Welfare and performance of slower growing broiler breeders during rearing

Aitor Arrazola, and Stephanie Torrey[1]

Department of Animal Biosciences, University of Guelph, Guelph, Ontario, N1G 2W1 Canada

ABSTRACT Current commercial strains of broiler breeders can only achieve an optimal reproductive performance under feed restriction. However, chronic feed restriction in broiler breeders is a welfare concern because of physiological and behavioral signs of hunger, lack of satiety, and frustrated feeding motivation. The objective of this research was to assess the welfare and performance of slower growing broiler breeders during rearing. A total of 360 broiler breeder chicks from 3 female strains (100 chicks per strain) and 2 male strains (20 and 40 chicks per strain) were raised in four identical pens per strain. Strain B and C pullets and X cockerels were slower growing strains, and strain A pullets and Y cockerels were intermediate growing strains. Birds were weighed and scored individually for footpad lesions, hock burns and feather coverage. Data were analyzed using generalized linear mixed models with pen nested in the models and age as a repeated measure. Compared to B and C pullets, strain A pullets grew faster, had poorer body weight uniformity, and started feed restriction 2 wk earlier to control growth rate. Strain A pullets also had higher feeding rate at 3 and 5 wk, higher water intake at 4 and 5 wk, and higher prevalence of footpad lesions at 6 wk than the other pullet strains. Fault bars in wing feathers (an indicator of chronic stress) were more numerous in A pullets than in B and C pullets. Our results indicate that pullets showed little feather coverage loss during early rearing and had good body weight uniformity and low cumulative feed intake at the end of rearing. Slower growing broiler breeders may still require some degree of feed restriction to control growth rate, and strains with lower feed restriction exhibited lower signs of feeding frustration and high body weight uniformity.

Key words: slow-growing chicken, broiler, feed efficiency, feed restriction, genetics

2021 Poultry Science 100:101434
https://doi.org/10.1016/j.psj.2021.101434

INTRODUCTION

Selection for fast growing broiler chickens has resulted in poor reproductive performance due to obesity-related problems (Savory et al., 1993; Hocking et al., 2001; Chen et al., 2006). Feed restriction is a common on-farm practice to achieve optimal reproductive performance in broiler breeders (de Jong and Guémené, 2011; Tolkamp and D'Eath, 2016) but raises welfare concerns because broiler breeders show physiological and behavioral signs of hunger, lack of satiety, and feeding frustration (D'Eath et al., 2009). These indicators include signs of distress and poor welfare such as elevated plasma corticosterone concentration (Savory et al., 1996; de Jong et al., 2003), high heterophil to lymphocyte ratio (Savory et al., 1996), basophilia (Arrazola et al., 2019), fault bars in plumage (Arrazola et al., 2019, 2020b), and the performance of abnormal repetitive behavior (Morrissey et al., 2014b; Arrazola et al., 2020a), severe feather pecking (Girard et al., 2017a), and overdrinking (Sandilands et al., 2005). Consequently, broiler breeders develop poor feather coverage and have high water usage during rearing (Sandilands et al., 2006; Morrissey et al., 2014a; van Emous et al., 2015), resulting in high litter moisture and pododermatitis (Arrazola et al., 2019). Therefore, the feeding management of conventional broiler breeders has raised welfare and sustainability concerns.

Much attention has been focused on developing alternative feeding strategies that reduce the feeding motivation of feed-restricted conventional broiler breeders (de Jong et al., 2005; Nielsen et al., 2011; Arrazola et al., 2019; Aranibar et al., 2020; Tahamtani et al., 2020). However, these feeding strategies do not eliminate signs of chronic hunger (Sandilands et al., 2005 and 2006; Morrissey et al., 2014a,b; Arrazola et al., 2019, 2020b) and can raise additional ethical concerns in the case of non-daily feeding schedules (Lindholm et al., 2018). Using slow growing strains can reduce or remove the need for feed restriction in broiler breeder production (Heck et al., 2004; Dawkins and Layton, 2012). There is

Received April 14, 2021.
Accepted August 15, 2021.

[1]Corresponding author: storrey@uoguelph.ca

growing interest in the production of slower growing strains of broiler chickens to improve their welfare and welfare outcomes (Dou et al., 2009; Dixon, 2020), which necessitates the use of slower growing broiler breeder strains. Alternative broiler breeder strains have a slower growth rate and require lower levels of feed restriction than conventional broiler breeder strains to achieve an optimal reproductive performance (Heck et al., 2004; Jones et al., 2004). From a welfare perspective, slower growing broiler breeders are expected show fewer signs of hunger, lack of satiety, and feeding frustration than conventional strains (de Jong et al., 2003). From the production perspective, commercial breeder guidelines for slower growing broiler breeders suggest that these strains require lower feed allotment and achieve higher hatching egg production than conventional strains (Aviagen, 2018; Hubbard, 2019; Sasso 2019). Using slower growing strains of broiler breeders may alleviate welfare concerns and lead to a more efficient and sustainable production system. Yet, little is known about the performance and welfare of slower growing broiler breeders. Thus, the objective of this study was to assess the welfare and performance outcomes of slower growing strains (2 slower growing strains and an intermediate growing strain of females, and 2 strains of males) of broiler breeders during rearing. Slower growing broiler breeder strains are hypothesized to show signs of improved welfare and performance while staying within target growth curves.

MATERIALS AND METHODS

All procedures used in this experiment were approved by the University of Guelph's Animal Care Committee (AUP # 3746) and were in accordance with the guidelines outlined by the Canadian Council for Animal Care (NFACC, 2016).

Experimental Design, Housing, and Management

A total of 360 broiler breeders from 5 strains of slower growing broiler breeders (3 female strains and 2 male strains) were raised at the research station of the University of Guelph from August 2018 to January 2019. Three female strains and 2 male strains were donated courtesy of an anonymous breeding company at 1 d of age. Birds were imported from Europe, via an approximate 8-h flight, 4-h lairage, and 1-h truck transport. Female strains were strain A (100 chicks), strain B (100 chicks) and strain C (100 chicks), and male strains were strain X (20 chicks) and strain Y (40 chicks). According to breeder guidelines, strain B and C pullets, and strain X cockerels were slow growing strains, and strain A pullets and strain Y cockerels were intermediate growing strains. In this experiment, strain A pullets and strain Y cockerels were considered the closest strains to conventional broiler breeders. The 5 strains were raised independently in 4 identical pens per strain (except for strain X cockerels with only 2 pens) during rearing. Each strain was raised under the same housing and management conditions, and feed management followed specific growth curves per strain.

