Timing of growth affected broiler breeder feeding motivation and reproductive traits

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ABSTRACT The amount and timing of growth are important factors that affect age at first egg, body conformation, reproductive performance, and hunger in broiler breeders. To investigate the effect of growth pattern on feeding motivation and reproductive performance, 10 unique growth trajectories were designed with 2 levels of the amount of early growth and 5 levels of timing of growth around puberty. A 3-phase Gompertz model that described growth in phase 1 (prepubertal), phase 2 (pubertal), and phase 3 (postpubertal) was used to design the growth trajectories. Second growth phase inflection point (**I_2**) was advanced by 0, 5, 10, 15, or 20% of the coefficient estimated from the breeder-recommended target BW. The growth trajectories were designed with 2 discrete levels of total gain in the prepubertal phase (**g_1**); g_1 was either the prepubertal phase gain coefficient, estimated from the breeder-recommended BW (**Standard g_1**) target, or 10% higher (**High g_1**). Forty females were randomly assigned to the growth trajectories using a precision feeding (**PF**) system. Analysis of covariance was conducted on dependent variables in ten 4-wk periods with g_1 and periods as discrete fixed effects, I_2 as a continuous fixed effect, and age as a random effect. Differences were reported at $P \leq 0.05$. For every week of earlier I_2, body weight at photostimulation (**BWPS**) increased by 126 g; BW at first egg (**BWFE**) increased by 94 g; 24 wk shank length increased by 0.038 and 1.495 mm in the Standard g_1 and High g_1 treatments; 24 wk body fat increased by 0.38%; pullets came to lay earlier by 0.49 d; egg weight (**EW**) increased by 0.27 g; egg production and egg mass (**EM**) increased by 0.33 egg/hen/d and 0.916 g/d in the High g_1 treatment but decreased by 0.27 egg/hen/d and 0.29 g/d in the Standard g_1 treatment, respectively. Increasing g_1 reduced feeding motivation index by 1.6 and 0.8 visits/meal during rearing and laying phase, respectively. Earlier pubertal growth showed prominent effects on the reproductive performance.

Key words: broiler breeder, feed restriction, Gompertz model, hunger

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INTRODUCTION

Broiler breeders are subjected to feed restriction programs to control excessive growth. In contrast with increasing growth rate in broilers (Zuidhof et al., 2014), broiler breeder BW targets have changed very little over the past decades (Renema et al., 2007). Thus, the gap between growth potential of broilers and broiler breeder target BW is increasing, which has resulted in increased feed restriction intensity. Reducing feed consumption to the levels required to control BW has created welfare concerns in underfed breeders (van Krimpen and de Jong, 2014). Some modern broiler breeder pullets do not have sufficient fat reserves to undergo sexual maturation due to severe feed restriction (van Emous et al., 2015; van der Klein et al., 2018a, b; Zuidhof, 2018). Leading up to the onset of lay, breeders should have adequate fleshing (body condition) with optimum levels of protein mass and fat tissue available. There is evidence to suggest that a minimum amount of body fat may be required for broiler breeder pullets to reach sexual maturity (Bornstein et al., 1984; Sun et al., 2006). Kwakkel et al. (1993) described the growth of the body and chemical components of laying hens in a multiphasic manner. They reported that after 11 wk of age, protein and fat deposition was mainly related to the development of the reproductive tract and abdominal fat deposition, respectively. In layers, skeletal frame size can be indirectly assessed by measuring shank length (Kwakkel et al., 1998). Robinson et al. (2007) noted that feed restriction can also limit broiler breeder shank length throughout the rearing period.

Reproductive performance has been compromised by both unrestricted BW in female breeders

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(Robinson et al., 1993; Heck et al., 2004) and severe feed restriction (Wilson and Harms, 1986). However, egg production and egg weight (**EW**) of unrestricted precision fed breeders did not change in response to a 2,007 g increase in the 22 wk BW compared to the standard BW group (Zukiwsky et al., 2021). In another study, high BW hens produced 1.39 times more eggs/hen than standard BW hens from 32 to 55 wk of age (van der Klein et al., 2018b). All high BW hens commenced egg production by the end of their experiment, whereas 37.6% of standard BW hens under 12L:12D photoschedule did not come to lay. The authors hypothesized that current breeder-recommended BW targets may not allow for sufficient body reserves required for the onset of lay in the standard BW hens. They concluded that increasing BW target provided the high BW hens with sufficient metabolic trigger to commence and sustain egg production.

Potential approaches to reduce the intensity of feed restriction in broiler breeders have been investigated in various studies through diet dilution (Zuidhof et al., 1995; Savory and Lariviere, 2000), relaxed feed restriction (Hocking et al., 2002a; Bruggeman et al., 2005; Zukiwsky et al., 2021), and introduction of alternative genetic stock (Heck et al., 2004; Bruggeman et al., 2005). Hocking et al. (2002a) found that increasing target BW by 20% at 18 wk of age did not affect egg or chick production. They reported no difference in the welfare traits (measure of immune function, physiological indices of stress, and behavioral changes) of the hens, which indicated no real benefit of the relaxed feed restriction protocols tested in their studies (Hocking et al., 2001, 2002b). Zukiwsky et al. (2021) increased broiler breeders target BW gain during prepubertal and pubertal phases incrementally up to 22.5% above the recommended BW target. They included a group of unrestricted birds in their study. Some of the unrestricted pullets commenced egg production 2 wk prior to photostimulation. These results strongly suggest that body composition and metabolic status have a role in triggering sexual maturation. Notably, the authors reported that relaxing growth restriction up to 22.5% above the recommended BW target decreased hunger in hens during laying phase but not in pullets during the rearing phase. Hadinia et al. (2020) increased broiler breeder's dietary energy by 302 kcal/kg from 22 to 26 wk of age. The percentage of birds which commenced laying was 100% in the high ME intake treatment and 30% in the low ME intake treatment. They concluded higher ME intake advanced the activation of hypothalamus-pituitary-gonadal axis, stimulated reproductive hormone levels, and increased lipid deposition in the body of high ME intake treatment group.

Designing strategic growth curves for broiler breeders for systematic evaluation was the main interest behind the current study. The objective of the current study was to evaluate the effect of increased BW gain during prepubertal growth phase and earlier pubertal growth phase on hunger, reproductive performance, body frame size, and body fat in broiler breeder pullets and hens.

MATERIALS AND METHODS

The animal protocol for the study was approved by the University of Alberta Animal Care and Use Committee for Livestock and followed the Canadian Council on Animal Care Guidelines and Policies (CCAC, 2009).

