Ciência Rural, Santa Maria, v.55:8, e20240317, 2025
http://doi.org/10.1590/0103-8478cr20240317
ISSNe 1678-4596
ANIMAL PRODUCTION

Feeding programs for the grower phase of two strains of meat-type breeding quails

Fernanda Gabryela Bezerra de Araújo[1*] Luana Ledz Costa Vasconcelos Rocha[1] Ester Araújo Sanil dos Santos[1] Antônio Miguel de Oliveira Alves[1] Barbara Stefanny Braga da Silva[1] Breno Oliveira de Sousa[1] Rafael Carlos Nepomuceno[1] Ednardo Rodrigues Freitas[1]

[1]Departamento de Zootecnia, Centro de Ciências Agrárias, Universidade Federal do Ceará (UFC), 60440-554, Fortaleza, CE, Brasil. E-mail: fernandag_araujo@hotmail.com. *Corresponding author.

ABSTRACT: The purpose of this study was to evaluate different feeding programs for the grower phase (14 to 42 days of age) of two strains of meat-type breeding quail. A total of 480 quails (360 females and 120 males) were distributed in a completely randomized design with a 3x2 factorial scheme (three feeding programs and two strains), totaling six treatments. The feeding programs were: P1 - *ad libitum*; P2 - controlled daily feeding; and P3 - daily feeding with a 10% restriction of the feed offered in P2. In the controlled daily feeding program, 20, 25, 30, and 30g of feed/bird/day were offered at the ages 14 to 21; 22 to 28; 29 to 35; and 36 to 42 days, respectively. The performance of the quails in the grower phase, sexual maturity, breeding performance, egg quality and incubation parameters were assessed. During the grower phase, it was observed that quails with a 10% feed restriction showed lower feed intake, weight gain and average weight at 42 days of age, in comparison to quails from the treatments. Among the strains, there was only difference in weight at 42 days of age. Regarding the sexual maturity indicators, it was found that quails with a 10% feed restriction were four days later in producing the first egg in comparison to the others. During the laying phase, quails subjected to 10% feed restriction consumed less feed and had lower body weight by the end of the experiment, while those fed *ad libitum* showed higher mortality. For egg quality parameters and incubation parameters, no interaction was observed between the factors strains and feeding programs. It is concluded that the feeding program with 10% feed restriction from 14 to 42 days of age reduces the weight of quails at 42 days of age, delays sexual maturity and reduces feed intake, mortality and body weight at the end of the laying cycle, without affecting the reproductive parameters of the quails, and is therefore, recommended.
Key words: quail breeding, performance, incubation, sexual maturity, feed restriction.

Programas de alimentação para fase de crescimento de duas linhagens de codornas de corte reprodutoras

RESUMO: Com o objetivo de avaliar diferentes programas de alimentação para a fase de crescimento (14 a 42 dias de idade) de duas linhagens de codornas de corte reprodutoras, 360 fêmeas e 120 machos, totalizando 480 animais, foram distribuídos em delineamento experimental inteiramente casualizado em esquema fatorial 3x2 (três programas alimentares e duas linhagens), com seis tratamentos. Os programas de alimentação foram: P1 - alimentação à vontade; P2 - alimentação diária controlada e P3 - alimentação diária com 10% de restrição da ração ofertada no P2. No programa de alimentação diária controlada, 20, 25, 30, e 30g de ração/ave/dia foram oferecidas às aves nas idades de 14 a 21; 22 a 28; 29 a 35; e 36 a 42 dias de idade, respectivamente. Foram avaliados o desempenho das aves na fase de crescimento, a maturidade sexual, o desempenho das matrizes, qualidade dos ovos e parâmetros de incubação. Na fase de crescimento observou-se que as aves com restrição alimentar de 10% apresentaram menor consumo de ração, ganho de peso e peso médio aos 42 dias de idade, em relação às aves dos demais programas de alimentação. E entre as linhagens, houve diferença apenas para o peso aos 42 dias de idade. Nos indicadores de maturidade sexual, verificou-se que as aves com alimentação restrita em 10% foram quatro dias mais tardias para produzir o primeiro ovo em comparação às demais. Na fase de postura, as aves restritas em 10% apresentaram menor consumo durante e menor peso corporal ao final do experimento, enquanto as aves alimentadas à vontade apresentaram maior mortalidade. Para os parâmetros de qualidade dos ovos e parâmetros de incubação, não foi observado interação entre fatores, linhagens e programas de alimentação. Conclui-se que o programa de alimentação de 14 a 42 dias de idade, com restrição em 10% avaliados, diminui o peso das codornas aos 42 dias de idade, atrasa a maturidade sexual e reduz o consumo de ração, a mortalidade e o peso corporal ao final do ciclo de postura, sem causar prejuízos nos parâmetros reprodutivos das matrizes, sendo, portanto, recomendado.
Palavras-chave: coturnicultura, desempenho, incubação, maturidade sexual, restrição alimentar.