Chicks were vaccinated against Marek's disease, coccidiosis, and infectious bronchitis at the hatchery based on local recommendations and the health program of the research facility. Beaks of females and males were left intact, and males received toe trimming at the hatchery. Chicks were placed in one double floor pen per strain (1.63 m wide × 1.22 m deep × 0.82 m height) upon arrival. Each pen was equipped with one round feeder (60 cm diameter), one 3-gallon hanging waterer (4 nipples; Farm Tuff, ON, Canada), and 2 heat mats (60 cm deep × 120 cm length; Kane MFG, IA). Heat mats were placed under softwood shavings. At 13 days old, chicks were moved to 4 identical floor pens per strain (0.82 m wide × 1.22 m deep × 0.82 m height) with 25 chicks per female pen and 10 chicks per male pen (except for strain X cockerels with only 2 pens). Pens had softwood shavings for bedding (at least 5 cm deep) and were equipped with one round feeder and one hanging waterer per pen. Chicks were reared in 2 rooms, and all the strains were represented in each room during early rearing (from 0 to 9 wk of age). Pullets and cockerels remained in this facility until 9 wk of age. At 10 wk of age, they were moved to another building where they were placed in four floor pens (25 pullets per pen and 10 cockerels per pen) per strain (except for strain X cockerels with only 2 pens). Pullets and cockerels were raised in separate rooms from 10 to 21 wk of age for independent light control. Floor pens were 2.36 m wide × 1.83 m deep (female pens: 5.8 pullets/m^2, and male pens: 2.3 cockerels/m^2) with softwood shavings and mineral PECKstones (Protekta, Inc., Lucknow, ON, Canada). Female pens were equipped with one trough feeder (13 cm wide × 152 cm long × 5 cm deep, 12.2 cm/pullet) and one drinker line (7 nipples, 1 nipple per 3.6 pullets), and male pens were equipped with one round feeder (15 cm/cockerel) and one drinker line (7 nipples, 1 nipple per 0.7 cockerels).

Pens were managed according to breeding company guidelines, and conditions were the same for all strains except for strain-specific feed allotment (see results for further detail). The room temperature was set at 32°C at placement and gradually decreased to 21°C by 6 wk of age. The light program started at 60 lux for 22L:2D at placement, and the photoperiod and light intensity gradually decreased to 10 lux for 8L:16D by 8 d of age. At 20 wk of age, light intensity increased to 30 lux at 10L:14D. Lights came on at 0900 h, and birds were fed approximately 30 min later. Pullets and cockerels were fed daily following a commercial feeding program with 3-stage diets during rearing (Bio-Plus Broiler Breeder starter, developer, and transition diets; Floradale, ON, Canada). Chicks were fed ad libitum until 2 wk of age for males and strain A females, and until 4 wk of age for strain B and C females. Then, the feed allotment of each strain was calculated to follow specific growth curves for each strain. Water was provided ad libitum throughout rearing. Birds were checked twice per day, and mortality was recoded as it occurred. Pullets and cockerels were vaccinated against infectious laryngotracheitis at 9 wk of age, and against Newcastle disease and infectious bronchitis at 12 wk of age.

Data Collection

Body Weight, Body Weight Uniformity, and Fleshing Chicks were weighed individually after feeding every week from 1 to 9 wk of age and at 21 wk of age, and in groups upon arrival and every week from 12 to 20 wk of age. Body weight uniformity is shown as the coefficient of variation (**CV**) and calculated weekly for each pen (standard deviation of body weight by average body weight). At 9 wk of age, pullets and cockerels were scored for fleshing conformation using a 3-point scale. Fleshing score 1 was defined as pronounced keel bone, fleshing score 3 indicated that keel bone was imbedded in breast muscle, and fleshing score 2 was intermediate. Fleshing was assessed 5-cm away from the front of keel bone using a square ruler.

Feed and Water Intake Feeder content was weighed at the end of each week and every time feed was added. Feeders were emptied at the end of the ad libitum feeding period, and feed allotment was weighed every day for each pen and adjusted for mortality as it occurred during feed restriction. Feed efficiency was calculated at 9 and 21 wk of age using the feed conversion ratio (**FCR**) of each pen by dividing the average body weight gain by the cumulative feed intake correspondingly for each period. Waterers were weighed at the end of each week and every time water was added until 9 wk of age. The daily water intake per bird was calculated by subtracting the initial waterer weight at the start of the week (plus every time water was added into waterers) minus the final waterer weight at the end of the week and dividing by 7 and the number of birds per pen.

Health and Welfare Indicators Birds were scored individually for footpad lesions and hock burns and feather coverage after being weighed during early rearing (every week from 1 to 9 wk of age). Birds were assessed for footpad lesions and hock burns according to the 5-point scoring system in Table 1. Feather coverage was scored using a 6-point scoring system for each given body area (score 0: no visible feather or skin damage; score 1: less than 10% feather damage or loss; score 2: between 10 and 50% feather damage or loss; score 3: more than 50% feather damage or loss; score 4: between 10 and 50% feather damage or loss with skin lesion[s]; score 5: more than 50% feather damage or loss with skin lesion[s]). Six body areas were assessed including head, neck, back, vent, wing, and tail. Scores from the 6 areas were summed together to result in a total feather coverage score from 0 to 30, with 30 being the worst feather coverage condition (Morrissey et al., 2014a; Arrazola et al., 2019).

Two wing feathers (P8, the third left and right of outer wing feathers) were collected at 10 wk of age during the juvenile-to-adult moult. Fault bars are translucent lines perpendicular to the rachis of the feather associated with stressful events during feather growth (Jovani and Rohwer, 2017; Arrazola and Torrey, 2019), and a researcher blind to strains counted the number of fault bars in each feather.

Feeding motivation was estimated using a 20-min feed intake test performed in the birds' home pens at 3, 5, 7, and 8 wk of age. At their regular feeding time, the feed intake in 20 min after being fed was determined. Feeders were weighed before and after the feed intake test, and birds were weighed after the feed intake test. The relative feed intake to body weight was calculated by dividing the feed intake during the test by body weight.

Statistical Analyses

The effect of the strain on the performance outcomes and welfare indicators was analysed separately by sex using generalized linear mixed models using SAS Ver. 9.4 (SAS Institute, Cary, NC). The degree of significance was set for probability values (P) lower than 0.05 and tendency for probability values equal to or lower than 0.10.

Strain, age, and their interaction were included as fixed effects for each model. Room, pen, and pen location within the room were included in the covariance structure as random effects with age as a repeated measure. Pairwise comparisons between strains were adjusted for multiple comparisons using the Tukey test. Model assumptions were assessed using the scatterplot of studentized residuals for homoscedasticity, linear predictor for linearity, and Shapiro-Wilk test for normality. Score data (fleshing score, footpad dermatitis, and hock burns) were analysed using the multinomial distribution.

