Performance of broilers to 21 days of age produced by early lay broiler breeders is affected by cumulative broiler breeder pullet nutrition during rearing

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Summary

To evaluate the effects of cumulative nutrition during broiler breeder rearing on performance of their broiler offspring, broiler chicks were hatched from breeders reared to 21 weeks of age on a range of cumulative nutrition in three trials that used graded levels of cumulative crude protein (CP) and metabolizable energy (ME) intakes (High, 116.3 MJ ME and 1.48 kg CP; Medium, 108.9 MJ ME and 1.39 kg CP; Low, 101.4 MJ ME and 1.30 g CP). Breeder reproductive performance was not significantly affected. Egg weights did not differ significantly except in Breeder Trial 3 at 34 weeks of age when eggs from the High group were larger. Broiler Trial 1 used chicks hatched from Breeder Trial 1 at 27 weeks of age. Broiler Trials 2 and 3 evaluated chicks hatched from Breeder Trial 2 at 28 and 39 weeks of age respectively, and Broiler Trial 4 used chicks hatched from Breeder Trial 3 at 33 weeks of age. The high plane of cumulative breeder nutrition increased 21 d broiler male bodyweight in Broiler Trials 1 ($P<0.05$), 2 ($P<0.06$), and 4 ($P<0.08$). There was no significant effect in Broiler Trial 3 ($P<0.31$) when the breeders were 39 weeks of age. Female broiler bodyweight was affected less consistently. Broiler breeder pullet nutrition during rearing appeared to affect subsequent male broiler growth from early lay broiler breeders without significant impact on breeder performance.

Keywords: broiler breeders, cumulative nutrition, broiler performance, maternal influences

Introduction

The broiler chicken has achieved remarkable feed conversion efficiency during the past half century due to relentless genetic selection for juvenile growth rate. This selection process has created genetically hyperphagic broiler breeders (broiler parent stock) that must be subjected to quantitative caloric (metabolizable energy, ME) restriction using specialized feed restriction regimens throughout their lives in order to maintain reasonable reproductive performance. This strict control of nutrient intake is necessary to limit the most obvious manifestation of hyperphagia, that is excessive bodyweight gain. To fully comprehend the degree of restriction one need only realize that the feed–restricted broiler breeder female will weigh at 20 weeks of age what the full–fed broiler female will weigh at 5 to 6 weeks of age. This classical approach has led to the development of 'standard' bodyweight guides that are intended for use with each specific strain of meat–type broiler parent stock. For many years it has been generally held that achieving these standard bodyweights was one of the most practically important goals to achieve while rearing broiler breeders. In fact, many managers exhibit somewhat of a 'fea' of deviating from these standards.

The mechanism by which broiler breeders can be grown to an 'acceptable' bodyweight and yet be nutrient deficient probably rests to some degree in the remarkable improvements in broiler feed conversion that have accompanied increased broiler growth rate. It must be recognized that the feed efficiency of the parent stock improves along with that of the progeny. This improvement in feed conversion allows broiler breeders to be grown to the same 'standard' bodyweight on ever decreasing amounts of nutrients over the course of a period of years. The amount of energy required to grow a broiler breeder pullet to a 2 kg bodyweight at 20 weeks of age has decreased from about 117 to around 83.7 MJ ME in about 15 years (Walsh 1996). However, there have been no compensatory adjustments in typical rearing diets or feeding programs. Exacerbating the situation is the fact that elite broiler stocks may be selected on high crude protein (>25% CP) and high ME (>12.97 MJ/kg) diets while broiler breeders (parent stock) may be reared on relatively lower protein (14 to 15% CP) and lower ME (11.3–12.1 MJ/kg) diets. The implications of the protein component of this process are illustrated nicely by the work of Lilburn *et al.* (1992) who reared a heavy weight quail line, selected for several generations on a 28% CP diet, to sexual maturity on a standard 24% CP diet known to produce sexual maturity at 42 days of age in a random bred control line. Sexual maturity was delayed in the heavy weight line when fed the 24% CP diet (a diet that is suggested by the NRC to be adequate) but the delay in sexual maturity was significantly decreased by rearing the heavy weight line birds on a 30% CP diet, which was more similar to the selection diet.