INTRODUCTION

European quails farming is gaining popularity among producers, driven by the demand for specific strains with superior meat quality genetics. The focus on selecting strains of high meat yield has led to increased feed intake among breeders (RENEMA & ROBINSON, 2004). A study

Received 06.11.24 Approved 10.30.24 Returned by the author 04.17.25
CR-2024-0317.R1
Editors: Rudi Weiblen Charles Kiefer

conducted by LEKSRISOMPONG et al. (2014) indicated that high feed intake during the laying cycle can result in an undesirable increase in weight and abdominal fat of the birds, negatively affecting productivity. To mitigate excess weight and ensure consistent and homogeneous production, the use of feed restriction in breeding birds is recommended, a practice that decreases follicular growth and favors the improvement in the quality and quantity of eggs produced (RENEMA & ROBINSON, 2004).

According to CARNEIRO et al. (2019), applying feed restriction during the growth of breeding birds results in significant improvements in reproductive performance, evidenced by an increase in egg production and maintenance of fertility and hatchability rates comparable to regular feeding. Therefore, feed restriction is an efficient method to moderate the exacerbated ovarian development in heavy birds, enhancing persistence and standardization in egg production (RENEMA & ROBINSON, 2004). The execution of this technique requires careful monitoring to ensure it is done at the right time, avoiding adverse impacts on bird development.

Quantitative and qualitative restrictions are the main strategies of this practice, where the first limits the amount of feed available and the second dilutes the feed with low nutritional or energetic value components, promoting an increase in the volume of feed without causing overfeeding (BENSON et al., 2022). Regarding quantitative restriction, methods such as intermittent feeding (skip-a-day), where birds are fed on alternate days, are examples, as well as options that involve hourly or daily feed quantity restrictions.

A correct feed restriction is crucial during the grower phase to minimize problems associated with obesity in females, avoiding consequences such as the excessive formation of yellow follicles organized in multi-hierarchies that reduce egg viability (JAAP & MUIR, 1968), and overweight that negatively impacts fertility and hatchability parameters (ROBINSON et al., 1993). Additionally, a study conducted by SUNDER et al. (2008) highlighted the importance of balanced nutrition, demonstrating that adjustments in breeding diets to lower energy levels resulted in benefits such as reduced abdominal fat and improved laying and fertility indices.

However, research on feed restriction in meat-type breeding quails remains scarce, since the majority of studies were carried out predominantly with Japanese quails in the laying phase (GEBHARDT-HENRICH & MARKS, 1995; HASSAN et al., 2003; OCAK & ERENER, 2005; BURAGOHAIN, 2013; ABBAS et al., 2015; MAHROSE et al., 2022) and few with European quails in the grower phase (GRIESER et al., 2017). In this context, the objective of this research was to evaluate the effects of different feeding programs applied during the grower phase of two strains of meat-type breeding quails on bird performance over the grower and laying phases, sexual maturity, egg quality and incubation parameters.

MATERIALS AND METHODS

The study included 480 European breeding quails (*Coturnix coturnix coturnix*), comprising 360 females and 120 males from two strains: S1, a commercial meat-type quail line provided by Granja Fujikura, and S2, from the meat-type quail breeding program of the Federal University of Ceará. From 1 to 14 days of age, the quails were housed in a protection circle containing tray-type feeders and cup-type drinkers, with the floor covered with sawdust, and lamps used as a heat source to warm the birds. During this period, the birds received 23 hours of light until ten days of age, with reduction to natural light after that age, and were fed with growth feed (Table 1) and water *ad libitum*. At 14 days of age, the birds of each strain were sexed, then the females were selected based on body weight (S1: 73.07 ± 0.38g and S2: 74.50 ± 0.81g) and distributed in the experimental units to obtain plots with homogeneous weight for each strain (SAKOMURA & ROSTAGNO, 2007). The experimental design was completely randomized in a 3x2 factorial scheme, with three feeding programs and two strains, totaling six treatments with five replications of 12 birds. The quails were housed in boxes measuring 0.60 x 0.60 m, in a stocking density of 3 cm^2/bird.

In this phase of the experiment, from 14 to 42 days of age, the birds were housed in a conventional shed measuring 9.5m in width and 9m in length, distributed in 30 boxes containing tubular-type feeders and pendulum drinkers. The light program provided only natural light (12 hours of light). The birds received water *ad libitum* and were fed with growth feed (Table 1) according to the feeding programs evaluated, which consisted of: P1 - *ad libitum*; P2 - controlled daily feeding; and P3 - daily feeding with a 10% restriction of the feed offered in P2. In the controlled daily feeding program, 20, 25, 30, and 30g of feed/bird/day were offered at the ages of 14 to 21; 22 to 28; 29 to 35; and 36 to 42 days, respectively.