Table 1. Scoring system for footpad lesions and hock burns based on the prevalence and severity of tissue damage using a 4-point scale for broiler breeders[1].

Score	Footpad lesions[2]	Hock burns
0	No visible	No visible
1	Lesion affected less than 25% of surface area without ulceration.	One hock burn affected less than 0.25 cm^2.
2	Lesion affected equal to or more than 25% of surface area without ulceration.	Two or more hock burns, the largest less than 0.25 cm^2.
3	Lesion(s) affected less than 25% of surface area with ulceration, covered by crust, or bumble foot or swollen.	One hock burn equal to or larger than 0.25 cm^2.
4	Lesion(s) affected equal to or more than 25% of surface area with ulceration covered by crust or, bumble foot, or swollen.	Two or more hock burns equal to or larger than 0.25 cm^2.

[1]Modified from Dawkins et al. (2004) and Allain et al. (2009, 2013).
[2]Footpad and toe pad included in total surface area.

RESULTS

Mortality was below 2% for pullets and 6% for cockerels during the first week of age and 3% for pullets (strain A: 6%, strain B: 1%, and strain C: 2%) and 0% for cockerels from 1 to 21 wk of age.

Body Weight, Body Weight Uniformity, and Fleshing

The growth curve of pullets differed among strains (Figure 1; $F_{14,63} = 16.84$, $P < 0.001$). Strain A pullets grew faster than strain B ($t_9 = 10.58$, $P < 0.001$) and C pullets ($t_9 = 6.48$, $P = 0.001$), resulting in strain A pullets being heavier than strain B and C pullets at 9 and 21 wk of age (Table 2). The growth rate was higher for strain B than C pullets from 1 to 9 wk of age ($t_9 = 4.10$, $P = 0.007$) but similar between both strains from 10 to 21 wk of age (Figure 1; $t_9 = 0.62$, $P = 0.81$). Cockerel strains followed similar growth curves throughout rearing without differences between strains (early rearing: $F_{7,28} = 0.59$, $P = 0.76$; and late rearing: $F_{6,24} = 0.91$, $P = 0.51$).

The CV of body weight differed significantly among pullet strains depending on their age until 9 wk of age (Figure 2; $F_{14,63} = 3.34$, $P < 0.001$) without differences at 21 wk of age ($F_{2,9} = 0.60$, $P = 0.57$). The CV of body weight increased for strain A pullets from 2 to 8 wk of age ($t_{63} = 3.93$, $P = 0.035$) and was higher by 9 wk of age for strain A pullets (10.2 ± 1.0%) compared to strain B pullets (5.9 ± 1.0%; $t_{14} = 3.06$, $P = 0.014$). At 21 wk of age, the CV of body weight was 7.9%, 8.3%, and 9.5% for strain A, B, and C pullets, respectively. The CV of body weight was similar between both strains of cockerels from 2 to 9 wk of age (Figure 2; $F_{1,4} = 0$, $P = 0.98$) but differed at 21 wk of age ($F_{1,4} = 8.57$, $P = 0.043$). At 21 weeks of age, strain Y cockerels had higher CV of body weight (12.8 ± 0.8%) than strain X cockerels (9.6 ± 1.1%; $t_4 = 2.93$, $P = 0.043$).

Table 3 summarized the frequency of fleshing scores at 9 wk of age. The frequency of score 3 (i.e., over-conditioning/fleshing) was higher for cockerels than pullets,

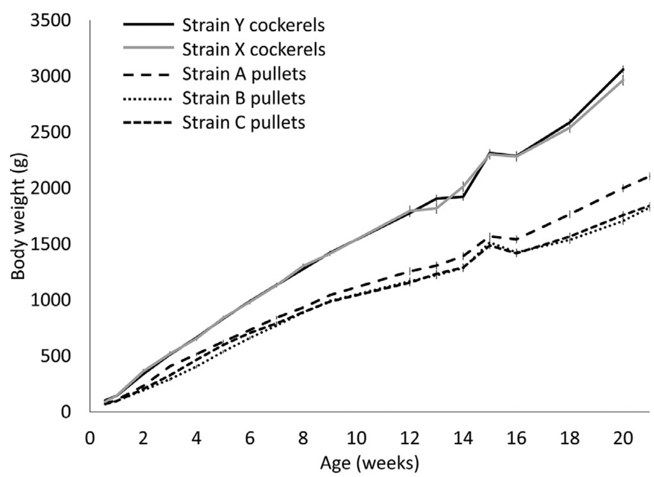

Figure 1. The growth rate of slower growing broiler breeders during rearing (mean ± SE). Solid lines refer to two strains of cockerels (X in gray, and Y in black), and broken lines to three strains of pullets (A in wide-dashed, B in dotted, and C in narrow-dashed). The growth rate of the broiler breeder pullets varied among strains over time ($P < 0.01$).

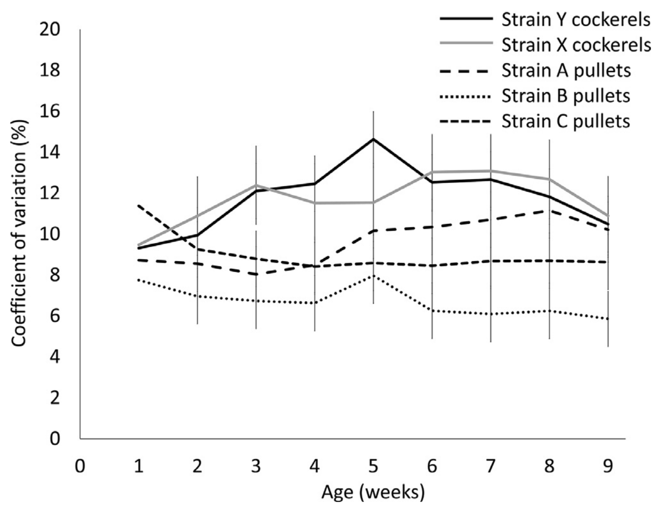

Figure 2. The body weight uniformity of slower-growing broiler breeders during early rearing (mean ± SE). Solid lines refer to two strains of cockerels (X in solid gray and Y in solid black), and broken lines to three strains of pullets (A in wide-dashed, B in dotted, and C in narrow-dashed). The CV of body weight for the broiler breeder pullets fluctuated depending on the strain over time ($P = 0.001$).

Table 2. The cumulative feed (FI) and water intake (WI) per bird, body weight (BW), and feed conversion ratio (FCR) of slower growing broiler breeders by strain at 9 and 21 wk of age (mean ± SE).

