ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 8 (6): 529-535, 2009
ISSN 1682-8356

Influence of Post-Peak Feed Withdrawal Rate on Egg Production by Broiler Breeders of Different Weights

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Abstract: Broiler breeder hens are subjected to feed withdrawal as production declines after about 30 weeks of age. This study investigated effects of fast and slow feed withdrawal rates in both high and low weight hens, since body weight influences energy needs and nutrient stores. Daily allotments accounted for weight differences between high and low weight groups while decreasing 20.2 g per hen (12.8%) from peak production to 60 weeks in the slow withdrawal treatment, and 40.4 g per hen (25.6%) in the fast withdrawal treatment. From 31-60 weeks, weight gain was greatest in slow (702 g), intermediate in high-fast (351 g), and least in the low-fast treatment (219 g). Egg production began earlier and was greater in the high than low weight treatment from 23-30 weeks, was unaffected by treatments from 31-40 weeks, was greater in the slow than fast withdrawal treatment from 41-50 weeks and was greater in the low than high weight treatment from 51-60 weeks. Total production was unaffected by weight but 4.6 eggs per hen less in the fast relative to slow withdrawal treatment. The egg weight increase from 30-60 weeks was 1.4 g less in the fast relative to slow withdrawal treatment. Feed efficiency was better in the low than high weight treatment, but only marginally reduced by the fast relative to slow withdrawal treatment. These results indicate low weight breeder hens produce similar egg numbers with greater efficiency than high weight hens. In addition, doubling the typical feed withdrawal rate limits body and egg weight increases, but since it reduces egg production it only minimally improves feed efficiency.

Key words: Broiler breeder, feed withdrawal rate, body weight, egg production, egg weight

INTRODUCTION

As broiler breeder egg production declines following its peak at about 30 weeks of age, hens are subjected to feed withdrawal which is a gradual reduction in daily allotments. If provided feed *ad libitum* or in excessive daily allotments during the post-peak period, mortality is increased (Whitehead *et al*., 1987; Hocking *et al*., 2002; Sun and Coon, 2005), body and egg weights increase more markedly (Costa, 1981; McDaniel *et al*., 1981; Whitehead *et al*., 1987; Hocking *et al*., 2002; Sun and Coon, 2005) and egg production (Costa, 1981; McDaniel *et al*., 1981; Whitehead *et al*., 1987; Fattori *et al*., 1991; Hocking *et al*., 2002), fertility (McDaniel *et al*., 1981; Whitehead *et al*., 1987), shell quality (Fattori *et al*., 1991), and hatchability decrease more rapidly (McDaniel *et al*., 1981), resulting in poorer measures of feed conversion (McDaniel *et al*., 1981; Fattori *et al*., 1991; Hocking *et al*., 2002; Sun and Coon, 2005). Changes in feeding programs over the last 30 years have reflected these observations, aided in the control of body and egg weights and improved the maintenance of egg production and shell quality. However, there has been little data published comparing different rates of feed withdrawal during the post-peak period on breeder performance (Lien and Hess, 1997; Meijerhof *et al*., 1997; Sun and Coon, 2005).

Primary breeders generally recommended that daily allotments be withdrawn at a rate of 0.5-0.75 g per hen weekly during the post-peak production period, resulting in a total decrease of 8-15% from about 35-65 weeks of age (Anonymous, 2007 and 2008). Recommended body weight curves increase about 10-15 g per week during this period (Fattori *et al*., 1991; Anonymous, 2008). These recommendations indicate that withdrawing feed at this rate will not completely prevent body weight gain and imply that breeder hens should be kept in a positive energy balance, or gaining weight, throughout the production period. They are likely based on the assumption that breeder hens will not maintain adequate production if feed is withdrawn at greater rates (Costa, 1981) and have led researchers to question whether breeder hens can utilize body fat and protein reserves to sustain production during the post-peak period. Due to the recommendations, assumptions and lack of specific information indicated above, breeder managers have been reluctant to withdraw feed at greater rates based on the fear that production will drastically decrease if hens are not provided daily allotments that allow the average flock body weight to continually increase throughout lay.

