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Short Communication

Effect of Feed Quantity on Reproductive Performance and Semen Production of Broiler Breeder Males

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ABSTRACT

An appropriate dietary quantity level is considered to be important in controlling body weight and improving semen quantity and quality in broiler breeder males. A total of 60 F line broiler breeder males from 20 maternal families were averagely distributed into three groups received treatments of 135.5, 125.5 and 115.5 g/d diet respectively with ME 2770 kcal/kg and CP 15.4% from 23 wk of age. Fertility trials were conducted in another three groups of F line hens with 20 hens in each group. A significantly positive interaction between dietary quantity and semen volume was observed ($p<0.05$) which showed that males fed with 135.5 g/d diet produced much more semen. Except for semen volume, there was no difference in semen concentration, sperm motility and useable spermatozoa/ejaculate before 32 wk of age ($p>0.05$). Feed quantity was correlated positively with sperm concentration and sperm motility. At 50 wk of age, higher sperm motility was observed in males fed with 135.5and 125.5 g/d diet than males fed with 115.5 g/d diet ($p<0.05$). While feed quantity was correlated positively with semen volume, sperm concentration, useable spermatozoa/ejaculate, negative correlations between body weight and sperm concentration. Body weight and sperm motility were significant ($p<0.05$) at 32 wk of age, but no significant correlations existed between body weight and semen characteristics at 50 wk of age ($p>0.05$). These data suggested that appropriate body weight or body weight gain after sexual maturity was necessary to optimize reproductive performance. In fertility trial, a significantly higher embryonic mortality (8.65%) and significantly lower hatchability (90.48%) was found in males fed with 135.5g/d diet than other two groups ($p<0.05$). Taken together, feed allocation of 125.5 g/d under ME 2770 kcal/kg and CP 15.4% was recommended to broiler breeder males of genetically modified F line after sexual maturity.

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Authors' Contribution
QW and ZZ designed the experiments. ZH, SL, HH and CL collected field data and samples. QW wrote the manuscript.

Key words
F line, Feed allocation, Reproductive performance, Semen quality

In this study, F line was selected as a high-quality yellow-feathered broiler breeder by the poultry research institute of the Chinese academy of agricultural sciences in 2010 with local chicken breeds. In C hina, F line was genetically modified to enhance growth rate and has been widely used as paternal line in the breeding of Chinese quality yellow-feathered broilers. There is no standard for the rearing of this breeder male in China so far. In the adult period, it is recommended that 110-140 g/d diet of ME 2750-2800 kcal/kg and CP 15.0-15.5% is the safety margin requirement for reproduction in F line broiler breeder males under cage system. However, within the broad range, the optimal diet quantity is still unclear. The object was to study the effect of feed allocation on reproductive performance and determine an appropriate diet quantity during adult in genetically modified F line broiler breeder males.

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Materials and methods

Fifty maternal families of the F line by the same one male line were established to produce offspring in order to eliminate the impact of paternal genetic background. All male offspring were reared in a controlled light facility. It uses a gradually decreasing and increasing light program, using 24 hours of light for the first two days, decreasing to 16 hours of light starting at 3 days of age, and decreasing the number of hours of light per wk until 5 hours of light per day at 18 wk of age. After that, the light stimulation was increased to 8 hours from the age of 19 wk, and was increased to 27 wk by wk, and the light was maintained for 15 hours to 37 wk, and then increased 1~2 hours appropriately according to the situation until 50 wk with 8 h light and 16 h dark from 5 to 22 wk of age, and fed with diet of ME 2700 kcal/kg and CP 15.2% (Table I) as suggested quantity according to body weight.

At 22 wks of age, 20 maternal families with 3 or more male offspring were selected for the following test. Breeder males from each family were randomly and averagely

distributed into three treatments, denoted as group I, II and III with 20 males in each group, and fed with three diet quantity levels, group I was high quantity diet (135.5 g/ d), group II was moderate quantity diet (125.5 g/d) and group III was low quantity diet (115.5 g/d) respectively. The diet was of ME 2770 kcal/kg and CP15.4% (Table I). Males were reared in single caged system during the experimental period. The ambient temperature was controlled at 20°C to 28 °C by automatic ventilation. The body weight of individual males was determined once every three weeks from 23 to 50 wk of age.

