treatment (Table 6; Figure 2). Even though egg weights of birds on the LS treatment were similar to those of birds on other treatments during the first few weeks of egg production, a low number of eggs produced and variability in BW might have caused a decrease in egg weight uniformity at this time. As the hens aged and as egg weights increased for all treatments, egg weight uniformity also increased (Table 6). Although BW was not normally distributed in the L uniformity treatments throughout the trial (Figure 3), a normal distribution of egg weights was still achieved by hens on these treatments (Figure 4). Robinson *et al.* [18] have indicated that egg weight is significantly greater in first-of-sequence eggs compared with subsequent eggs. Because an individual hen may lay eggs that vary in size at a given age, differences in BW may not have adverse effects on egg weight distribution. According to Wilson [19], light hens are expected to lay small eggs, and heavy hens are expected to lay large eggs. Because average feed allotments were probably more than required for light hens, this might have led to increased egg weight for these birds. Allotments were probably relatively less for heavy hens and might have resulted in smaller egg weights caused by increased energy needs for maintenance. This effect of feed intake on egg weight might also have led to the generally normal distributions of egg weights.

Conclusions and Applications

1. Higher egg production observed for birds on the high uniformity treatment may be attributed to similar ages at sexual maturity among the hens.
2. Providing faster than normal increases in pre-peak feed allotments to nonuniform hens improved uniformity and stimulated early egg production but also led to greater BW and numerically lower egg production during peak.
3. Prolonging S feeding of nonuniform hens resulted in a delay in the onset of lay, low cumulative egg production up to 35 weeks, and increased average egg weights. However, weekly egg production recovered by 30 weeks.
4. Although BW distribution may not be normal, a normal distribution of egg weights may still be achieved.

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