In small scale trials conducted in our laboratory (Lien and Hess, 1997) and a report by Meijerhof *et al*. (1997), it was observed that feed can be withdrawn at markedly greater than recommended rates without serious adverse effects on production. We also observed that feed withdrawal rates which result in slight decreases in body weight and a stabilization of egg weight will maintain near typical production levels. Therefore, a trial was conducted to compare the egg production of broiler breeder hens subjected to a near recommended post-peak feed withdrawal rate and a more rapid rate. Since the hen's ability to maintain egg production in the face of decreasing feed intake is dependent on body weight and hence nutrient stores, these programs were tested on hens of two different body weights.

MATERIALS AND METHODS

Birds, husbandry and treatments: A total of 640 commercially-reared broiler breeder pullets (Cobb 500 strain) were selected on the basis of body weight at 20 weeks. High weight birds weighed between 2.0 and 2.2 kg and low weight birds weighed between 1.7 and 1.9 kg. They were transported to a light and environmentally controlled house at the Auburn University Poultry Research Unit and randomly distributed by weight group in 16 pens (8.4 m^2, 40 pullets/pen). A light cycle of 8L:16D providing an intensity of 7.5 lux at floor level, which was the same as the birds had been exposed to from 1 week, was provided to 21 weeks. Feeding programs were provided to maintain growth rates which resulted in average body weights for the 2 groups of 1.9 and 2.2 kg at 21 weeks. Controlled allotments of a 16% CP, 2915 kcal ME/kg and 1.5% Ca corn-soy prebreeder feed were provided to 23 weeks (Table 1). Water was continuously provided for *ad libitum* consumption by nipple drinkers.

A photostimulatory light cycle of 15L:9D providing an intensity of 40 lux at floor level was provided from 21-60 weeks. Allotments of a 16% CP, 2915 kcal ME/kg and 3.0% Ca corn-soy breeder feed were provided daily from 23-60 weeks. Feed allotments provided to the low and high weight groups were increased and at 29 weeks reached peak levels of 154.4 and 161.2 g/hen/day, or 450 and 470 kcal/hen/day, respectively (Table 1). Peak feed allotments were provided through peak egg production. From then on, half the pens in each weight group were provided one of two post-peak feed withdrawal treatments (Table 2). Daily feed allotments provided by the slow withdrawal treatment were decreased 1.36 g/hen weekly for 3 weeks after egg production failed to increase for 3 successive weeks, and 0.68 g/hen weekly thereafter. This resulted in a total decrease of 20.2 g/hen/day or an average of 12.8% at 60 weeks in the slow withdrawal treatment. Daily feed allotments provided by the fast withdrawal treatment were decreased 2.27 g/hen biweekly for 2 weeks as soon as their 3 day running average of egg production failed to increase and 1.14 g/hen weekly thereafter. This resulted in a total decrease of 40.4 g/hen/day or an average of 25.6% at 60 weeks in the fast withdrawal treatment.

Table 1: Daily feed and energy allotments provided to low and high weight broiler breeder hens during pre-peak production

	Weight[1]			
	Low		High	
Age weeks	g/hen /day	kcal/hen /day	g/hen /day	kcal/hen /day
21	88.1	257	98.1	286
22	94.4	275	102.2	298
23	102.6	299	111.7	326
24	111.2	324	119.9	350
25	121.7	355	129.8	378
26	133.9	390	141.6	413
27	143.0	417	149.8	437
28	149.8	437	156.6	456
29	154.4	450	161.2	470

[1]At 20 weeks, low and high weight treatment hens weighed from 1.7-1.9 and 2.0-2.2 kg, respectively.

Data collection and analysis: Pullets were weighed individually and average body weight and uniformities were calculated at 21, 25, 30 and 60 weeks. Each pen was weighed as a group and mean body weights were calculated to aid in adjusting feed allotments weekly from 22-24, 26-29 and 31-32 weeks and at 2 week intervals thereafter. Cumulative mortality was calculated as a percentage from 21-60 weeks.