	Pullets			Cockerels	
Until wk 9	A	B	C	X	Y
BW (kg)	1.04 ± 0.01[a]	0.99 ± 0.01[b]	0.99 ± 0.01[b]	1.44 ± 0.01	1.42 ± 0.02
FI (kg/bird)	2.61 ± 0.01[a]	2.60 ± 0.01[a]	2.51 ± 0.01[b]	3.28 ± 0.01[a]	3.07 ± 0.01[b]
WI (l/bird)	6.37 ± 0.08[a]	3.82 ± 0.08[c]	4.45 ± 0.08[b]	7.49 ± 0.27	6.87 ± 0.19
FCR	2.46 ± 0.03[b]	2.63 ± 0.03[a]	2.56 ± 0.03[a]	2.16 ± 0.01[†]	2.09 ± 0.01[‡]
Until wk 21:					
BW (kg)	2.07 ± 0.04[a]	1.83 ± 0.04[b]	1.84 ± 0.02[b]	2.97 ± 0.02[‡]	3.06 ± 0.02[†]
FI (kg/bird)	8.33 ± 0.12[a]	7.70 ± 0.12[b]	7.80 ± 0.12[b]	10.20 ± 0.19	10.06 ± 0.12
FCR	4.21 ± 0.18	4.36 ± 0.17	4.34 ± 0.17	3.53 ± 0.07	3.37 ± 0.05

[a-b]Different letters indicate significant mean differences within a row for pullet or cockerel strains.
[†-‡]Different symbols refer to a tendency for mean difference within a row for pullet or cockerel strains.

Table 3. Frequency of fleshing scores in slow growing broiler breeder pullets ($F_{1,13} = 6.71$, $P = 0.019$) and cockerels ($F_{1,3} = 0$, $P = 0.97$) by strain at 9 wk of age.

	Pullets			Cockerels	
Score[1]	A	B	C	X	Y
1	60.6%	59.2%	31.3%	5.0%	2.5%
2	39.4%	40.8%	68.7%	80.0%	87.5%
3	0.0%	0.0%	0.0%	15.0%	10.0%

[1]Score: 1 (pronounced keel bone), 2 (evident keel bone), and 3 (keel bone embedded in breast muscle).

and none of the pullets scored 3 at 9 wk of age. Pullets scored differently depending on their strain ($F_{1,13} = 6.71$, $P = 0.019$) whereas both strains of cockerels scored similarly ($F_{1,3} = 0$, $P = 0.97$). Strain C pullets scored higher than strain A ($F_{1,8} = 10.74$, $P = 0.011$) and B pullets ($F_{1,8} = 9.6$, $P = 0.014$), and strain A and B pullets scored similarly (Table 3; $F_{1,8} = 0.03$, $P = 0.87$).

Feed and Water Intake

The daily feed intake per bird is illustrated in Figure 3A, and the cumulative feed intake per bird is summarized in Table 2. Feed restriction started at 2 wk of age for strain A pullets and 2 wk later for strain B and C pullets. Feed allotment increased weekly for all pullets during feed restriction, but this increase was smaller for strain C pullets compared to the other pullet strains (Figure 3A). The cumulative feed intake per pullet until 9 wk of age was lower for strain C than for strain A ($t_8 = 3.8$, $P = 0.012$) and B pullets ($t_8 = 6.85$, $P < 0.001$). At the end of rearing, the cumulative feed intake per pullet was higher for strain A than for strain B ($t_8 = 5.81$, $P < 0.001$) and C pullets ($t_8 = 5.41$, $P = 0.001$). Both male strains started feed restriction at 2 wk of age, and weekly feed allotment was larger for strain X cockerels compared to strain Y cockerels (Figure 3A). The cumulative feed intake per cockerel until 9 wk of age was lower for Y compared to X cockerels ($t_4 = 54.61$, $P < 0.001$) without significant differences until 21 wk of age (Table 2).

The daily water intake per bird is illustrated in Figure 3B, and the cumulative water intake per bird is summarized in Table 2. The strain of pullets affected the daily water intake depending on the week of age ($F_{12,54} = 4.76$, $P < 0.001$) without differences in daily water intake between both strains of cockerels ($F_{6,24} = 1.04$, $P = 0.43$). The daily water intake was significantly higher for strain A pullets than for strain B pullets from 2 to 8 wk of age and than for C pullets from 3 to 7 wk of age (Figure 3B). The cumulative water intake was higher for strain A pullets than for B ($t_9 = 21.3$, $P < 0.001$) and C pullets ($t_9 = 15.91$, $P < 0.001$) and higher for C than for B pullets ($t_9 = 5.39$, $P < 0.001$).

Health and Welfare Indicators

The severity of footpad lesions and hock burns was minor during early rearing (from 0 to 9 wk of age). The prevalence of footpad lesions differed among strains of pullets over time ($F_{14,72}=3.42$, $P < 0.001$) without significant differences between strains of cockerels ($F_{7,28} = 1.23$, $P = 0.32$). At 6 and 7 wk of age, the prevalence of footpad lesions was significantly higher in strain A pullets (25 ± 5%) than in strain B (2 ± 5%) and C pullets (9 ± 5%). Overall, the prevalence of footpad lesions was higher in cockerel strains (40%) than in pullets (9%) from 6 to 9 wk of age. Hock burns were more prevalent from 6 to 8 wk of age in cockerels, and the average prevalence of hock burns was 4% for strain X and Y cockerels without significant difference between strains. All strains, pullets and cockerels, had near perfect feather coverage and no signs of skin lesions.

Figure 4 illustrates that the feed intake relative to body weight during the feeding motivation test varied among the strains of pullets over time during early rearing ($F_{6,27} = 12.57$, $P < 0.001$). At 3 and 5 wk of age,