Table I. Composition of grower (5 to 22 wk) and breeder (23 to 50 wk) diets.

Item	5 to 22 wk	23 to 50 wk
Ingredients (%)		
Corn	63.40	58.9
Wheat	0.00	3.5
Wheat bran	9.00	8.50
Zeolite	5.00	3.00
Soybean meal	19.00	19.00
Limestone	1.00	1.00
Dicalcium phosphate	1.30	1.20
Salt	0.30	0.30
1% Premix[1]	1.00	1.00
Calculated analysis		
CP (%)	15.20	15.40
ME (kca/kg)	2700	2770

[1]1% premix contained the following per kilogram of diet: vitamin A, 10,500 IU; cholecalciferol, 3,300 IU; vitamin E, 40 IU; riboflavin, 10.0 mg; d pantothenic acid, 15.0 mg; niacin, 50 mg; choline, 600 mg; vitamin B12, 0.025 mg; menadione, 4 mg; folic acid, 1.5 mg; thiamine mononitrate, 4 mg; pyridoxine, 5 mg; biotin, 0.2 mg; Cu, 8.0 mg; Fe, 50 mg; I, 1.2 mg; Mn, 120 mg; Se, 0.3 mg; Zn, 110 mg.

Table II. Mean (SEM) bogy weght (g) of broiler breeder by feed treatment at various ages[1].

Age (wk)	Group I	Group II	Group III
23	2582.1±67.7	2579.1±66.1	2586.4±69.9
26	2850.8±69.0	2846.5±71.5	2855.6±71.2
29	3030.8±83.1	3025.2±82.1	3034.3±80.6
32	3113.8±88.1	3104.3±90.2	3116.3±91.6
35	3188.8±99.1	3179.8±96.0	3186.3±97.4
38	3211.3±104.6	3201.3±106.8	3205.9±107.6
41	3287.8±109.7	3272.5±110.1	3278.5±111.4
44	3326.3±120.6	3315.4±127.0	3321.3±125.1
47	3353.8±117.5	3344.3±124.0	3346.3±126.0
50	3350.7±123.1	3338.5±134.8	3340.2±137.5
Body weght gain	768.6±57.5	759.4±51.2	753.8±52.3

[1]No significant difference was found among groups at each age stage.

Males were trained for semen collection using abdominal massage technique, and being teased weekly throughout the experiment to prevent any possible negative effect on reproductive efficiency. Semen quality was analyzed at 32 and 50 wk of age. Individual ejaculate was collected and any contaminating material was removed with a glass Pasteur pipette. Semen volume was measured indirectly by weight (1 g ≈ 1 mL). Semen was mixed well for pH, sperm concentration and motility determination using the method according to previous study (Abu, 2013). Usable spermatozoa per ejaculate were calculated as semen volume×concentration×sperm motility.

Fertility trials were also conducted at 32 and 50 wk of age respectively. Briefly, semen was collected into a conical tube from males in each group and mixed for artificial insemination. Six hundred hens of genetically modified F line were also distributed into three groups randomly and averagely with 200 hens in each. Each group was artificially inseminated with semen collected from the fixed group of males, as the daily routinely utilized insemination scheme implemented by poultry industry. The frequency of artificial insemination was once every four days. Eggs from each group of hens were collected twice daily for 10 consecutive days beginning on the 3rd day following the first insemination, and stored individually in a room at 20°C until incubated. The incubator was maintained at 37.8°C and 55% RH. Embryos were then transferred to a hatcher at 19d and maintained at 37.2 °C and 75% RH until 21 d of hatching. Fertility, embryonic mortality and hatchability analysis of three groups were carried out individually. Fertility was expressed as the percentage of fertile eggs of all collected eggs from each group. Hatchability was expressed as the percentage of chicks hatched from the total number of fertile eggs set. Health rate of day old chicken (DOC) was expressed as the percentage of healthy DOC of all chicks hatched. All unhatched eggs were counted, opened and examine the macro evidence of embryonic development by a professional and therefore “apparent fertility” as previously reported (Walsh and Brake, 1997). Eggs without macroscopic signs of development are considered sterile. As a result, embryonic mortality could be calculated.