Eggs were picked up 4 times daily and the total production of normal, double yolked, very small, mis-shapen and cracked eggs by each pen was recorded daily. Individual egg weights of all normal eggs were determined daily from 24-30 weeks. Individual egg weights of all normal eggs laid on 1 or 2 days per week ($n \geq 30$ per pen) were determined weekly from 31-36 weeks and at 4 week intervals thereafter. Specific gravities of all normal eggs laid during weeks 40, 50 and 60 were determined using the salt water flotation method.

Four replicate pens served as the experimental units for each feed withdrawal by body weight treatment of the 2 by 2 factorial arrangement. Data on total and settable egg production and daily feed allotments were used to calculate total feed provided per hen and lifetime feed efficiencies. The PROC GLM procedure of the SAS statistical package (2004 version, SAS institute, Inc., Cary, NC) was used to determine treatment effects. The statistical significance of differences is indicated in the text and tables by their P values.

RESULTS AND DISCUSSION

Body weight, uniformity and mortality: Throughout the trial, body weights of high and low weight treatments remained different ($p<0.0001$) (Table 3). At 21 weeks,

Table 2: Daily feed and energy allotments provided to low and high weight broiler breeder hens subjected to slow and fast feed withdrawal treatments during post-peak production

Age	Slow withdrawal				Fast withdrawal			
	Low weight[1]		High weight[1]		Low weight[1]		High weight[1]	
Week	g/hen/day	kcal/hen/day	g/hen/day	kcal/hen/day	g/hen/day	kcal/hen/day	g/hen/day	kcal/hen/day
30	154.4	450	161.2	470	154.4	450	161.2	470
30.5	154.4	450	161.2	470	154.4	450	158.9	463
31	154.4	450	161.2	470	154.4	450	156.6	456
31.5	154.4	450	161.2	470	152.1	443	154.4	450
32	154.4	450	161.2	470	149.8	437	152.1	443
32.5	154.4	450	161.2	470	147.6	430	151.0	440
33	154.4	450	161.2	470	145.3	424	151.0	440
33.5	154.4	450	161.2	470	144.1	420	149.8	437
34	154.4	450	159.8	466	144.1	420	149.8	437
35	153.0	446	158.4	462	143.0	417	148.7	433
36	151.6	442	157.1	458	141.9	414	147.6	430
37	150.3	438	156.4	456	140.7	410	146.4	427
38	149.6	436	155.7	454	139.6	407	145.3	423
	Continue withdrawal of 0.68 g/ hen/day or about 2 kcal/hen/day on weekly basis				Continue withdrawal of 1.14 g/ hen/day or about 3.3 kcal/hen/day on weekly basis			
60	134.6	392	140.7	410	114.6	334	120.3	351

[1]At 20 weeks, low and high weight treatment hens weighed from 1.7-1.9 and 2.0-2.2 kg, respectively.

Table 3: Body weights and mortality of low and high weight broiler breeder hens subjected to slow and fast feed withdrawal treatments during post-peak production

Item	Slow withdrawal[1]		Fast withdrawal[1]			Effects (P values)		
	Low weight[2]	High weight[2]	Low weight[2]	High weight[2]	SEM[3]	Weight	With-drawal	Interaction
Body weight at 21 weeks (kg)	1.97	2.29	1.95	2.28	0.031	<0.0001	0.3102	0.5266
Body weight at 25 weeks (kg)	2.68	3.00	2.66	3.02	0.036	<0.0001	0.3464	0.4722
Body weight at 31 weeks (kg)	3.39	3.66	3.42	3.66	0.037	<0.0001	0.3826	0.4178
Body weight at 35 weeks (kg)	3.60[b]	3.84[a]	3.60[b]	3.77[ab]	0.035	<0.0001	0.0484	0.0805
Body weight at 42 weeks (kg)	3.82	4.06	3.65	3.91	0.040	<0.0001	<0.0001	0.5645
Body weight at 50 weeks (kg)	4.00	4.22	3.70	4.00	0.087	<0.0001	<0.0001	0.3201
Body weight at 60 weeks (kg)	4.12	4.34	3.64	4.01	0.100	<0.0001	<0.0001	0.1235
Body weight increase[4] (g)	725[a]	679[a]	219[c]	351[b]	43.7	0.3498	<0.0001	0.0644
Uniformity at 60 weeks[5] (%)	81.7[b]	88.5[a]	78.8[b]	78.7[b]	1.83	0.0953	0.0059	0.0884
Mortality[6] (%)	4.4	1.8	5.2	3.1	1.15	0.0647	0.3915	0.8436