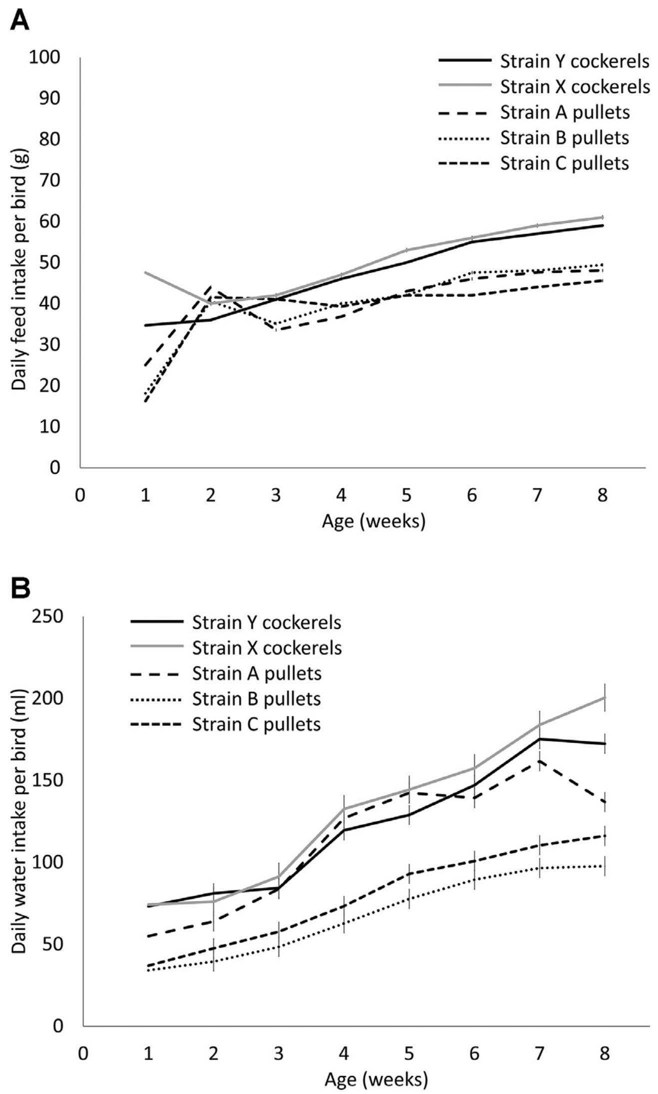

Figure 3. The daily intake of feed (A) and water (B) per bird by strain of slower growing broiler breeder pullets and cockerels during early rearing (mean ± SE). Solid lines refer to two strains of cockerels (X in gray and Y in black), and broken lines to three strains of pullets (A in wide-dashed, B in dotted, and C in narrow-dashed). During early rearing, the daily intake of feed and water per bird varied among broiler breeder strains ($P = 0.001$).

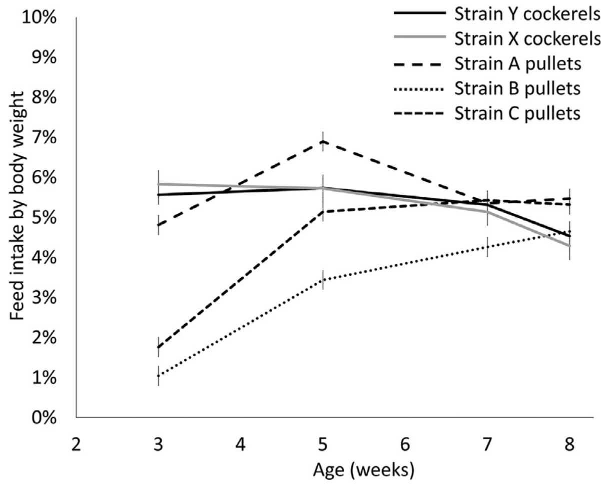

Figure 4. The feed intake of slower-growing broiler breeders on a feed intake test during early rearing (mean ± SE). Solid lines refer to two strains of cockerels (X in gray and Y in black), and broken lines to three strains of pullets (A in wide-dashed, B in dotted, and C in narrow-dashed). The relative feeding intake of slow-growing broiler breeder pullets differed over time ($P < 0.001$) without significant differences between both cockerel strains.

strain A pullets had significantly higher relative feed intake than B and C pullets (Figure 4). The relative feed intake was also higher in strain C pullets compared to strain B pullets at 5 wk of age ($t_{36} = 4.75$, $P = 0.003$). There was no difference in the relative feed intake of cockerel strains during the feeding motivation test (Figure 4; $F_{3,12} = 0.50$, $P = 0.69$).

The number of fault bars in the wing feathers differed among the strains of pullets ($F_{2,10} = 52.19$, $P < 0.001$) and cockerels ($F_{1,8} = 8.96$, $P = 0.016$). Strain A pullets had a higher number of fault bars (4.6 ± 0.4) than strain B (0.1 ± 0.2; $t_5 = 10.42$, $P < 0.001$) and C pullets (0.6 ± 0.2; $t_5 = 9.22$, $P < 0.001$), and strain Y cockerels had more fault bars (7.2 ± 1.1) than strain X cockerels (3.0 ± 0.9; $t_8 = 2.99$, $P = 0.016$).

DISCUSSION

Chronic feed restriction is a major welfare concern in broiler breeder production (D'Eath et al., 2009; de Jong and Guémené, 2011; Tolkamp and D'Eath, 2016), and strategies to reduce the feeding motivation of conventional broiler breeder strains are only modestly successful (Arrazola et al., 2019, 2020b; Aranibar et al., 2020; Tahamtani et al., 2020). For this reason, improving the welfare of broiler breeders may require using alternative, slower growing strains (Dawkins and Layton, 2012). Increasing focus on using slower growing broiler strains requires the use of slower growing broiler breeder strains (Dixon, 2020), and the information about performance and welfare of the parent stock of slower growing broilers is yet unknown. This study was designed to describe and compare the welfare and performance of 3 slow growing strains of pullets and 2 strains of cockerels. The strains with the lower growth rate potential (strain B and C pullets, and strain X cockerels) were expected to have the highest welfare, production, and health outcomes. Our results indicate that slower growing broiler breeder pullets can achieve a controlled and uniform growth rate with low levels of feed restriction, almost perfect feather coverage, and low prevalence of footpad lesions and hock burns during rearing. These results agree with other studies assessing the performance of slower growing broiler breeders (de Jong et al., 2003; Heck et al., 2004; Jones et al., 2004).

Slower Growing Broiler Breeder Pullets

Welfare indicators that have been studied in conventional broiler breeders were chosen to permit comparisons between the strains used in our study and those used in other studies. Slower growing broiler breeder pullets ate less feed (relative to BW) during the feeding motivation test and had fewer feather fault bars than conventional broiler breeder pullets tested at similar ages and under similar conditions (Arrazola et al., 2019). Conventional broiler breeders can consume their daily feed allotment in less than 10 min after feeding time (Arrazola et al., 2020b), whereas all strains in this experiment had feed remaining in their feeders by the end of the 20-min feed intake test. This is a clear indicator of high feeding motivation and hunger due to severe feed restriction in conventional strains of broiler breeders (Savory et al., 1993; e.g., Girard et al., 2017b; Arrazola et al., 2019), and our results indicate that slower growing broiler breeders may have experienced lower feeding motivation. In line with these results, fault bars in feathers are feather malformations due to chronic stressful events during feather growth (Jovani and Rohwer, 2017; Arrazola and Torrey, 2019), and conventional broiler breeders show high number of fault bars in their plumage presumably due to their chronic feed restriction (Arrazola et al., 2019, 2020b; Tahamtani et al., 2020). In this study, slow growing pullets (strain B and C) had a low number of fault bars in feather whereas intermediate growing pullets (strain A) had similar numbers of fault bars as conventional broiler breeder pullets reared under similar management (Arrazola et al., 2019). These results suggest that slow growing pullets showed lower feeding motivation and fewer signs of chronic stress due to feed restriction than intermediate growing pullets during rearing. Similarly, de Jong et al. (2003) assessed the effect of ad libitum feeding and mild feed restriction (at 70% of ad libitum) on the welfare of faster vs slower growing broiler breeders. Under mild feed restriction, slower growing broiler breeders showed fewer signs of hunger (lower glucose/nonesterified fatty acids ratio and lower feeding motivation) than faster growing broiler breeders (de Jong et al., 2003).