Experimental Design

The current experiment was conducted as a randomized controlled trial. A total of 40 female Ross 708 broiler breeder pullets were equally and randomly assigned to 10 growth trajectories (Figure 1). Growth trajectories

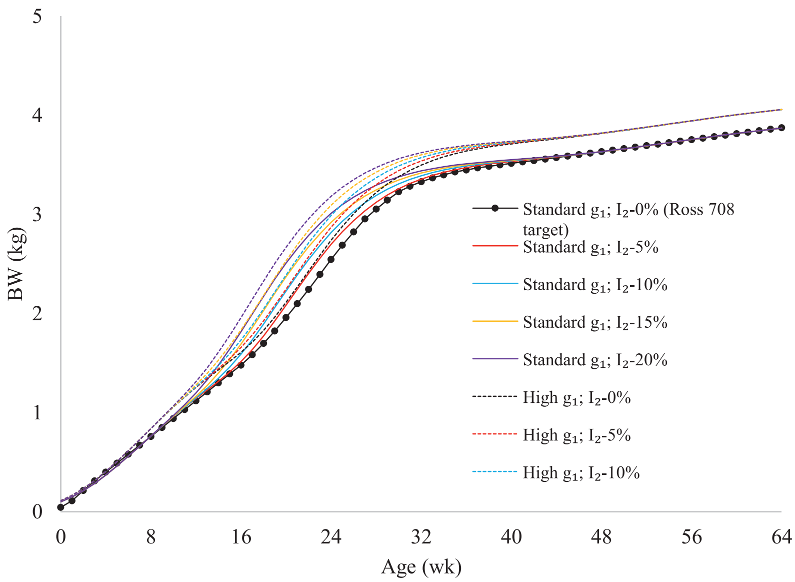

Figure 1. Growth trajectories designed using estimated coefficients of a 3-phase Gompertz model. General model form was $BW_t = \sum_{i=1}^{i=3} g_i exp^{-exp^{-b_i(t-I_i)}}$ where BW_t was BW (kg) at time t (wk); g_i was the total amount of gain (kg) in phase i; b_i was the growth rate coefficient; t was age (wk); I_i was the inflection point (wk), or the age at which growth for phase i reached its maximum rate. g_1 coefficient (g_1) was the prepubertal phase gain coefficient estimated by fitting the model to the standard Ross 708 recommended BW gain target (Standard g_1) or 10% higher (High g_1). Pubertal phase inflection point coefficient (I_2) was advanced by 0, 5, 10, 15, and 20% creating inflection points at 22.29, 21.16, 20.05, 18.94, and 17.82 wk of age, respectively.

were designed with 2 levels of the amount of early growth and 5 levels of timing of growth around puberty. Coefficients of growth parameters for breeder-recommended growth trajectory were estimated using a 3-phase Gompertz model fit to the breeder-recommended target BW (Aviagen, 2016). The model had the form (Zuidhof, 2020):

$$\mathrm{BWt} = \sum_{i=1}^{i=3} g_i exp^{-exp^{-b_i(t-I_i)}} + \varepsilon_t$$

where BW_t was BW (kg) at time t (wk); g_i was the total amount of gain (kg) accruing in phase i ; b_i was the growth rate coefficient for the i^{th}; t was age (wk); I_i was the inflection point (wk), or the age at which growth for phase i reached its maximum rate; and ε_t was the residual error with an expected value of 0, and a normally distributed variance estimated by the software $\varepsilon_t \sim N(0, SD^2)$; i was the growth phase (i = 1 to 3) where phase 1, 2, and 3 corresponded roughly to prepubertal, pubertal, and postpubertal growth phases, respectively. Other growth trajectories were designed with 2 levels of the prepubertal phase gain coefficient (**g_1**) as discrete variables; g_1 was either the estimated gain for phase 1 derived from the breeder-recommended standard BW (**Standard g_1**) target, or 10% higher (**High g_1**). The coefficient I_2, which defined the inflection point of the pubertal growth phase (**I_2**), was advanced by 0, 5, 10, 15, or 20% of the coefficient estimated when fitting to the breeder-recommended target BW. I_2 was a continuous variable within both the Standard g_1 and High g_1 groups. The BW trajectories were applied to each individual bird using a precision feeding (**PF**) system. Therefore, each bird was an experimental unit.

Animals and Management

The pullets (n = 40) were housed in a single pen containing 2 PF systems, from hatch to 43 wk of age at a stocking density of 3.0 birds per m^2. All birds were fed a commercial diet: starter (crumble; ME 2,726 kcal/kg, 21.0% CP, 1.00% Ca, and 0.45% available P) from hatch to d 34; grower (mash; ME 2,799 kcal/kg, CP 15.0%, 0.79% Ca, and 0.44% available P) from d 35 to d 179; and breeder diet (crumble; ME 2,798 kcal/kg, 15.3% CP, 3.30% Ca, and 0.38% available P) from 180 d onward. Water was provided ad libitum throughout the experiment. The photoschedule was 24L:0D (100 lx) from d 0 to 3 then reduced to 8L:16D (15 lx) on d 4. Pullets were photostimulated at wk 22 by increasing the photoperiod to 11L:13D (20 lx); to 12L:12D (25 lx) on wk 23, then at wk 24 to 13L:11D (50 lx) for the remainder of the experiment. Each PF station had 5 green LED lights (2 lx) that illuminated the inside for 24 h/d so that birds could see their way through the station during the scotophase, without causing photostimulation (Rodriguez, 2017). Room temperature was maintained at 33°C during the first 2 d, and from d 3 onwards temperature was gradually reduced to 20°C by wk 5. A trap nest with 8 nesting sites and a nest box with 8 nesting sites equipped with RFID readers which identified and weighed eggs of individual hens were installed in the room at 14 wk of age; thus, the pullets had the chance to adapt to the nesting system prior to the onset of lay.

All birds were fed individually using a PF system (Zuidhof et al., 2019) that permitted feed intake levels appropriate to achieve the target growth trajectories of each individual bird. Each PF station consisted of 2 motorized entry doors, a sorting and feeding stage, a feeder, and a ramp giving access to the sorting stage. In addition to feed availability from the PF station, supplemental feed was provided on paper plates located around the ramp, on the ramp, and throughout the station and was gradually removed over the first wk to encourage chicks to enter the station individually to reach the feeder. During the training period (first 2 wk), the chicks were placed on the ramp, sorting stage, and feeding stage to get trained to use the PF stations. At 14 d of age each bird was equipped with a wing band containing radiofrequency identification (**RFID**) transponder to be recognized individually by the PF system. Birds were individually weighed by the PF system in real-time. The treatment BW trajectories were uploaded to the PF system on 14 d of age. The PF system provided access to a meal if the individual birds' real-time BW was equal or less than the pre-programmed target BW; otherwise, the system gently ejected the birds from the PF station. The chicks were weighed manually daily during the first 3 wk to confirm growth and adoption to the PF system. Feed intake and visit frequency were checked daily to ensure all birds were accessing the PF system. Chicks were provided with additional training to adapt to individual feeding within the feeding station if their BW gain was less than 5 g, FI was less than 2 g, or had less than 3 station visits over the last 24 h. The birds had access to the PF system 24 h per day throughout the experiment.