[1]Beginning 3 weeks after peak production, feed allotments of the slow withdrawal treatment decreased 1.36 g/hen for 3 weeks and 0.68 g/hen weekly thereafter. Allotments of the fast withdrawal treatment decreased 2.27 g/hen biweekly for 2 weeks immediately after peak production and 1.14 g/hen weekly thereafter. [2]At 20 weeks, low and high weight treatment hens weighed from 1.7-1.9 and 2.0-2.2 kg, respectively. [3]Pooled SEM for interaction effect (n = 4). [abc]Interaction treatment means with different superscripts differ significantly (p< 0.05). [4]Increase in body weight from 31-60 weeks. [5]Percent within 15% of mean body weight. [6]Cumulative mortality from 20-60 weeks.

the body weight of the high weight treatment was 325 g greater than the low treatment. This body weight difference between the high and low treatments was accounted for and maintained by feed allotments provided and was 255 g at 31 weeks and 295 g at 60 weeks. At 21 weeks, the body weight of the high treatment in the present study was 170 g below the primary breeder's standard (Anonymous, 2008), while the low treatment was 500 g below it. Then at 31 weeks, the body weight of the high treatment was 130 g above the standard, while the low treatment was 120 g below it. Therefore, both treatments gained more weight than recommended from photostimulation to peak production. This resulted in the high treatment being slightly above and the low treatment slightly below the breeder's recommended body weight at peak production. These body weights and rates of gain during the period from photostimulation to peak production were not markedly different from those in previous breeder research reports (Costa, 1981; Fattori *et al*., 1991; Lien and Yuan, 1994; Hocking *et al*., 2002) and used in the commercial industry (Anonymous, 2007 and 2008).

The fast and slow feed withdrawal treatments were initiated at from 31-34 weeks when body weights of these treatments did not differ (p = 0.3826) (Table 3). Body weights of the fast and slow withdrawal treatments began to differ at 35 weeks (p = 0.0484) and their difference increased through 60 weeks (p<0.0001). At 60 weeks, the body weight of the slow withdrawal treatment averaged 410 g more (p<0.0001) than that of the fast treatment. There was an interaction effect (p = 0.0644) between weight and withdrawal treatments on body weight increase from 31-60 weeks (Table 3). During this period, the weight of the low-slow and high-slow treatments increased to the same degree (725 and 679 g) while weights of the high-fast treatment (351 g) increased less than the slow withdrawal treatments but more than the low-fast treatment (219 g). About 110 of the approximately 130 g more gain that occurred in the high-fast relative to the low-fast treatment occurred from 42-60 weeks (Table 3) just before or concurrent with the low-fast treatment producing about 4 more eggs/hen than the high-fast treatment (Table 5). The fast withdrawal treatment was quite successful at minimizing weight gain throughout the post-peak decline in egg production. However, it most efficaciously controlled body weight late in the laying period in the low weight treatment in which the mean body weight actually decreased 10 g from 42-60 weeks. Some reports on breeder hen feed withdrawal have not observed a comparable degree of body weight control (McDaniel *et al*., 1981; Sun and Coon, 2005) in comparison to that attained in the present study, while others have reported limiting gains to a similar degree (Meijerhof *et al*., 1997; Hocking *et al*., 2002). Management guides published by primary breeders typically indicate that breeder hens should gain 10-15 g per week or a total of about 430 g from 31-60 weeks (Anonymous, 2008).

Uniformities did not differ between the weight treatments at 21 weeks (p = 0.6747), but were decreased in the low relative to the high weight treatment at 25 (p = 0.0080) and 30 (p = 0.0748) weeks (Table 4). At 60 weeks, there was an interaction (p = 0.0884) between weight and withdrawal treatments in which the high-slow treatment had the greatest uniformity while the other 3 treatments had similarly reduced uniformities (Table 3). Increased competition for more limited allotments provided to the low weight and fast withdrawal treatments may have resulted in these declines in uniformity. In addition, changes in the degree of competition associated with segregation of high and low weight birds into different groups at the beginning of the study might be expected to result in a greater dispersal of body weight in birds of either low weight or subjected to more limited feed allotments. It is generally suspected, but not often substantiated, that uniformity decreases as the degree of feed restriction is increased (Fattori *et al*., 1991) as was the case in the present study.