Intermediate growing broiler breeders (strain A) in this study required greater feed restriction starting at 2 wk of age to control their growth rate. Compared to the other 2 strains studied, strain A had higher feeding motivation, more fault bars, increasing water usage over time, and higher prevalence of footpad lesions at 4 wk of age, plausibly due to wet litter (authors' personal observation). Overdrinking and high water usage are signs of feeding frustration in broiler breeders (Savory et al., 1992; Hocking et al., 2001; Sandilands et al., 2005), and the high water usage by strain A pullets can indicate the increasing feeding motivation and feed restriction level during early rearing. At the same age (from 7 to 10 wk of age), the water intake of strain A pullets was similar to values reported for conventional broiler breeders by Nielsen et al. (2011).

Another sign of feeding frustration in conventional broiler breeder pullets is the onset of gentle feather pecking (Arrazola et al., 2020a). This behavior develops in conventional broiler breeders during early rearing (around 6 wk of age) and can lead to loss of feather coverage in vent and tail areas (Morrissey et al., 2014a; Arrazola et al., 2019, 2020b). Therefore, feather coverage loss and the presence of skin lesions in vent and tail areas are indirect indicators of feather pecking and severe pecking behavior, respectively, due to feed restriction in broiler breeders. Very little feather coverage loss and very few skin lesions were observed in any of the strains of broiler breeder pullets in this study, even though they had intact beaks. In line with the previous results, these results indicate that slower growing broiler breeder pullets showed few signs of gentle and severe feather pecking and distress due to feeding frustration during early rearing.

Achieving a uniform mature body weight and fleshing conformation at photostimulation (around 20 wk of age) is essential to synchronize laying onset and laying rate among hens, and our results suggest that slower growing pullets can achieve a controlled growth rate with good body weight uniformity (CV <10%). In contrast, conventional strains of broiler breeders show poor body weight uniformity under commercial conditions (e.g., Cobb 500 [de Beer and Coon, 2007, 2009], and Ross 308 [Zuidhof et al., 2015; de los Mozos et al., 2017]). Poor body weight uniformity results from unequal distribution of feed allotment among birds due to small daily feed allotment and feeding competition (Lindholm et al., 2015; Girard et al., 2017b). Under feed restriction, dominant birds fight for feeder space and larger feed ration leading to poor body weight uniformity, feather coverage loss, and presence of skin lesions in the head and back of subordinate birds. Our results indicate that feeding competition was low in slower growing breeders as there were no signs of severe pecking and good body weight uniformity. The body weight uniformity of strain A pullets decreased with age and feed restriction but was still below 8% (CV) by the end of rearing. Jones et al. (2004) also reported that slower growing broiler breeders fed ad libitum achieved good body weight uniformity (CV <8%) at a healthy body weight during mid rearing.

Additionally, feeding cost is a major economic factor in broiler breeder production and lower cumulative feed intake per bird can lower production cost. In our study, the cumulative feed intake was lower in slower growing broiler breeder pullets (7.7−7.8 kg/pullet) compared to conventional pullets (Ross 308 and 708: 7.8 to 8.2 kg/pullet; Aviagen, 2016a,b). Slow growing pullets (strain B and C) had lower cumulative feed intake during rearing than intermediate growing pullets (strain A), although strain A pullets were more efficient due to higher body weight gain. These differences in the cumulative feed intake can relate to differences in feed efficiency, growth rate, and nutritional requirements among strains. Thus, the development of feeding programs and nutrient specifications for these alternative strains are needed to optimize feed allotment and achieve a slow growth rate and a healthy and mature body conformation.

The results of this study indicate that slower growing broiler breeder pullets showed lower feed and water intake, better body weight uniformity, and fewer signs of feeding frustration (e.g., less overdrinking, lower feeding motivation, no signs of feather pecking and feather coverage loss/skin lesions, etc) and chronic stress (e.g., low number of fault bars in feathers) due to lower feed restriction level and, overall, better welfare. Despite lower feed efficiency, using slower growing strains can lower the feeding cost of broiler breeder production and reduce the welfare problems of feed restriction. For this reason, raising slower growing strains may be more economically and socially sustainable than conventional strains of broiler breeders.

Slower Growing Broiler Breeder Cockerels

Cockerels showed higher feeding motivation and more signs of chronic stress (as indicated by the high number of fault bars) than the pullets, with little differences between the 2 cockerel strains. Faster growing broiler breeder cockerels (strain Y) achieved a heavier body weight at a lower feed intake but also had a higher number of fault bars and poorer body weight uniformity than intermediate growing broiler breeder cockerels (strain X). These results suggest that the feed restriction needed to control the growth rate of strain Y cockerels was more stressful than that of strain X cockerels. Due to chronic feed restriction, conventional broiler breeder cockerels often show poor feather coverage and skin lesions due to gentle feather pecking, severe pecking, and fighting. However, cockerels (strain X and Y) in the current study did not show feather coverage loss or skin lesions until 10 wk of age (feather coverage was not assessed afterward), even though they had intact beaks. These results suggest that despite the higher feed restriction in faster growing broiler breeder cockerels, they showed fewer sings of chronic feed restriction, feather pecking problems, and feeding competition than conventional strains. However, both cockerel strains in this study showed increasing water intake with age and feed restriction and high prevalence of footpad lesions at 9 wk of age, plausibly due to high-water spillage. Overdrinking and high-water usage are signs of feeding frustration in broiler breeders that can lead to health problems if litter quality is not considered during rearing. Producers should therefore consider means to alleviate feeding motivation and frustration in slower growing cockerels such as using diluted diets or providing nonnutritious dietary supplements (e.g., Tahamtani et al., 2020).

The cumulative feed intake of the slower growing broiler breeder cockerels during rearing was lower compared to conventional broiler breeder cockerels (Ross 308: 11.1 kg/bird; Aviagen, 2016a). Slower growing cockerels (strain X and Y) also achieved an optimal body weight uniformity (CV around 10%) by the end of rearing, and most cockerels (80−90%) show optimal fleshing (i.e., score 2) at 9 wk of age (fleshing was not assessed afterwards). Uniform body weight, similar fleshing condition, low mortality, and no signs of severe pecking suggest that feeding competition was low in both cockerel strains.