Data Collection

The birds were weighed manually at the same time every morning during the training period. After individual feeding started on d 14, the PF stations recorded individual bird real-time BW and feed intake information upon entry into the station (Zuidhof et al., 2017). The station visit frequency, meal frequency, size of each meal, and ADFI were calculated from the PF system database.

At 24 wk of age, right shank (tibiotarsus) length was measured using digital calipers (Model CD-8″C, Mitutoyo, Japan) from the top of the flexed hock joint to the bottom of the footpad. Simultaneously, abdominal skinfold thickness was measured: each bird was held in standing position with the abdominal skin midway between the vent and the posterior end of the keel bone (sternum) grasped firmly between the tip of the thumb and forefinger of the nondominant hand then lifted such that the skin and subcutaneous fat were drawn away from the underlying tissues. A skinfold caliper (Model Harpenden C-136) was then placed perpendicular to the skin fold, dial up, approximately 1-cm away from the finger and thumb. While maintaining the grasp of the skinfold, the Caliper was gently released so that full tension was placed on the skinfold. The dial was read to the nearest 0.50 mm, 1 to 2 s after the spring tension had been fully applied. Body fat as a percentage of BW was estimated using the following model.

$$\textit{Body fat}\ (\%) = 24.83 + 6.75\ (\ln \textit{skinfold}) - 3.87\ \textit{BW},$$

where skinfold was abdominal skinfold thickness (cm), and BW was measured in kg. The model was created using data from Ross, Avian, and Sex-Links strains with an $R^2 = 0.63$ (Latshaw and Bishop, 2001).

The cloaca of all hens was palpated daily in the morning just after initiation of photoperiod to detect hard-shelled eggs in the shell gland. Presence or absence of a hard-shelled egg in the shell gland was recorded daily for each hen. The palpation records were used to determine age at first egg (**AFE**) and daily oviposition records of individual birds from 20 to 43 wk. Eggs were collected from nest boxes, weighed, and assigned to individual birds daily. Over the duration of the study, there were a total of 10 floor eggs. Floor eggs were assigned to the hen that laid the egg according to palpation records that were cross referenced with daily records of hens that had laid an egg in the nest boxes. Body weight was evaluated in 2 wk periods from 3 to 42 wk of age. Average daily feed intake and feed seeking behavior (daily station visit:meal ratio) were evaluated in 4-wk periods for the rearing (3−6, 7−10, 11−14, 15−18, and 19−22 wk of age) and laying (23−26, 27−30, 31−34, 35−38, and 39−42 wk of age) phases, separately. Egg production, EW, and egg mass (**EM**) were evaluated in these same laying phase time periods.

Statistical Analysis

Analysis of covariance was conducted on hen-day egg production, EW, EM, station visit frequency, meal frequency, meal size, and visit:meal ratio variables using the MIXED procedure of SAS (Version 9.4, SAS Institute Inc., Cary, NC), with g_1 and time period as discrete sources of variation, and I_2 as a continuous predictor variable. Period was included in the model as a random effect with individual bird as the subject to account for within-bird variation. The same analysis was conducted on shank length, estimated body fat, AFE, BW at photostimulation (**BWPS**), and BW at first egg (**BWFE**) without including period in the analysis. Pairwise differences between means within each period were determined using Tukey's HSD test and were reported as different when $P \leq 0.05$. Trends were reported where $0.05 < P \leq 0.10$.

RESULTS AND DISCUSSION

Standard coefficients of growth parameters in the 3-phasic Gompertz model were estimated for Ross 708 breeder-recommended BW trajectory (Table 1; Figure 1). Then g_1 was increased by 10% to create High g_1 BW trajectories (Table 1). The breeder-recommended I_2 at 22.29 wk of age predicted accumulation of 90% of the total growth for the pubertal phase in approximately 20 wk, from 17 to 37 wk of age. Pubertal inflection point was advanced in both Standard and High g_1 treatments creating inflection points that varied by 1.1 wk (7.8 d) in the range of 17.82 to 22.29 wk of age. Correspondingly, the predicted timeframe for accumulation of 90% of the total pubertal growth advanced by 7.8 d with each 5% advancement of I_2 (Table 1; Figure 2).

Body Weight

Body weight was similar across BW trajectories from 3 to 6 wk of age (Table 2). Target BW might have not diverged enough among BW trajectories (Figure 1) to

Table 1. Estimated coefficients of a 3-phase Gompertz model[1] used to generate target BW trajectories[2] for Ross 708 broiler breeder.

	BW trajectory									
	Standard g_1					High g_1				
Growth parameter	I_2-0%	I_2-5%	I_2-10%	I_2-15%	I_2-20%	I_2-0%	I_2-5%	I_2-10%	I_2-15%	I_2-20%
n[3]	4	4	4	4	4	4	4	4	4	4
Mortality	0	0	0	1	0	0	0	1	1	0
g_1 (kg)	1.880	1.880	1.880	1.880	1.880	2.068	2.068	2.068	2.068	2.068
b_1	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
I_1 (wk)	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
g_2 (kg)	1.696	1.696	1.696	1.696	1.696	1.696	1.696	1.696	1.696	1.696
b_2	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
I_2 (wk)	22.29	21.16	20.05	18.94	17.82	22.29	21.16	20.05	18.94	17.82
g_3 (kg)	0.451	0.451	0.451	0.451	0.451	0.451	0.451	0.451	0.451	0.451
b_3	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
I_3 (wk)	54.85	54.85	54.85	54.85	54.85	54.85	54.85	54.85	54.85	54.85

[1]The coefficients for "Standard g_1, Standard I_2-0%" BW trajectory were estimated by fitting a 3-phase Gompertz model to the breeder-recommended Ross 708 female broiler target BW. General model form was $BW_t = \sum_{i=1}^{i=3} g_i exp^{-exp^{-b_i(t-I_i)}}$ where BW_t was BW (kg) at time t (wk); g_i was the total amount of gain (kg) accruing in phase i; b_i was the growth rate coefficient; t was age (wk); I_i was the inflection point (wk), or the age at which growth for phase i reached its maximum rate.