Cumulative mortality from 21-60 weeks was greater (p = 0.0647) in low weight birds, but was not influenced (p = 0.3915) by withdrawal treatment (Table 3). It is assumed that the greater uniformity and lower mortality of the high-slow treatment birds, which were receiving the greatest feed allotments (Table 2) and were heaviest (Table 3), were due to decreased competition for feed in these birds. Previous reports have indicated that mortality is unaffected by increasing degrees of feed restriction (Fattori *et al*., 1991) or increased post-peak feed withdrawal rates (Whitehead *et al*., 1987; Hocking *et al*., 2002) similar to typical commercial levels, but that mortality is reduced by increased feed withdrawal rates relative to *ad libitum* consumption (Sun and Coon, 2005).

Table 4: The onset of lay and body weight uniformity during pre-peak production in low and high weight broiler breeder hens

	Weight Treatment[1]			
Item	Low	High	SEM[2]	Probability
Uniformity[3] (%)				
21 weeks of age	98.4	98.8	0.58	0.6747
25 weeks of age	88.0	94.6	1.52	0.0080
30 weeks of age	91.0	93.9	1.06	0.0748
50% HDP[4] (days post 21 weeks)	43.1	41.1	0.65	0.0631

[1]At 20 weeks, low and high weight treatment hens weighed from 1.7-1.9 and 2.0-2.2 kg, respectively. [2]Pooled SEM for main effect (n = 8). [3]Percent within 15% of mean body weight. [4]The number of days from photostimulation to when each pen of hens reached 50% hen-day egg production.

Egg production: Age at 50% HDP occurred two days later (p = 0.0631) in the low than high weight treatment (Table 4). This delay in onset of lay due to reduced body weights is similar in magnitude to that observed in previous studies in our lab (Lien and Yuan, 1994) and other reports (Fattori *et al*., 1991; Hocking *et al*., 2002; Sun and Coon, 2005). Egg production by the high weight treatment was also nearly three eggs greater (p<0.0001) than by the low weight treatment during the pre-peak production period (from 23-30 weeks of age) but did not differ between weight groups or feeding treatments during post-peak production period 1 (from 31-40 weeks) (Table 5). The fast withdrawal treatment resulted in about a three egg decrease (p = 0.0389) in production relative to the slow treatment during post-peak production period 2 (from 41-50 weeks). Weekly hen-day egg production by the fast withdrawal treatment was consistently depressed from 2-5% relative to the slow treatment from 42-50 weeks of age (data not shown). This indicates that just before or during this period feed allotments of the fast withdrawal treatment were not adequate to maintain greater production levels and likely indicates that withdrawing 1.14 g/hen/day on a weekly basis (Table 2) was too aggressive at this particular time. Typically, it has been recommended that allotments not be reduced for several weeks following peak production (Costa, 1981; Anonymous, 2007); however, production did not begin to decrease until 10

Table 5: Egg production by low and high weight broiler breeder hens subjected to slow and fast feed withdrawal treatments during post-peak production