Data were subject to ANOVA using the GLM procedure of SPSS as a complete randomized block design (SPSS version 11.5 for Windows; SPSS Inc and Chicago IL). Multiple comparisons were made using Dunnett’s test to detect significant differences of parameters among feeding treatments. A $\chi 2$ test was adopted to analyze the fertility, embryonic mortality, hatchability and health rate of DOC. Statement of statistical significance was based on $P \leq 0.05$. A relationship of semen characteristics with body weght and feed quantity during rearing was assessed by correlation and regression analysis.

Table III. Semen characters of fresh spermatozoa from three groups at 32 and 50 wk of age.

Item[1]	32 wk of age			50 wk of age		
	Group I	Group II	Group III	Group I	Group II	Group III
SV	0.73±0.08[a]	0.66±0.06[b]	0.59±0.07[c]	0.75±0.07[a]	0.66±0.09[b]	0.56±0.09[c]
pH	7.3±0.1	7.3±0.1	7.3±0.1	7.4±0.1	7.3±0.1	7.4±0.1
SC	25.93±5.31	24.03±5.14	22.96±3.60	22.70±3.01	20.30±3.50	20.55±2.92
SM	0.73±0.07	0.76±0.07	0.69±0.07	0.79±0.07[a]	0.810±0.03[a]	0.73±0.05[c]
US/E	15.03±4.35	13.67±4.89	14.37±5.81	12.83±4.11	12.07±4.08	9.81±2.89

[a–c]Means within a row with different superscripts differ (P < 0.05). [1]SV, semen volume (ml); SC, sperm concentration (a hundred million/ml); SM, sperm motility; US/E, useable spermatozoa/ejaculate (billion).

Results

Body weight changed with age was shown in Table II. Body weight gain of F line Broilers in group I with 135.5 g/d was 768.6 g, 759.4 g in group II with 125.5 g/d and 753.8 g in group III with 115.5 g/d. F line Broilers fed with higher feed allocation showed a numerically increase in body weight. It is obvious that the body weight gain was positively correlated with feed quantity. Uniformity of body weight showed no significant change in group I, II and III (p>0.05), and an obvious wave was observed in three group changing from 10% at 26 wk to 30% at 44 wk (data not shown). Another interesting aspect of body weight is that the mean body weight in all three groups exhibited slight reduction from 47 to 50 wk of age.

Semen volume of males differed among treatments both at 32 and 50 wk of age (Table III), and was the highest in males fed with 135.5 g/d diet. Semen pH and concentration had no difference among treatments. Sperm motility showed no difference before 32 wk of age, however, at 50 wk of age, it was greater in group I and II than that of group III (p<0.05). Useable spermatozoa/ejaculate showed no difference among treatments at 32 and 50 wk of age. Covariance analysis, with body weight the covariate, indicated that feed quantity but not body weight directly affected 32 to 50 wk semen volume. In other words, it was feed quantity perse but not body weight that had a direct influence on semen volume of males. Thus, relationships of semen characteristics with feed quantity instead of body weight were analyzed further. Correlations between feed quantity and semen volume were significant (p<0.01) both at 32 and 50 wk of age (Table IV). Sperm motility and Useable spermatozoa/ejaculate were also correlated positively with feed quantity at 50 week of age. There were significant correlations between body weight and Sperm concentration, body weight and Sperm motility (p<0.05) at 32 wk of age, but no significant correlations existed between body weight and semen characteristics at 50 wk of age (Table V).

Table IV. Correlation coefficients of semen characteristics with feed quantity and body weight at 32 and 50 wk of age.

Item[1]	SV	SC	SM	US/E
32 wk of age				
Feed quantity	0.657**	0.373	0.285	0.199
Body weight	0.181	-0.410*	-0.475*	-0.277
50 wk of age				
Feed quantity	0.720**	0.270	0.414*	0.523**
Body weght	0.003	0.391	0.281	0.268

[1]For abbreviation, see Table III. ** Correlated significantly at P < 0.01. * Correlated significantly at P < 0.05.