[2]g_1 was either the gain coefficient for the prepubertal phase, estimated from the breeder-recommended standard BW gain (Standard g_1) target, or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk; I_2-5% = 21.16 wk; I_2-10% = 20.05 wk; I_2-15% = 18.94 wk; I_2-20% = 17.82 wk.

[3]n was number of birds grown in each growth trajectory.

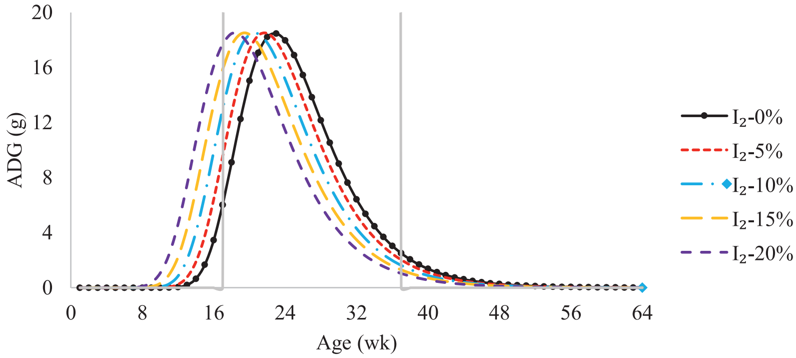

Figure 2. Pubertal BW gain estimated by fitting a 3-phase Gompertz growth model to target BW of female Ross 708 broiler breeders. Standard pubertal inflection point (I_2) was advanced by 0, 5, 10, 15, or 20% creating inflection points at 22.29, 21.16, 20.05, 18.94, and 17.82 wk of age. Vertical gray reference lines show the timeframe (17−37 wk) for accumulation of 90% of the pubertal gain for the standard I_2.

detect significant differences in bird BW by 6 wk of age. High g_1 pullets had a greater average BW than that of their Standard g_1 counterparts from 7 to 8 wk of age. However, earlier I_2 did not increase BW within the Standard g_1 and High g_1 treatments by 8 wk of age. Pullet BW started to diverge within the Standard g_1 and High g_1 treatments starting at 9 wk of age due to earlier I_2 (earlier pubertal growth). Increasing g_1 by 10% increased BWPS for High g_1 hens by 6.4% (167 g) compared to that of the Standard g_1 hens ($P < 0.001$, Table 3). For every week earlier I_2, BWPS and BWFE increased by 126 g ($P < 0.001$) and 94 g ($P < 0.001$). After 36 wk of age, there were no differences among bird BW within the Standard g_1 and High g_1 treatments (Table 2) as the target growth trajectories started to converge (Figure 1).

Shank Length and Body Fat

Shank length and estimated body fat were used as proxies for body frame size and body composition, respectively. Advancing the inflection point of the second (pubertal) growth phase increased shank length at 24 wk of age by 0.038 and 1.495 mm/wk within the Standard g_1 and High g_1 treatments, respectively ($P = 0.046$, Table 4). Renema et al. (2007) noted that feed restriction can limit shank length throughout the rearing phase. Achieving adequate body frame development threshold provides the bird the foundation for a successful laying cycle (Shi et al., 2020). Increasing g_1 by 10% did not affect the estimated body fat. For every week of earlier pubertal growth, estimated body fat increased by 0.38% ($P = 0.013$, Table 4). It was shown that carcass fat at sexual maturity is between 11 and 15% of total BW (Joseph et al., 2000; Renema et al., 2007), which is not consistent with the estimated body fat in the current study (8.0 ± 0.4 and 8.5 ± 0.4% for the Standard g_1 and High g_1 treatments, respectively). This might be due to low body fat in Ross 708 strain (Renema et al., 2007) and the fact that body fat has decreased in modern broiler breeders (Caldas et al., 2018). To commence egg production and support adequate reproductive performance in broiler breeders, a minimum percentage of body fat is required (Sun and Coon, 2005; de Beer and Coon, 2009; van Emous et al., 2013). In the current study all birds reached the sexual maturity and commenced egg laying; thus, the minimum body fat threshold is likely below 8%.

Age at First Egg

Standard g_1 and High g_1 hens commenced lay at almost the same age (176 d, Table 3). Age at first egg advanced by 0.49 d/wk of earlier I_2 ($P = 0.046$, Table 3). This might be because birds with earlier pubertal growth had higher estimated body fat, as a measure of body composition, and longer shank length, as a measure of body frame size, compared to their counterparts with standard I_2 (Table 4). These birds may have reached the BW and body composition thresholds required for onset of lay because of earlier pubertal growth. Thus, achieving those thresholds may have provided sufficient metabolic triggers for sexual maturation. Extra ME and nutrients at this time can advance the sexual maturation process in broiler breeder individuals by advancing the activation of the hypothalamus-pituitary-gonadal axis and increasing body lipid deposition (Renema et al., 1999; Hadinia et al., 2020). However, Renema et al. (2007) did not find advancement in AFE when they increased 12-wk target BW by 150 and 200% and photostimulated the birds at 22 wk of age. We previously reported that there is individual variation in the thresholds for sexual maturity because each bird might have a unique BW threshold to reach sexual maturity (Zukiwsky et al., 2021).

Egg Production, EM, and EW

Compared to the Standard g_1 hens High g_1 hens produced one more egg/hen/period ($P = 0.013$, Table 5) and 2.95 g/d greater EM ($P = 0.022$). High and Standard g_1 hens produced 110 and 105 eggs/hen throughout the laying phase, respectively ($P = 0.047$; data not shown). Increasing BW by 20% (430 g) at 20 wk of age increased number of eggs per hen housed (Ekmay et al., 2012). In the current study for every week of earlier I_2, BW at 20 wk of age increased by 6.5%; number of eggs/hen increased by 0.33 egg/hen for the High g_1 treatment and decreased by 0.27 egg/hen and for the Standard g_1

Table 2. Effect of BW trajectory[1] (W) and time period on BW during rearing and laying phases in Ross 708 broiler breeder.