These results suggest that intermediate growing broiler breeder cockerels required lower cumulative feed intake and less feed restriction during rearing than conventional strains, resulting in better body weight uniformity, improved liveability, and fewer signs of behavioral problems such as feeding competition, overdrinking, and feather pecking.

Public pressure and consumer concerns about the health and welfare of conventional broiler strains are moving the meat chicken industry toward using slower growing strains. However, science-based information about the performance and welfare of slower growing broilers and broiler breeders is very limited. Recent studies have addressed this topic (e.g., Dixon, 2020; Weimer et al., 2020), including the progeny of the broiler breeders in this study (Santos et al., 2021; Torrey et al., 2021), but there is a lack of studies evaluating the welfare and performance of slower growing broiler breeders. This study indicates that slower growing broiler breeders (pullets and cockerels) showed good welfare (few signs of distress, no signs of feather pecking, and low feeding motivation, competition, and frustration), acceptable performance (good body weight uniformity, and fleshing), and low production costs (low cumulative feed intake per bird). There is however limited knowledge on the performance and welfare of slow(er) growing broilers and broiler breeders, and future research should examine this topic as well as strain-specific management, nutrient requirements, and housing conditions during rearing and lay (in the case of broiler breeders) to maximize the production and well-being of these alternative strains.

ACKNOWLEDGMENTS

The authors thank the Canadian Hatching Eggs Producers and the Mitacs Accelerate Fellowship for support for this project, and the anonymous breeding company for providing the chicks. We also acknowledge the support of Global Animal Partnership, the Canada First Research Excellence Fund and the Ontario Agri-Food Innovation Alliance. Further thanks go to the Arkell Poultry Research Station personnel for their diligent care of the birds used in this trial. We also thank Alan Abdulkadar, Madeleine Browne, Veronica Cheng, Siobhan Mellors, Nyasha Mombeshura, Quinn Rausch, and Leah Wellard for their assistance during data collection.

DISCLOSURES

All the authors reviewed the manuscript and approved the submission to Poultry Science, and confirmed that the manuscript has not been published and is not under consideration and review by another journal. We declare no conflict of interest on the publication of this manuscript.

REFERENCES

Allain, V., D. Huonnic, M. Rouina, and V. Michel. 2013. Prevalence of skin lesions in turkeys at slaughter. Br. Poult. Sci. 54:33–41.

Allain, V., L. Mirabito, C. Arnould, M. Colas, S. Le Bouquin, C. Lupo, and V. Michel. 2009. Skin lesions in broiler chickens measured at the slaughterhouse: relationships between lesions and between their prevalence and rearing factors. Br. Poult. Sci. 50:407–417.

Aranibar, C. D., C. Chen, A. J. Davis, W. I. Daley, C. Dunkley, W. K. Kim, . . ., J. L. Wilson. 2020. Impact of an alternate feeding program on broiler breeder pullet behavior, performance, and plasma corticosterone. Poult. Sci. 99:829–838.

Arrazola, A., E. Mosco, T. M. Widowski, M. T. Guerin, E. G. Kiarie, and S. Torrey. 2019. The effect of alternative feeding strategies for broiler breeder pullets: 1. Welfare and performance during rearing. Poult. Sci. 98:3377–3390.

Arrazola, A., E. Mosco, T. M. Widowski, M. T. Guerin, E. G. Kiarie, and S. Torrey. 2020a. The effect of alternative feeding strategies during rearing on the behaviour of broiler breeder pullets. Appl. Anim. Behav. Sci. 224:104929.

Arrazola, A., T. M. Widowski, M. T. Guerin, E. G. Kiarie, and S. Torrey. 2020b. The effect of alternative feeding strategies on the feeding motivation of broiler breeder pullets. Animal. 14:2150–2158.

Arrazola, A., and S. Torrey. 2019. The development of fault bars in domestic chickens (Gallus gallus domesticus) increases with acute stressors and individual propensity: implications for animal welfare. Anim. Welf. 28:279–286.

Aviagen. 2016a. Parent Stock Performance Objectives: Ross 308. Aviagen, Ltd., Huntsville, AL.

Aviagen. 2016b. Parent Stock Performance Objectives: Ross 708. Aviagen, Ltd., Huntsville, AL.

Aviagen. 2018. Parent Stock Performance Objectives: Ranger Premium. Aviagen, Ltd., Huntsville, AL.

Chen, S., J. McMurtry, and R. Walzem. 2006. Overfeeding-induced ovarian dysfunction in broiler breeder hens is associated with lipotoxicity. Poult. Sci. 85:70–81.

D'Eath, R. B., B. J. Tolkamp, I. Kyriazakis, and A. B. Lawrence. 2009. Freedom from hunger' and preventing obesity: the animal welfare implications of reducing food quantity or quality. Anim. Behav. 77:275–288.

Dawkins, M. S., C. A. Donnelly, and T. A. Jones. 2004. Chicken welfare is influenced more by housing conditions than by stocking density. Nature. 427:342–344.

Dawkins, M., and R. Layton. 2012. Breeding for better welfare: genetic goals for broiler chickens and their parents. Anim. Welf. 21:147.

Dixon, L. M. 2020. Slow and steady wins the race: the behaviour and welfare of commercial faster growing broiler breeds compared to a commercial slower growing breed. PloS One. 15:e0231006.

de Beer, M., and C. N. Coon. 2007. The effect of different feed restriction programs on reproductive performance, efficiency, frame size, and uniformity in broiler breeder hens. Poult. Sci. 86:1927–1939.

de Beer, M., and C. N. Coon. 2009. The effect of feed restriction programs and growth curves on reproductive performance, in vitro lipogenesis and heterophil to lymphocyte ratios in broiler breeder hens. Int. J. Poult. Sci. 8:373–388.

de Jong, I., and D. Guémené. 2011. Major welfare issues in broiler breeders. Worlds Poult. Sci. J. 67:73–82.

de Jong, I. C., H. Enting, A. S. van Voorst, and H. J. Blokhuis. 2005. Do low-density diets improve broiler breeder welfare during rearing and laying? Poult. Sci. 84:194–203.

de Jong, I. C., A. S. van Voorst, and H. J. Blokhuis. 2003. Parameters for quantification of hunger in broiler breeders. Physiol. Behav. 78:773–783.

de Los Mozos, J., A. García-Ruiz, L. den Hartog, and M. Villamide. 2017. Growth curve and diet density affect eating motivation, behaviour, and body composition of broiler breeders during rearing. Poult. Sci. 96:2708–2717.