	Slow withdrawal[1]		Fast withdrawal[1]			Effects (P values)		
Item	Low weight[2]	High weight[2]	Low weight[2]	High weight[2]	SEM[3]	Weight	With-drawal	Interaction
Pre-peak period[4] (eggs/hen)	15.6	18.0	14.8	18.2	0.48	<0.0001	0.5578	0.3876
Post-peak period 1[4] (eggs/hen)	51.7	51.1	50.1	51.7	0.76	0.5518	0.5518	0.1756
Post-peak period 2[4] (eggs/hen)	43.5	43.4	40.7	40.1	1.33	0.7760	0.0389	0.8327
Post-peak period 3[4] (eggs/hen)	36.2	34.4	36.2	32.6	0.63	0.0012	0.1826	0.1826
Total production (eggs/hen)	146.9	146.9	141.9	142.6	2.47	0.8858	0.0793	0.8858
Settable production[5] (eggs/hen)	141.1	139.8	135.4	136.3	2.42	0.9394	0.0846	0.6580
Unsettable prodn.[6] (eggs/hen)	5.8[b]	7.1[a]	6.5[ab]	6.3[ab]	0.30	0.0791	0.7635	0.0253
Double-yolked prodn. (eggs/hen)	0.9[c]	1.8[a]	1.2[b]	1.5[ab]	0.13	0.0012	0.9336	0.0325
Small production[7] (eggs/hen)	2.6	2.4	2.7	2.5	0.26	0.5494	0.6798	0.9281
Defective prodn.[8] (eggs/hen)	2.3	3.0	2.6	2.3	0.25	0.4291	0.4562	0.1066
Mean egg weight (g)	64.7	64.9	63.5	63.8	0.36	0.5010	0.0061	0.8952
Egg weight increase[9] (g)	11.4	10.4	9.5	9.6	0.44	0.3166	0.0118	0.2278

[1]Beginning 3 weeks after peak production, feed allotments of the slow withdrawal treatment decreased 1.36 g/hen for 3 weeks and 0.68 g/hen weekly thereafter. Allotments of the fast withdrawal treatment decreased 2.27 g/hen biweekly for 2 weeks immediately after peak production and 1.14 g/hen weekly thereafter. [2]At 20 weeks, low and high weight hens weighed from 1.7-1.9 and 2.0-2.2 kg, respectively. [3]Pooled SEM for interaction effect (n = 4). [4]The pre-peak and post-peak periods 1, 2 and 3 were from 23-30, 31-40, 41-50 and 51-60 weeks, respectively. [5]Intact normal eggs weighing over 50 g. [6]Cracked, misshapen, thin and soft shelled and double-yolked eggs and eggs weighing less than 50 g. [abc]Interaction treatment means with different superscripts differ significantly (p<0.05). [7]Eggs weighing less than 50 g. [8]Cracked, misshapen, and thin and soft shelled eggs. [9]Increase in egg weight from 30-60 weeks.

weeks later, so it is doubtful that the initial rate and timing of the onset of feed withdrawal caused this effect. Meijerhof *et al.* (1997) withdrew feed even more radically immediately after peak and reported similarly decreased breeder egg production; however, Sun and Coon (2005) did not observe such a negative effect. During post-peak production period 3 (from 51-60 weeks) there was no longer a negative effect of the fast withdrawal treatment on egg production, in fact production was numerically equal in the low-slow and low-fast treatments (Table 5). The low weight birds produced about three more (p = 0.0012) eggs than high weight birds during this period. Increased egg production late in the laying period has consistently been observed in breeders that were lighter, and had a later onset of lay and reduced production levels early in the laying period (Fattori *et al.*, 1991; Lien and Yuan, 1994; Hocking *et al.*, 2002; Sun and Coon, 2005). The fact that there was only a transitory decrease in production in the fast withdrawal treatment suggests nutrient intake needs were only temporarily limiting or that the birds were able to compensate for their decreased nutrient intakes. Overall, the fast withdrawal treatment resulted in only about a 4-5 egg decrease in total (p = 0.0793) and total settable (p = 0.0846) egg production from 23-60 weeks while post-peak production body weight gains were reduced approximately 50% in the high-fast and 66% in the low-fast treatment. Total and total settable production were not influenced by weight treatment.

It was presumed that in response to the fast feed withdrawal treatment, high weight birds would maintain greater egg production levels than the low weight birds, since they had greater stored nutrient reserves available to maintain production if nutrient intake became less than that needed to support it. However, from 40-60 weeks the high-fast treatment generally had the poorest egg production (Table 5). Apparently, greater maintenance needs of high-fast birds resulted in decreased nutrient availability for egg production and they were not able to draw upon nutrient reserves to maintain production to any greater extent than low weight birds with lesser reserves.