		BW trajectory																			
		Standard g_1										High g_1									
		I_2-0%		I_2-5%		I_2-10%		I_2-15%		I_2-20%		I_2-0%		I_2-5%		I_2-10%		I_2-15%		I_2-20%	
Phase	Period	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM	LSMean	SEM
	— wk —	— g —																			
Rearing	3	341	22.9	332	22.9	302	22.9	320	26.5	328	22.9	360	22.9	320	26.5	313	26.5	296	26.5	350	22.9
	5	553	15.7	555	15.7	538	15.7	554	18.2	560	15.7	610	15.7	595	18.2	598	18.2	544	18.2	581	15.7
	7	761^{b}	6.5	760^{b}	6.5	760^{b}	6.5	760^{b}	7.5	760^{b}	6.5	836^{a}	6.5	834^{a}	7.5	834^{a}	7.5	810^{a}	7.5	832^{a}	6.5
	9	957^{d}	1.0	955^{d}	1.0	957^{d}	1.0	960^{d}	1.2	967^{c}	1.0	1,051^{b}	1.0	1,052^{b}	1.2	1,052^{b}	1.2	1,055^{ab}	1.2	1,061^{a}	1.0
	11	1,136^{g}	1.0	1,136^{g}	1.0	1,142^{g}	1.0	1,161^{f}	1.2	1,198^{e}	1.0	1,248^{d}	1.0	1,250^{d}	1.2	1,257^{c}	1.2	1,274^{b}	1.2	1,310^{a}	1.0
	13	1,295^{i}	1.9	1,312^{h}	1.9	1,338^{g}	1.9	1,395^{f}	2.2	1,470^{c}	1.9	1,425^{e}	1.9	1,438^{d}	2.2	1,469^{c}	2.2	1,525^{b}	2.2	1,605^{a}	1.9
	15	1,462^{j}	1.3	1,513^{i}	1.3	1,587^{h}	1.3	1,687^{e}	1.6	1,811^{c}	1.3	1,604^{g}	1.3	1,652^{f}	1.6	1,729^{d}	1.6	1,829^{b}	1.6	1,955^{a}	1.3
	17	1,673^{j}	0.9	1,771^{i}	0.9	1,888^{g}	0.9	2,022^{e}	1.1	2,166^{c}	0.9	1,826^{h}	0.9	1,923^{f}	1.1	2,041^{d}	1.1	2,178^{b}	1.1	2,321^{a}	0.9
	19	1,945^{j}	1.1	2,078^{i}	1.1	2,218^{g}	1.1	2,362^{e}	1.3	2,499^{c}	1.1	2,106^{h}	1.1	2,237^{f}	1.3	2,378^{d}	1.3	2,523^{b}	1.3	2,660^{a}	1.1
	21	2,255^{j}	1.1	2,398^{i}	1.1	2,534^{g}	1.1	2,665^{e}	1.3	2,781^{c}	1.1	2,422^{h}	1.1	2,563^{f}	1.3	2,703^{d}	1.3	2,833^{b}	1.3	2,948^{a}	1.1
Laying	23	2,556^{j}	2.8	2,687^{i}	2.8	2,804^{g}	2.8	2,909^{e}	3.3	3,000^{c}	2.8	2,730^{h}	2.8	2,848^{f}	3.3	2,975^{d}	3.3	3,083^{b}	3.3	3,164^{a}	2.8
	25	2,813^{f}	16.2	2,922^{e}	16.2	2,989^{de}	16.2	3,094^{cd}	18.7	3,163^{bc}	16.2	2,996^{de}	16.2	3,029^{de}	18.7	3,187^{bc}	18.7	3,270^{ab}	18.7	3,328^{a}	16.2
	27	3,018^{f}	18.4	3,099^{ef}	18.4	3,150^{de}	18.4	3,231^{bcd}	21.3	3,280^{bc}	18.4	3,195^{cde}	18.4	3,207^{cde}	21.3	3,346^{ab}	21.3	3,412^{a}	21.3	3,439^{a}	18.4
	29	3,177^{e}	16.7	3,225^{de}	16.7	3,283^{cd}	16.7	3,324^{cd}	19.2	3,364^{bc}	16.7	3,356^{c}	16.7	3,332^{cd}	19.2	3,468^{ab}	19.2	3,503^{a}	19.2	3,531^{a}	16.7
	31	3,293^{f}	13.9	3,325^{ef}	13.9	3,365^{def}	13.9	3,395^{cde}	16.1	3,426^{cd}	13.9	3,466^{bc}	13.9	3,445^{cd}	16.1	3,558^{ab}	16.1	3,578^{a}	16.1	3,597^{a}	13.9
	33	3,382^{f}	13.5	3,402^{ef}	13.5	3,431^{def}	13.5	3,446^{def}	15.6	3,468^{cde}	13.5	3,552^{bc}	13.5	3,512^{cd}	15.6	3,619^{ab}	15.6	3,638^{ab}	15.6	3,651^{a}	13.5
	35	3,436^{d}	18.5	3,445^{d}	18.5	3,471^{d}	18.5	3,483^{cd}	21.4	3,485^{d}	18.5	3,604^{abc}	18.5	3,544^{bcd}	21.4	3,658^{ab}	21.4	3,671^{ab}	21.4	3,680^{a}	18.5
	37	3,478^{b}	17.8	3,483^{b}	17.8	3,496^{b}	17.8	3,505^{b}	20.5	3,497^{b}	17.8	3,646^{a}	17.8	3,595^{ab}	20.5	3,691^{a}	20.5	3,694^{a}	20.5	3,697^{a}	17.8
	39	3,510^{b}	22.0	3,506^{b}	22.0	3,517^{b}	22.0	3,528^{b}	25.4	3,536^{b}	22.0	3,677^{a}	22.0	3,596^{ab}	25.4	3,711^{a}	25.4	3,721^{a}	25.4	3,714^{a}	22.0
	41	3,530^{b}	25.0	3,532^{b}	25.0	3,533^{b}	25.0	3,548^{b}	28.8	3,558^{b}	25.0	3,661^{ab}	25.0	3,581^{ab}	35.3	3,733^{a}	28.8	3,732^{a}	28.8	3,733^{a}	25.0
Source of variation		— *P*-value —																			
Rearing	W	< 0.001																			
	Period	< 0.001																			
	W × Period	< 0.001																			
Laying	W	< 0.001																			
	Period	< 0.001																			
	W × Period	< 0.001																			

[1] A 3-phase Gompertz growth model was fitted to the Ross 708 female broiler breeder-recommended target BW to estimate the model coefficients. BW trajectories were designed with two levels of prepubertal BW gain (g_1) coefficient and 5 levels of pubertal growth phase inflection point (I_2) coefficient. g_1 was estimated from the breeder-recommended standard BW gain (Standard g_1) target, or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk, I_2-5% = 21.16 wk, I_2-10% = 20.05 wk, I_2-15% = 18.94 wk, I_2-20% = 17.82 wk.

[a–j] Means within rows with no common superscript differ ($P < 0.05$).