It is tempting to suggest that improvements in broiler feed conversion are reducing the amount of feed (ME and CP) required to rear a broiler breeder to a given bodyweight, but selection for growth–rate, feed efficiency and conformation on high CP/ME diets is apparently not decreasing the nutrient requirements for proper sexual development in a proportionate manner. In fact, it may be that many reproductive problems are simply due to insufficient nutrition given the genetic background of the breeding stock. This is suggested by the work of Sorneson (1980, 1985) who selected meat–type chickens for increased growth on high and low protein diets. When tested on the low protein diet, the low protein selected line progeny grew substantially faster than the high protein line progeny.

Another topic of continuing concern among commercial broiler producers is the relatively poor performance of broilers produced by early lay (‘pullet flocks’) broiler breeders. The present investigation details a new approach to this problem based upon our research with the concept of minimum cumulative nutrition. Our laboratory has established that cumulative nutrient intake of broiler breeder pullets prior to photostimulation is positively associated with subsequent fertility and egg production of those hens and that an absolute minimum of 1.20 kg CP and 96 MJ ME per pullet exists for minimally acceptable reproductive function (Walsh 1996; Walsh and Brake 1997). As a certain amount of nutrition during rearing has been shown to be required for minimal reproductive function it is suggested that a similar minimum may exist for minimal broiler progeny performance. Preliminary data from our laboratory has suggested that cumulative nutrient intake of broiler breeder cockerels was positively related to improved feed efficiency of broiler chicks produced by those roosters during the initial stages of egg production. Therefore, it was hypothesized that a higher plane of rearing nutrition may also allow early lay broiler breeders (pullet flocks) to produce better performing broilers.

Materials and methods

To evaluate effects of cumulative nutrition during the breeder rearing period on the performance of their broiler offspring, four trials were conducted using chicks hatched from broiler breeders reared on a range of cumulative nutrition in three consecutive trials. Breeder Trials 1 and 2 each used to 21 weeks of age three graded levels of cumulative crude protein (CP) and metabolizable energy (ME) intakes; these were High (116.3 MJ ME and 1.48 kg CP), Medium (108.9 MJ ME and 1.39 kg CP), and Low (101.4 MJ ME and 1.30 kg CP). Breeder Trial 3 used only the High and Low levels. The Low treatment was similar to the level that our laboratory has established to be the minimum for acceptable reproductive performance. The feeding programs are shown in Figure 1 and diets in Table 1. The cumulative nutrient intakes are based upon calculated values. Feed was manufactured in a commercial feed mill where routine ingredient analyses were used to adjust the formulations as required. The total study detailed in this report comprised three years. Proximate analyses of each batch of feed delivered ensured that that the diets were mixed as formulated. Males were grown sex–separate on the starter diet to a cumulative nutrient intake of about 133.9 MJ ME and 1.60 kg CP as determined by our laboratory to be satisfactory (Peak 1996, 2001). The three pullet groups were fed the same starter and grower diets with cumulative differences achieved by varying the volume fed as shown in Figure 1. A single breeder laying diet and identical management practices were applied to breeder hens in all three breeder trials. Males and females were fed sex–separately the same breeder laying

Table 1 Calculated nutrient composition of breeder pullet rearing diets and broiler breeder diets used in Breeder Trials 1, 2 and 3.