Egg quality and weight: Unsettable egg production (cracked, misshapen, thin and soft shelled and double-yolked eggs and eggs weighing less than 50 g) was affected by an interaction (p = 0.0253) between weight and withdrawal treatments (Table 5). When subjected to the slow withdrawal treatment, the high weight treatment produced the most unsettable eggs while the low weight treatment produced the least. Unsettable production by the fast withdrawal treatment was intermediate to these two groups and unaffected by weight. Similar results were found when data on double yolked (p = 0.0325) and defective (p = 0.1066) eggs (cracked, misshapen, and thin and soft shelled) were considered separately; however, small egg production was unaffected by weight or withdrawal treatment. In general, unsettable egg production by all treatments was modest and differences, though sometimes significant, were minimal. Clearly, the fast withdrawal treatment did not have a marked negative effect on egg quality. Other reports on breeder feed withdrawal have generally not investigated egg quality or found few differences (Sun and Coon, 2005).

Relative to the slow withdrawal treatment, mean egg weights for the entire study were decreased (p = 0.0061)

Table 6: Total feed provided from hatch to 60 weeks of age and "life of flock" feed efficiency of low and high weight broiler breeder hens subjected to slow and fast feed withdrawal treatments during post-peak production

	Slow withdrawal[1]		Fast withdrawal[1]			Effects (P values)		
Item	Low weight[2]	High weight[2]	Low weight[2]	High weight[2]	SEM[3]	Weight	With-drawal	Interaction
Total Feed Provided[4] (kg/hen)	47.0	50.2	44.3	47.3	---	---	---	---
Feed/Dozen Eggs (kg)	3.85	4.10	3.75	3.98	0.067	0.0033	0.1374	0.8838
Feed/Dozen Settable Eggs[5] (kg)	4.00	4.31	3.92	4.16	0.072	0.0026	0.1492	0.6619

[1]Begining 3 weeks after peak production, daily feed allotments of the slow withdrawal treatment were decreased 1.36 g/hen for 3 weeks and 0.68 g/hen weekly thereafter. Daily feed allotments of the fast withdrawal treatment were decreased 2.27 g/hen biweekly for 2 weeks beginning immediately after peak production and 1.14 g/hen weekly thereafter. [2]At 20 weeks, low and high weight hens weighed 1.7-1.9 and 2.0-2.2 kg, respectively. [3]Pooled SEM for interaction effect (n = 4). [4]Based on feed provided to the entire flock it was calculated that a total of 8.60 and 9.09 kg of feed would have been required to rear the low and high weight pullets to 21 weeks of age, respectively. [5]Intact normal eggs weighing over 50 g.

over 1 g by the fast withdrawal treatment but were unaffected (p = 0.5010) by weight treatments (Table 5). Egg weights were similar at 30 weeks just before withdrawal treatments were initiated (data not shown), then they increased a greater amount (p = 0.0118) in the slow than fast withdrawal treatment from 30-60 weeks of age (Table 5). Decreases in mean egg weight, likely due to similar modulations of the increase in egg weight, were observed in response to increasing the rate of feed withdrawal in previous studies (McDaniel *et al*., 1981; Whitehead *et al*., 1987; Meijerhof *et al*., 1997; Sun and Coon, 2005). A primary reason for interest in more rapid feed withdrawal in breeders is to limit the increase in egg weight, and typically corresponding decrease in egg shell thickness, which is generally accepted to contribute to the decrease in hatchability occurring during post-peak production (McDaniel *et al*., 1981). Egg specific gravity remained good in all treatments throughout the present study (averaging 1.0802 at 40 weeks of age, 1.0787 at 50 weeks and 1.0789 at 60 weeks); therefore, not surprisingly, it was unaffected by either weight or withdrawal treatment. In previous reports, specific gravity was observed to be improved by more rapid feed withdrawal (McDaniel *et al*., 1981), as was hatchability (McDaniel *et al*., 1981; Meijerhof *et al*., 1997).