Table 3. Effects of prepubertal BW gain and pubertal growth inflection on BW at photostimulation (BWPS) and BW at first egg (BWFE) of Ross 708 broiler breeder pullets.

Effect[1]	g_1	AFE	SEM	BWPS	SEM	BWFE	SEM
		day		g			
g_1	Standard g_1	175.7	1.3	2,614[b]	2.42	2,943[b]	21.96
	High g_1	175.6	1.4	2,781[a]	2.64	3,112[a]	23.94
		day/wk		g/wk			
I_2		0.49	0.83	126	1.52	94	13.75
$I_2 \times g_1$	Standard g_1	0.49	0.83	126	1.52	94	13.75
	High g_1	1.48	1.19	190	2.17	59	19.71
Source of variation		*P*-value					
g_1		0.22		< 0.001		0.58	
I_2		0.046		< 0.001		< 0.001	
$I_2 \times g_1$		0.22		0.53		0.33	

[1]g_1: Prepubertal phase gain coefficient estimated by a 3-phasic Gompertz growth model fitted to the standard Ross 708 recommended BW gain target (Standard g_1) or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk, I_2-5% = 21.16 wk, I_2-10% = 20.05 wk, I_2-15% = 18.94 wk, I_2-20% = 17.82 wk.

[a–b]Means within columns with no common superscript differ ($P < 0.05$).

treatment ($P = 0.021$); EM increased by 0.916 g/d for the High g_1 treatment and decreased by 0.29 g/d for the Standard g_1 treatment ($P = 0.040$). As the decision of the PF system to feed birds was based on their target BW, the High g_1 birds received more feed during the laying phase compared to their Standard g_1 counterparts. Thus, after meeting their maintenance ME requirements, their egg production potential would not have been less limited by restricted ME intake, compared to the Standard g_1 hens. To our knowledge, this is the first time to investigate the effect of a systematically designed pubertal growth inflection point on EW and EM.

Increasing g_1 by 10% (160 g at 20 wk of age, Table 2) did not affect EW. This is in agreement with the results of previous studies where increasing target BW by 8% (158 g) at 20 wk of age (Fattori et al., 1991), 20% (365 g) at 18 wk of age (Hocking et al., 2002b), 8% (163 g) at 20 wk of age (van Emous et al., 2013), or 16% (370 g) at 20 wk of age (Gous and Cherry, 2004) did not affect EW. The reason for lack of an effect of increasing g_1 on EW maybe because the difference in BW at 20 wk of age (160 g) between the Standard and High g_1 birds was not large enough to affect the average EW. However, increasing target BW in other research by 21% (338 g) or 13% (229 g) at 20 wk of age was sufficient to increase EW (Renema et al., 2001; Sun and Coon, 2005). EW increased by 0.27 g/week of earlier I_2 ($P = 0.036$, Table 5). The difference in BW between birds with standard I_2 (22.29 wk) and those with I_2-20% (17.82 wk) was 554 g within both Standard and High g_1 hens at 20 wk of age (Table 2). This large difference in BW due to earlier pubertal growth might have increased EW in hens with advanced I_2 but did not persist once the BW trajectories started merging at 36 wk of age (Figure 1). The effect of BW trajectories on EW toward later phase of laying is not clear as the current study analysis was conducted until 42 wk of age.

Feeding Motivation

The frequency of daily station visits, visit:meal ratio, and meal size could all be indicators of feeding motivation. During the rearing phase, Standard g_1 pullets had approximately 7 more daily station visits compared to the High g_1 pullets ($P = 0.005$, Table 6), which would be

Table 4. Effects of prepubertal BW gain and pubertal growth inflection on shank length and estimated body fat content at 24 weeks of age in Ross 708 broiler breeder hens.

Effect[1]	g_1	Shank length[2]	SEM	Body fat[3]	SEM
		mm		%	
g_1	Standard g_1	98.4	0.8	8.04	0.38
	High g_1	99.9	0.8	8.47	0.38
		mm/wk		%/wk	
I_2		−0.038	0.511	−0.38	0.24
$I_2 \times g_1$	Standard g_1	−0.038	0.511	−0.38	0.24
	High g_1	−1.495	1.216	−0.53	0.59
Source of variation		*P*-value			
g_1		0.19		0.44	
I_2		0.036		0.013	
$I_2 \times g_1$		0.046		0.67	

[1]g_1: Prepubertal phase gain coefficient estimated by a 3-phasic Gompertz growth model fitted to the standard Ross 708 recommended BW gain target (Standard g_1) or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk, I_2-5% = 21.16 wk, I_2-10% = 20.05 wk, I_2-15% = 18.94 wk, I_2-20% = 17.82 wk.

[2]Shank length = tibiotarsus measured from top of flexed hock joint to bottom of footpad.

[3]Body fat (%) estimated by $\textit{Body fat}\ (\%) = 24.83 + 6.75\ (\ln \textit{skinfold}) - 3.87\ \textit{BW}$ where skinfold is abdominal skinfold thickness in cm and BW is in kg (Latshaw and Bishop, 2001).

Table 5. Effects of prepubertal BW gain and pubertal growth inflection on egg weight (EW), egg mass (EM), and number of eggs during 4 wk periods from 23 to 42 wk of age of Ross 708 broiler breeder hens.

Effect[1]	g_1	Period (wk)	EW	SEM	EM	SEM	Egg	SEM
			g		g/d		Egg/hen/period	
g_1	Standard g_1		59.2	0.4	42.73[b]	0.70	20[b]	0.3
	High g_1		60.0	0.4	45.68[a]	0.76	21[a]	0.4
Period		23 to 26	52.8[d]	0.5	20.15[c]	1.70	11[d]	0.9
		27 to 30	56.8[c]	0.5	52.07[a]	0.86	26[a]	0.4
		31 to 34	59.6[b]	0.5	44.29[b]	1.06	21[c]	0.5
		35 to 38	64.5[a]	1.1	53.73[a]	1.40	24[ab]	0.6
		39 to 42	64.1[a]	0.8	50.78[a]	0.90	23[bc]	0.4
			g/wk		g/d/wk		Egg/hen/wk	
I_2			−0.27	0.21	0.29	0.40	0.27	0.18
$I_2 \times g_1$	Standard g_1		−0.27	0.21	0.29	0.40	0.27	0.18
	High g_1		−0.37	0.52	−0.916	0.99	-0.33	0.44
Source of variation			P-value					
g_1			0.13		0.022		0.013	
I_2			0.036		0.29		0.13	
$I_2 \times g_1$			0.75		0.040		0.021	
Period			< 0.001		< 0.001		< 0.001	

[1]g_1: Prepubertal phase gain coefficient estimated by a 3-phasic Gompertz growth model fitted to the standard Ross 708 recommended BW gain target (Standard g_1) or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk, I_2-5% = 21.16 wk, I_2-10% = 20.05 wk, I_2-15% = 18.94 wk, I_2-20% = 17.82 wk.