Nutrient[1]	Starter diet[2]	Grower diet[3]	Breeder diet[4]
ME, MJ/kg	12.13	12.13	12.13
Crude protein, %	17.0	15.0	15.5
Lysine, %	0.88	0.75	0.80
Methionine + cystine, %	0.70	0.60	0.60
Calcium, %	0.90	0.90	2.70
Available phosphorus, %	0.45	0.45	0.40

[1]Nutrient values expressed on an as fed basis. Crude protein confirmed by proximate analysis of each batch of feed delivered
[2]Starter diet offered to breeder cockerels from 0–24 weeks and breeder pullets from 0–3 weeks
[3]Grower diet offered to breeder pullets from 4–24weeks
[4]Breeder diet offered to male and female breeders from 25 weeks onwards

diet during the laying period. The broiler breeders were from a Cobb 500 package in all cases with approximately 2000 birds in each flock with four replicate pens for each cumulative nutrition treatment in Breeder Trials 1 and 2 and six replicate pens in Breeder Trial 3. The breeder facility was a two–thirds slat design with curtains and fans for ventilation. Breeders were moved from a black–out rearing (8 h of light) facility to the laying facility and photostimulated (14 h of light) at 22 weeks of age. Breeder performance was monitored by egg production, fertility, fertile hatchability, egg weight, and percentage shell.

Identity of breeder treatments was preserved during egg collection, egg storage, egg incubation, and chick processing. Broiler Trial 1 used chicks hatched from Breeder Trial 1 at 27 weeks of age. Broiler Trials 2 and 3 evaluated chicks hatched from Breeder Trial 2 at 28 and 39 weeks of age respectively, and Broiler Trial 4 used chicks hatched from Breeder Trial 3 at 33 weeks of age. Chicks from each breeder pen were sexed and assigned to six broiler pens of 15 chicks each. Thus, there were ultimately 12 pens of male and 12 pens of female broiler chicks from each breeder pullet cumulative nutrition treatment in Broiler Trials 1, 2, and 3. There were 18 pens per sex in Broiler Trial 4. Broilers were fed broiler starter crumbles to 21 days of age. The breeder experimental design was one–way with three levels of cumulative nutrition in Breeder Trials 1 and 2 and two levels of cumulative nutrition in Breeder Trial 3. The broiler experimental design was either a 3 x 2 (Broiler Trials 1, 2, 3) or 2 x 2 (Broiler Trial 4) factorial with breeder cumulative nutrition and broiler sex as main effects.

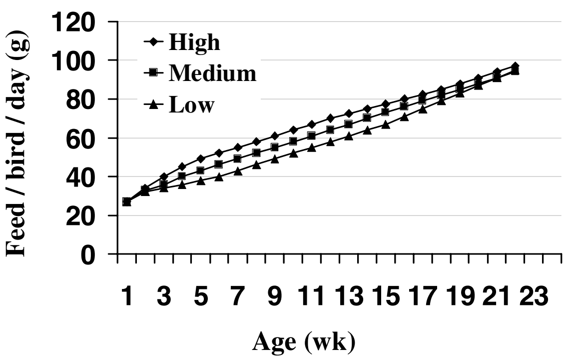

Figure 1 Pullet feeding programs used to produce three graded levels of cumulative metabolizable energy and crude protein intakes (High, 116.3 MJ ME and 1.48 kg CP; Medium, 108.9 MJ ME and 1.39 kg CP; Low, 101.4 MJ ME and 1.30 kg CP) to 21 weeks of age.

Results

There was no consistent effect of cumulative pullet nutrition on any reproductive variable measured. Egg production, fertility and fertile hatchability were very similar and quite acceptable while percentage shell was not significantly affected (data not shown). Egg weight (Table 2) was not significantly affected except at 34 weeks in Breeder Trial 3 where the High treatment exhibited greater egg weight. All pullets were weighed at 22 weeks of age to confirm treatment effects and the Low, Medium, and High treatments weighed 2.45, 2.55 and 2.66 kg, respectively. Although pullet bodyweight did differ during rearing, these differences gradually disappeared during the laying period (Figure 2). Sample bodyweights taken from 20 hens per pen near the time of each egg collection for each Broiler Trial are shown in Table 3.