Feed conversion: The low weight treatment was provided 3.1 kg less feed per bird from hatch to 60 weeks than the high weight treatment, while the fast withdrawal treatment was provided 2.8 kg less feed per bird than the slow treatment (Table 6). Therefore, the low-fast treatment received 5.9 kg per bird less feed than the high-slow treatment. Relative to the high weight treatment, feed per dozen total (p = 0.0033) and settable (p = 0.0026) eggs (which are measures of life of flock feed conversion) were decreased an average of 240 and 275 g by the low weight treatment, respectively. Since both total and settable egg production did not differ between the high and low weight treatments, the lesser amount of feed provided to the low weight birds resulted in improved feed efficiency relative to high weight birds. Similarly, life of flock feed conversion (feed per dozen hatching eggs) was improved an average of 11 g for each 1% decrease in daily feed allotments in breeder hens provided 8%, 16% and 24% less than primary breeder recommendations in a previous report (Fattori *et al*., 1991). However, the improvement in feed conversion of the low weight treatment, which was provided 6.4% less feed than the high weight treatment in the present study, was more marked.

Feed per dozen total (p = 0.1374) and settable eggs (p = 0.1492) were not significantly affected by withdrawal treatment (Table 6). The 2.8 kg decrease in feed provided per hen (5.8%) in the fast relative to the slow withdrawal treatment was offset by their 4.65 egg decrease in production (3.3%) which resulted in a numerical average decrease in life of flock feed per dozen total and settable eggs of about 113 g (2.8%). Sun and Coon (2005) observed that feed conversion from 24-65 weeks was improved about 68 g per dozen eggs for hens provided a faster feed withdrawal program that reduced total feed provided by about 0.6 kg per hen. McDaniel *et al*. (1981) reported that hens provided 3.3 kg less feed per hen during the post-peak period, relative to what was then a typical industry program, had a feed conversion that was reduced 300 g per dozen eggs produced.

Clearly, maintaining relatively low body weights and withdrawing feed from breeder hens at greater rates both have the potential to improve egg production efficiency if egg numbers are not markedly reduced. Although egg production was reduced by faster feed withdrawal in the present study, production was maintained quite well relative to the amount of feed provided late in the laying period. Ultimately the greatest positive effect of more rapid feed withdrawal may be realized through its potential modulation of the increase in egg weights and related declines in shell quality and hatchability.

ACKNOWLEDGEMENT

The excellent technical assistance of Frank Dillman is sincerely appreciated and sorely missed.

REFERENCES

Anonymous, 2008. Cobb Breeder Management Guide. http://www.cobb-vantress.com/contactus/brochures/Breeder_guide_2008.pdf.

Anonymous, 2007. 708 Parent Stock Nutrition Specification. http://www.aviagen.com/docs/Ross%207080%20PS%20Nutrition%Spec.pdf.

Costa, M.S., 1981. Fundamental principles of broiler breeders nutrition and the design of feeding programmes. World's Poult. Sci., 37: 177-192.

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.

Hocking, P.M., R. Bernard and G.W. Robertson, 2002. Effects of low dietary protein and different allocations of food during rearing and restricted feeding after peak rate of lay on egg production, fertility and hatchability in female broiler breeders. Br. Poult. Sci., 43: 94-103.

Lien, R.J. and J.B. Hess, 1997. Feed allotment decrease rate and laying status effects on late cycle broiler breeder hens. Poult. Sci., 76 (Suppl.1): 53.

Lien, R.J. and T. Yuan, 1994. Effect of delayed light stimulation on egg production by broiler breeder pullets of low body weight. J. Appl. Poult. Res., 3: 40-48.

McDaniel, G.R., J. Brake and R.D. Bushong, 1981. Factors affecting broiler breeder performance. 1. Relationship of daily feed intake level to reproductive performance of pullets. Poult. Sci., 60: 307-312.

Meijerhof, R., J. van der Haar and A. Havard, 1997. Severe feed restriction of broiler breeder hens using an automatic weighing system. Poult. Sci., 76(Suppl.1): 53.

SAS Institute, 2004. SAS Users Guide, Statistics, SAS Institute, Inc, Cary, NC.

Sun, J. and C.N. Coon, 2005. The effects of body weight, dietary fat and feed withdrawal rate on the performance of broiler breeders. J. Appl. Poult. Res., 14: 728-739.

Whitehead, C.C., K.M. Herron and D. Waddington, 1987. Reproductive performance of dwarf broiler breeders given two different allowances of food during the rearing and breeding periods and two lighting programs. Br. Poult. Sci., 28: 415-427.