[a–d]Means within columns with no common superscript differ ($P < 0.05$).

Table 6. Effects of prepubertal BW gain and pubertal growth inflection on the station visit frequency, meal frequency, feeding motivation index, and meals size during rearing phase of Ross 708 broiler breeder pullets.

Effect[1]	g_1	Period	Visits	SEM	Meals	SEM	Feeding motivation index[2]	SEM	Meal size	SEM	ADFI	SEM
		wk	visit		meals		visits/meal		g/visit		g/day	
g_1	Standard g_1		53.7[a]	1.9	7.1[b]	0.1	8.6[a]	0.3	9.0	0.1	62.2[b]	0.8
	High g_1		46.0[b]	2.1	7.6[a]	0.1	7.0[b]	0.4	9.2	0.1	67.3[a]	0.9
Period		3 to 6	34.9[c]	3.2	8.4[a]	0.3	6.1[c]	0.7	7.0[d]	0.3	50.6[c]	2.8
		7 to 10	63.1[a]	4.0	6.2[c]	0.2	11.0[a]	0.7	8.6[c]	0.2	53.3[c]	2.0
		11 to 14	55.7[ab]	3.6	6.6[c]	0.1	8.9[ab]	0.6	8.7[c]	0.1	56.2[c]	0.5
		15 to 18	49.5[b]	2.6	7.2[b]	0.1	7.3[bc]	0.5	10.3[b]	0.1	74.0[b]	1.0
		19 to 22	46.1[b]	2.5	8.3[a]	0.2	5.9[c]	0.4	11.0[a]	0.2	89.5[a]	1.0
			visit/wk		meals/wk		visits/meal/wk		g/visit/wk		g/day/wk	
I_2			2.55	1.15	−0.34	0.05	0.75	0.19	−0.08	0.06	−3.9	0.3
$I_2 \times g_1$	Standard g_1		2.55	1.15	−0.34	0.05	0.75	0.19	−0.08	0.06	−3.9	0.3
	High g_1		−1.08	1.65	−0.34	0.08	0.16	0.47	−0.03	0.09	−3.4	0.8
Source of variation			*P*-value									
g_1			0.005		< 0.001		< 0.001		0.17		< 0.001	
I_2			0.37		< 0.001		0.001		0.21		< 0.001	
$I_2 \times g_1$			0.029		0.99		0.038		0.038		0.35	
Period			< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	

[1]g_1: Prepubertal phase gain coefficient estimated by a 3-phasic Gompertz growth model fitted to the standard Ross 708 recommended BW gain target (Standard g_1) or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk, I_2-5% = 21.16 wk, I_2-10% = 20.05 wk, I_2-15% = 18.94 wk, I_2-20% = 17.82 wk.

[2]Feeding motivation index was defined as daily station visit:meal ratio.

[a–c]Means within columns with no common superscript differ ($P < 0.05$).

consistent with a higher degree of hunger in the Standard g_1 birds. For every week that I_2 was advanced, the station visit frequency decreased by 2.55 visits in the Standard g_1 pullets and increased by 1.08 visits in the High g_1 group. Birds with earlier I_2 started to accumulate pubertal gain earlier than those with standard I_2 resulting in a lower degree of feed restriction. Thus, it is possible that those Standard g_1 birds with earlier I_2 were less hungry and less motivated to enter the feeding station to seek feed compared to their counterparts with standard I_2. High g_1 pullets might have approached a point of satiety because of having 10% higher g_1; thus, earlier I_2 did not decrease their daily station visits. During the laying phase, the frequency of daily station visits was not affected by g_1 but was increased by 0.83 and 4.97 visits/d/wk of earlier I_2 ($P = 0.002$).

Increasing g_1 by 10% increased meal frequency during rearing ($P < 0.001$, Table 6) and laying phase ($P = 0.041$, Table 7) because of increased target BW in the High g_1 birds to support maintenance requirements, prepubertal growth (muscle and skeletal development) during rearing, pubertal growth (development of reproductive tract and fat deposition) toward the end of rearing, and egg production throughout the laying phase. Meal frequency increased by 0.34 meal/wk of earlier I_2 during the rearing phase ($P < 0.001$, Table 6). This was

Table 7. Effects of prepubertal BW gain and pubertal growth inflection on the station visit frequency, meal frequency, motivation index, and meals size during laying phase of Ross 708 broiler breeder hens.

Effect[1]	g_1	Period	Visits	SEM	Meals	SEM	Feeding motivation index[2]	SEM	Meal size	SEM	ADFI	SEM
		—wk—	—— visit ——		—— meals ——		——— visits/meal ———		—— g/visit ——		—— g/day ——	
g_1	Standard g_1		37.8	1.5	9.4^{b}	0.2	4.8^{a}	0.2	15.1	0.2	132.9^{b}	0.9
	High g_1		34.4	1.6	10.0^{a}	0.2	4.0^{b}	0.2	15.2	0.3	141.0^{a}	0.9
Period		23 to 26	45.0^{a}	2.8	10.8^{a}	0.4	5.4^{a}	0.4	9.7^{d}	0.2	101.1^{d}	1.9
		27 to 30	33.6^{b}	2.2	11.6^{a}	0.4	3.2^{b}	0.3	13.8^{c}	0.4	147.6^{b}	1.2
		31 to 34	37.9^{ab}	2.4	9.2^{b}	0.3	5.2^{a}	0.4	18.5^{a}	0.5	159.7^{a}	1.8
		35 to 38	31.4^{b}	2.4	8.2^{b}	0.3	4.1^{ab}	0.3	17.5^{ab}	0.5	138.3^{c}	1.4
		39 to 42	32.5^{b}	2.1	8.9^{b}	0.3	4.2^{ab}	0.3	16.2^{b}	0.5	138.1^{c}	1.0
			— visit/wk —		– meals/wk –		——— visits/meal/wk ———		— g/visit/wk —		– g/day/wk –	
I_2			−0.83	0.90	0.25	0.12	−0.33	0.12	−0.18	0.12	1.3	0.5
$I_2 \times g_1$	Standard g_1		−0.83	0.90	0.25	0.12	−0.33	0.12	−0.18	0.12	1.3	0.5
	High g_1		−4.97	1.29	0.08	0.29	−0.54	0.29	−0.14	0.18	−1.2	0.7
Source of variation			———		———		——— *P*-value ———		———		———	
g_1			0.11		0.041		0.010		0.70		< 0.001	
I_2			< 0.001		0.055		< 0.001		0.068		0.88	
$I_2 \times g_1$			0.002		0.34		0.22		0.83		< 0.001	
Period			0.002		< 0.001		< 0.001		< 0.001		< 0.001	

[1] g_1: Prepubertal phase gain coefficient estimated by a 3-phasic Gompertz growth model fitted to the standard Ross 708 recommended BW gain target (Standard g_1) or 10% higher (High g_1). Second growth phase (pubertal) inflection point (I_2) was advanced such that I_2-0% = 22.29 wk, I_2-5% = 21.16 wk, I_2-10% = 20.05 wk, I_2-15% = 18.94 wk, I_2-20% = 17.82 wk.