There were no consistent significant effects of plane of pullet cumulative nutrition on broiler feed conversion or mortality to 21 days of age (data not shown). However, there were consistent effects on broiler bodyweight as shown in Table 4. The high plane of cumulative breeder nutrition increased 21 day broiler male BW in Broiler Trials 1 ($P<0.05$), 2 ($P<0.06$), and 4 ($P<0.08$). There was no effect in Broiler Trial 3 when

Table 2 Effect of High, Medium and Low cumulative pullet nutrition during the rearing period on subsequent egg weight.

Breeder trial	Breeder age (weeks)	Egg weights (g) after cumulative pullet nutrition[1]			*P* value
		High	Medium	Low	
1	28	57.15	56.39	56.38	0.64
1	34	63.89	62.89	63.89	0.29
1	46	68.29	68.16	68.36	0.96
2	28	55.26	57.23	54.49	0.07
2	34	63.79	63.19	62.71	0.18
2	40	67.38	66.95	66.69	0.58
3	28	58.55	–	57.44	0.12
3	34	64.75	–	63.68	0.05
3	40	66.55		66.18	0.52

[1]Breeder Trials 1 and 2 each used the three graded levels of cumulative metabolizable energy and crude protein intakes (see text) to 21 weeks of age. Breeder Trial 3 used only the High and Low levels

the breeders were 39 weeks of age. Female BW was affected by plane of breeder nutrition in Broiler Trial 2 ($P<0.05$) only and the effect appeared to be less consistent for female offspring. It is interesting to note that the male bodyweights at 21 days of age are in the 900 gram range. This is exceptional early broiler growth by most standards and the fact that the increased bodyweight observed in the male was evidenced in the presence of such good control (Low) performance is remarkable.

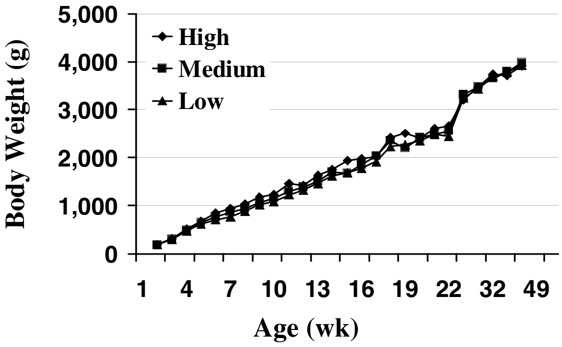

Figure 2 Female bodyweights during the rearing and laying periods resulting from the Low, Medium, and High cumulative feeding programs during rearing.

Discussion

It is common in commercial broiler production to receive complaints of poor performance of broilers from young broiler breeder flocks. There have been several attempts at explanation of this phenomenon that included the hypothesis of problems with nutrient transfer from dam to progeny, specifically involving fatty acids. It has been shown that the fatty acid composition of hatching eggs and of chicks is dependent upon the age of the breeder flock, with younger breeders (36 weeks of age) fed diets containing poultry fat producing chicks with higher levels of oleic acid as a percentage of total fatty acids, compared to chicks produced from older parent flocks at 51 and 54 weeks of age (Latour *et al*. 1998). This vertical breeder age effect on chick composition is further supported by data from an earlier study that showed newly hatched chicks from 26–week old hens to have elevated levels of total cholesterol, low density lipoprotein cholesterol and high density lipoprotein cholesterol when compared with chicks from breeder hens at either 36 or 46 weeks of age. Conversely in the same study, the chicks from the 26–week old breeder flock also exhibited lower serum glucose levels than chicks from the older flocks

Table 3 Effect of cumulative pullet nutrition during the rearing period on subsequent breeder hen weight[1].