The fertility, hatchability, embryonic mortality and health rate of DOC were measured in each group at 32 and 50 wk of age respectively. As shown in table 5, there was no difference in each parameter but with a numerically higher embryonic mortality in group I (8.05%) at32 wk of age. At 50 wk of age, the insemination results were highly different among treatments. Except for the egg fertility, the lowest hatchability and health rate of DOC and highest embryonic mortality was observed in group I.

Table V. Fertility, hatchability, health rate of DOC and embryonic mortality comparison among three groups at 32 and 50 wk of age.

Item (%)	32 wk of age			50 wk of age		
	Group I	Group II	Group III	Group I	Group II	Group III
Fertility	90.70	89.40	88.90	90.90	93.33	91.54
Hatchability	91.10	92.50	93.50	90.48[a]	99.00[b]	99.70[b]
Embryo mortality	8.05	6.67	5.78	8.65[a]	0.93[b]	0.30[b]
Health rate of DOC	98.63	99.14	99.06	95.76[a]	97.80[ab]	98.01[b]

[a,b] Means within a row with different superscripts differ (P < 0.05).

It is obvious that males fed with 115.5-125.5 g/d dietary quantity after sexual maturity showed a fairly well fertility, hatchability and embryonic survival rate in the genetically modified F line.

Discussion

In modern broiler breeders, the broiler industry has successfully used the expression of high genetic characteristics such as modern breeding technology and feed innovation technology to improve body weight, meat yield and semen quality. However, these improvements may be accompanied by decreased reproductive variables in broiler breeder (Barbato, 1999), especially reduced fertility that has been generally associated with excess body weight (Hocking, 1990). Although the effect of the average performance of male breeds is important when considering group fertility, it is reasonable to assume that changes in individual body weight have different effects on fertility. Thus it might be reasonable that males in group Ⅰ produced a relatively higher semen quantity. The highest semen volume in group Ⅰ during the whole experimental period and higher sperm motility during late rearing period of 50 wk were observed, however, do not suggest that more diet consuming would produce even more usable spermatozoa from further trials in this experiment. In the latter fertility trials, sperm concentration and motility were correlated negatively to body weight at 32 wk of age, and males in group Ⅰ with higher body weight exhibited lower reproductive performance at 50 wk of age. This was highly consistent to the previous reports that males subjected to raise nutrition level exhibited lower fertility (Clémenta *et al*., 2012; Attia and Kamel, 2012). At 32 wk of age, feed quantity was correlated positively with semen volume while body weight was correlated negatively to sperm concentration and sperm motility. This further suggested significant body weight gain does not achieve optimal semen characteristics and reproductive performance.

It is suggested that body weight grows slowly but steadily after sexual maturity was important to Increase sperm count per ejaculation and sperm production (Zhang *et al*., 1999; Sha *et al*., 2016; Liu *et al*., 2017). In this experiment, no significant difference in SC, SM, US/E and fertility was observed before 32 wk of age, while a significantly higher hatchability, health rate of DOC, and significantly lower embryo mortality was also observed in males fed with moderate or low quantity diet at 50 wk of age. This may be caused by the greater body weight gain during 23 to 32 wk of age and smaller body weight gain from 32 to 50 wk of age. Semen characteristics differed among diet levels. Semen volume from group I was always significantly higher than that of group II and group III. At 50 wk of age, sperm motility in group I was significantly higher than that of group III and nearly equal to group II, which might infer that breeder males of genetically modified F line received diet around 125.5 g/d could be the most appropriate. However, in the further experiment, the hatchability of fertilized eggs was traced. In the early period before 32 wk of age, fertility parameters showed no significant difference but with a numerically higher embryonic mortality in group I. During the latter part of the experiment, all of the fertility related indices suggested that males fed with high quantity diet had poorer reproductive performance. Taken together, the results indicated that the optimal feed quantity for breeder males of the genetically modified F line is 125.5 g per day per bird under ME 2770 kcal/kg and CP 15.4% after 23 wk of age. At this quantity level, the optimal reproductive performance could be maintained.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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