[2] Feeding motivation index was defined as daily station visit:meal ratio.

[a–c] Means within columns with no common superscript differ ($P < 0.05$).

expected, as feed restriction is reportedly most severe from 8 to 16 wk of age when broiler breeders are restricted 25 to 30% of the intake of unrestricted birds (de Jong and Jones, 2006). Thus, increasing BW target by advancing I_2 decreased the level of feed restriction as the birds had access to feed based on their BW. This is in line with an increase in ADFI by 3.9 g/d/wk of earlier I_2 ($P < 0.001$). However, for every week of earlier I_2, meal frequency tended to decrease by 0.25 meals/d during the laying phase ($P = 0.055$, Table 7).

Feeding motivation index was defined as the visit:meal ratio indicating the feed seeking motivation, driven by the number of meals allowed. Feeding motivation index for the Standard g_1 and High g_1 birds was 8.6 and 7.0 visits/meal during the rearing phase (Table 6) and 4.8 and 4.0 visits/meal during the laying phase (Table 7), respectively. Thus, High g_1 birds had 1.6 and 0.8% lower feeding motivation index than that of the Standard g_1 birds during the rearing and laying phase, respectively. Earlier I_2 reduced feeding motivation index during the rearing phase by 0.75 and 0.16 visits/meal in the Standard g_1 and High g_1 pullets, respectively ($P = 0.038$, Table 6). A lower reduction in feeding motivation index of High g_1 pullets compared to their Standard g_1 counterparts indicates that increasing g_1 by 10% had already decreased their hunger in such a way that earlier I_2 (further release in growth restriction) just had a minor effect on alleviating their hunger. These results are in line with Savory and Lariviere (2000) who investigated broiler breeder feeding motivation using an operant conditioning system during the rearing phase. The birds were receiving feed as a reward after pecking at a disc implemented in the operant system. The authors measured the number of operant responses in 12 min as a proxy of feeding motivation and found a positive relationship between feed motivation and suppression of growth rate. Their study showed that the number of operant responses decreased by 63, 45, 57, and 62 times per each kg increase in BW at 8, 10, 12, and 14 wk of age, respectively. However, the results of the current study during the rearing phase are in contrast with results from Zukiwsky et al. (2021) who did not observe a decrease in feed seeking behavior during the rearing phase as BW increased up to 22.5% above the recommended BW target. In fact, they used daily station visits as an indicator of feed seeking behavior and did not account for the meal frequency by calculating the visit:meal ratio. In the current analysis, the feeding motivation index accounted for the meal frequency. Earlier pubertal growth reduced feeding motivation index for both Standard g_1 and High g_1 pullets. However, using daily station visit frequency on its own showed an increase in "feeding motivation" for those High g_1 pullets with earlier I_2 compared with their counterparts with a standard I_2. Therefore, it could be hypothesized that visit:meal ratio might be a better indicator of feeding motivation compared to daily station visit frequency.

Feeding motivation is affected by both external and internal factors. For instance, feeding motivation in broiler breeders is affected by both increased appetite because of genetic selection (internal) and the availability and allocation of feed in the environment (external). Every day a hen produced an egg, BW of the hen was reduced by the weight of the egg, so the hen qualified for additional feed allocation through the PF system, as the PF feed allocation decision was based on BW. During the laying phase, feeding motivation index increased by 0.33 visits/meal/wk of earlier I_2 ($P < 0.001$). As the birds with earlier I_2 commenced egg production earlier than those with standard I_2 ($P = 0.046$, Table 3), they qualified for additional feed allocation as an external feeding motivation. It could have motivated the birds with earlier I_2 to seek feed from the PF system leading to an increased visit:meal ratio.

Meal size might also be an indicator of hunger and feeding motivation. A larger meal size was related to a faster feed intake rate, as birds had 60 s to eat off the feeder before being ejected from the PF system. Meal size increased by age ($P < 0.001$, Tables 6 and 7) but was not affected by the g_1 treatment during rearing and laying phases. During the rearing phase meal size increased by 0.08 and 0.03 g/visit/wk of earlier I_2 for the Standard g_1 and High g_1 pullets, respectively ($P = 0.038$, Table 6). This corresponds with an increase in ADFI by 3.9 g/d/wk of earlier I_2 to fulfill nutrient requirements associated with weight gain ($P < 0.001$). Furthermore, High g_1 pullets had 5.1 g/d greater ADFI than that of Standard g_1 pullets ($P < 0.001$), which was because of decreased feed restriction in the High g_1 pullets. During the laying phase, meal size tended to increase by 0.18 g/visit/wk of earlier I_2 ($P = 0.068$, Table 7). Earlier I_2 decreased ADFI by 1.3 g/d/wk for the Standard g_1 hens and increased it by 1.2 g/d/wk for the High g_1 birds ($P < 0.001$). This might have been due to higher station visit frequency with earlier I_2 for High g_1 birds (4.97 visit/wk) compared to that of Standard g_1 (0.83 visit/wk) hens during the laying phase (Table 7).

To decrease the gap between broiler breeders and their offspring target BW, and mitigate adverse effects of severe feed restriction, the current study was designed focusing on relaxed growth restriction during prepubertal growth phase and earlier pubertal growth phase. To our knowledge, this is the first investigation of the effects of systematic evaluation of BW targets using designed growth trajectories based on earlier pubertal growth phase in broiler breeders. The results of the current study indicated that the strategy of earlier pubertal growth could reduce hunger in broiler breeders during rearing and laying phase. Furthermore, it allowed female breeders to achieve a sufficient foundation and appropriate fat level for sexual maturation, which advanced sexual maturation. Relaxed feed restriction during prepubertal phase and earlier pubertal growth showed prominent effects on egg production, EM, and EW as proxies for reproductive output.

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DISCLOSURES

The authors declare that there is no conflict of interest.

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