Dou, T. C., S. R. Shi, H. J. Sun, and K. H. Wang. 2009. Growth rate, carcass traits and meat quality of slow-growing chicken grown according to three raising systems. Anim. Sci. Pap. Rep. 27:361–369.

Girard, M. T. E., M. J. Zuidhof, and C. J. Bench. 2017a. Feeding, foraging, and feather pecking behaviours in precision-fed and skip-a-day-fed broiler breeder pullets. Appl. Anim. Behav. Sci. 188:42–49.

Girard, T. E., M. J. Zuidhof, and C. J. Bench. 2017b. Aggression and social rank fluctuations in precision-fed and skip-a-day-fed broiler breeder pullets. Appl. Anim. Behav. Sci. 187:38–44.

Heck, A., O. Onagbesan, K. Tona, S. Metayer, J. Putterflam, Y. Jego, J. Trevidy, E. Decuypere, J. Williams, and M. Picard. 2004. Effects of ad libitum feeding on performance of different strains of broiler breeders. Br. Poult. Sci. 45:695–703.

Hocking, P. M., M. H. Maxwell, G. W. Robertson, and M. A. Mitchell. 2001. Welfare assessment of modified rearing programs for broiler breeders. Br. Poult. Sci. 42:424–432.

Hubbard. 2019. Parent Stock Performance Summary: JA57 & JA57K. Hubbard, Ltd., Mauguerand, France. Accessed March 8, 2021. https://www.hubbardbreeders.com/media/pspsja57ja57kfrenes__019215400_1558_26062017.pdf.

Jones, E. K. M., V. Zaczek, M. MacLeod, and P. M. Hocking. 2004. Genotype, dietary manipulation and food allocation affect indices of welfare in broiler breeders. Br. Poult. Sci. 45:725–737.

Jovani, R., and S. Rohwer. 2017. Fault bars in bird feathers: mechanisms, and ecological and evolutionary causes and consequences. Biol. Rev. 92:1113–1127.

Lindholm, C., A. Calais, J. Jönsson, N. Yngwe, E. Berndtson, E. Hult, and J. Altimiras. 2015. Slow and steady wins the race? No signs of reduced welfare in smaller broiler breeder hens at four weeks of age. Anim. Welf. 24:447–454.

Lindholm, C., A. Johansson, A. Middelkoop, J. J. Lees, N. Yngwe, E. Berndtson, G. Cooper, and J. Altimiras. 2018. The quest for welfare-friendly feeding of broiler breeders: effects of daily vs. 5:2 feed restriction schedules. Poult. Sci. 97:368–377.

Morrissey, K. L. H., T. Widowski, S. Leeson, V. Sandilands, A. Arnone, and S. Torrey. 2014a. The effect of dietary alterations during rearing on feather condition in broiler breeder females. Poult. Sci. 93:1636–1643.

Morrissey, K. L. H., T. Widowski, S. Leeson, V. Sandilands, A. Arnone, and S. Torrey. 2014b. The effect of dietary alterations during rearing on growth, productivity, and behaviour in broiler breeder females. Poult. Sci. 93:285–295.

National Farm Animal Care Council (NFACC). 2016. Code of Practice for the Care and Handling of Hatching Eggs, Breeders, Chickens and Turkeys. NFACC, Ottawa, ON, Canada.

Nielsen, B. L., K. Thodberg, J. Malmkvist, and S. Steenfeldt. 2011. Proportion of insoluble fibre in the diet affects behaviour and hunger in broiler breeders growing at similar rates. Animal. 5:1247–1258.

Sandilands, V., B. J. Tolkamp, and I. Kyriazakis. 2005. Behaviour of food restricted broilers during rearing and lay-effects of an alternative feeding method. Physiol. Behav. 85:115–123.

Sandilands, V., B. J. Tolkamp, C. J. Savory, and I. Kyriazakis. 2006. Behaviour and welfare of broiler breeders fed qualitatively restricted diets during rearing: are there viable alternatives to quantitative restriction? Appl. Anim. Behav. Sci. 96:53–67.

Sasso. 2019. Parent Stock Performance Summary: SA51. Sasso, Ltd., Sabres, France. Accessed March 2021. http://www.sasso.fr/sasso-sa51-red-label-breeding-hen.html.

Santos, M. N., D. Rothschild, T. M. Widowski, S. Barbut, E. G. Kiarie, I. Mandell, M. T. Guerin, A. M. Edwards, and S. Torrey. 2021. In Pursuit of a better broiler: carcass traits and muscle myopathies in conventional and slower-growing strains of broiler chickens. Poult. Sci. 100:101309.

Savory, C. J., E. Seawright, and A. Watson. 1992. Stereotyped behaviour in broiler breeders in relation to husbandry and opioid receptor blockade. Appl. Anim. Behav. Sci. 32:349–360.

Savory, C. P., M. Hocking, J. Mann, and M. Maxwell. 1996. Is broiler breeder welfare improved by using qualitative rather than quantitative food restriction to limit growth rate? Anim. Welf. 5:105–127.

Savory, C., K. Maros, and S. Rutter. 1993. Assessment of hunger in growing broiler breeders in relation to a commercial restricted feeding programme. Anim. Welf. 2:131–152.

Tahamtani, F. M., H. Moradi, and A. B. Riber. 2020. Effect of qualitative feed restriction in broiler breeder pullets on stress and clinical welfare indicators. Front. Vet. Sci. 7:316.

Tolkamp, B. J., and R. B. D'Eath. 2016. Hunger associated with restricted feeding system. Nutrition and the Welfare of Farm Animals. C. J. C. Phillips, ed. Animal Welfare 16, Springer International Publishing, AG, Switzerland.

Torrey, S., M. Mohammadigheisar, M. N. Dos Santos, D. Rothschild, L. C. Dawson, Z. Liu, E. G. Kiarie, A. M. Edwards, I. Mandell, N. Karrow, and D. Tulpan. 2021. In pursuit of a better broiler: growth, efficiency, and mortality of 16 strains of broiler chickens. Poult. Sci. 100:100955.

van Emous, R. A., R. Kwakkel, M. van Krimpen, and W. Hendriks. 2015. Effects of different dietary protein levels during rearing and different dietary energy levels during lay on behaviour and feather cover in broiler breeder females. Appl. Anim. Sci. 168:45–55.

Weimer, S. L., A. Mauromoustakos, D. M. Karcher, and M. A. Erasmus. 2020. Differences in performance, body conformation, and welfare of conventional and slow-growing broiler chickens raised at 2 stocking densities. Poult. Sci. 99:4398–4407.

Zuidhof, M. J., D. E. Holm, R. A. Renema, M. A. Jalal, and F. E. Robinson. 2015. Effects of broiler breeder management on pullet body weight and carcass uniformity. Poult. Sci. 94:1389–1397.