Broiler trial	Breeder trial	Breeder age (weeks)	Bodyweight (kg) after cumulative pullet nutrition: High	Medium	Low
1	1	26	3.21	3.32	3.25
2	2	28	3.62	3.56	3.45
3	2	40	3.96	3.96	3.89
4	3	32	3.76	–	3.80

[1]Hen bodyweights taken from a random sample of 20 hens from each of twelve 200–hen pens at the ages shown

Table 4 Effect of cumulative High, Medium and Low pullet nutrition during the rearing period on subsequent 21–day broiler bodyweights.

Broiler trial	Breeder trial (weeks)	Breeder age	Broiler sex	BW (g) at 21 d at cumulative nutrition levels[1]: High	Medium	Low	P value
1	1	27	M	913	847	896	0.01
1	1	27	F	813	805	803	0.93
2	2	28	M	946	935	901	0.06
2	2	28	F	896	873	859	0.03
3	2	39	M	953	924	917	0.31
3	2	39	F	870	886	871	0.57
4	3	33	M	924	–	894	0.09
4	3	33	F	834	–	856	0.28

[1]Breeder Trials 1 and 2 each used the three graded levels of cumulative metabolizable energy and crude protein intakes to 21 weeks of age. Breeder Trial 3 used only the High and Low levels

(Latour *et al*. 1996). Since chicks immediately post–hatch are heavily dependent upon fatty acids transferred to the liver during the last few days of incubation as a source of energy but must make a rapid transition to a carbohydrate dependent metabolism, it tempting to postulate that alterations to the fatty acid profile of the yolk and chick, as a result of age of parent flock, may affect their ability to perform post–hatch. It is also tempting to postulate that cumulative ME and CP nutrition during rearing may affect the body reserves available to the young breeder for incorporation into the egg, possibly altering egg lipid composition and subsequent chick performance, but at present we have no direct evidence on this point. With the particular corn–soy based diets used in the present study there would have been an increased intake of linoleic acid with increased cumulative nutrient intake during rearing.

The expected explanation of these data would be an increased egg weight (yolk?) from larger hens producing larger broilers but our data show a significant effect on egg weight only in Breeder Trial 3; in any case, this would not explain the differential effect on the male broiler *vs* the female broiler in three of four trials. However, there does appear to be a trend towards increased female bodyweight with cumulative pullet nutrition, based upon a sample of hens at 28 weeks of age in Breeder Trial 2 (Table 3). The broiler chicks sourced from this group of eggs at this hen age exhibited an increased bodyweight for both male and female chicks at 21 days of age (Table 4). In this one broiler trial an argument could be made for a link between female bodyweight, but not egg weight, with broiler bodyweight. Another possible explanation is that we have somehow changed the age at which pullets with 'high genetic potential' commence lay, but the absence of effects on rate of lay and fertility marginalizes this explanation.

It may well be that it simply takes more nutrition for the full genetic potential of the breeder pullet to be expressed at an early stage of egg production in much the same manner that a certain minimum amount of nutrition is required for minimum reproductive performance. It is intriguing to remind oneself that the parent female in chickens is the heterogametic sex and determines which chicks will be male. Maybe the abrupt photostimulation associated with black–out rearing interrupts or delays some nutrient accumulation process that is required for optimum progeny quality. It is tempting to surmise that the parent female derived from a selection process based upon nutrient–dense diets may just require more CP and ME to fully express its genetic potential and that of its progeny. Maybe there is simply a minimum nutrient requirement for the progeny quality aspect of reproduction that exceeds that required for basic egg production, fertility and hatchability. Investigations at the molecular level will be required to determine this. The data of this study also suggest that the long–standing fear of excess bodyweight during pullet rearing may be considerably overstated and actually hindering broiler performance.

Nevertheless, the data of the present study suggest that one means to correct the problem of poor quality chicks from young breeders is simply to provide the pullets with more feed during rearing, similar to what has been done in the past before the feed conversion of the breeder pullet improved so much. In fact, the High treatment in the present study had a cumulative nutrient intake similar to what our laboratory has calculated to have been the rearing intake typical of broiler breeder pullets in the mid–1980s.

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