At 42 days of age, keeping the same experimental design, the females were transferred to

Table 1 - Composition of the experimental diets offered to the meat-type breeding quail.

Ingredients	Percentage in the feed	
	Grower	Laying
Corn	54.936	49.871
Soybean meal	40.842	37.266
Soybean oil	1.263	2.403
Limestone	1.185	8.414
Common salt	0.355	0.529
Dicalcium phosphate	0.944	1.127
DL-methionine	0.275	0.187
L-lysine	0.000	0.054
Vitamin supplement[1]	0.150	0.100
Mineral supplement[2]	0.050	0.050
Total	100.00	100.00
Nutritional and energy composition calculated		
Metabolizable energy (kcal/kg)	2.950	2.800
Crude protein (%)	23.000	21.000
Digestible lysine (%)	1.142	1.078
Digestible methionine + cystine (%)	0.890	0.747
Digestible methionine (%)	0.580	0.460
Digestible threonine (%)	0.784	0.690
Digestible tryptophan (%)	0.266	0.352
Calcium (%)	0.750	3.500
Available phosphorus (%)	0.290	0.320
Sodium (%)	0.160	0.230

[1]Composition per kg of grower diet: 13500 IU of vitamin A, 3750 IU of vitamin D3, 40 IU of vitamin E, 3.75 mg of vitamin K3, 3 mg of vitamin B1, 9 mg of vitamin B2, 52.25 mg of niacin, 18 mg of pantothenic acid, 12 mg of vitamin B6, 0.15 mg of biotin, 2.25 mg of folic acid, 0,025 mg of vitamin B12,0,38 mg of selenium; Composition per kg of laying diet: 9000 IU of vitamin A, 2500 IU of vitamin D3, 20 IU of vitamin E, 2.50 mg of vitamin K3, 2 mg of vitamin B1, 6 mg of vitamin B2, 0,018 mg of vitamin B12, 35 mg of niacin, 12 mg of pantothenic acid, 8 mg of vitamin B6, 2 mg of folic acid, 0.10 mg of biotin, 0,25 mg of selenium; [2] Composition per kg of diet: 50 mg of iron, 0.10 mg of copper, 65 mg of manganese, 65 mg of zinc, 1 mg of iodine.

the laying shed with galvanized wire cages measuring 35 x 25 x 20 cm (length x width x height) arranged in a pyramidal system and equipped with a linear-type galvanized trough feeder, nipple-type drinker, and egg collector tray. The birds of each replication were housed in four cages in the proportion of three females per cage. Subsequently, when all plots reached 50% laying, the males were introduced into the cages in the proportion of one male for every three females. Evaluations of the laying cycle comprised the period between the 6th and 51st weeks of age, which was subdivided into 15 periods of 21 days each. During the entire laying period, the feed (Table 1) and water were offered *ad libitum*, and production data were recorded daily. The light program consisted of a light stimulus with 14 hours of light per day (natural + artificial) at 42 days, followed by weekly increases of 30 minutes of artificial light until reaching 15 hours and 30 minutes (natural + artificial), maintaining this amount of daily light until the end of the experimental period. In all phases of the experiment, the temperature and air relative humidity in the sheds were recorded by a data logger, and the average, maximum and minimum values in each phase are presented in table 2. The experimental diets (Table 1) were formulated considering the nutritional requirements recommended by SILVA & COSTA (2009) and the nutritional and energetic composition values of the ingredients presented by ROSTAGNO et al. (2017).

Performance during the grower phase

To evaluate performance during the grower phase (14 to 42 days of age), birds and feed were weighed at the beginning and end of the phase to determine the average weight at 42 days (g/bird), weight gain (g/bird), feed intake (g/bird), and feed conversion. Uniformity was calculated using individual bird weighing data at 42 days of age (6th week).

Table 2 - Temperature and air relative humidity (minimum, average and maximum) registered in grower and laying phases.

Phase	----------Temperature (ºC)----------			----------Relative humidity (%)----------		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Grower	24.70	28.60	31.10	37.40	65.70	90.60
Laying	25.65	29.33	35.81	21.50	65.80	90.70

Sexual maturity

Sexual maturity was evaluated through parameters measured at the onset of laying, including average age (days), average weight of females (g), and egg weight (g). To determine the age of maturity, the date of the first egg for each plot was recorded and subtracted from the bird's birth date. The average weight of the females and the egg was obtained by individually weighing the females in each plot using a digital scale of 1 g precision, and the eggs using a semi-analytical scale with 0.01 g sensitivity. The data of both variables were considered as the arithmetic mean. Feed intake and weight gain were calculated by the weight difference in feed and females at 42 days of age and the laying date of the first egg.

Performance during the laying phase

During the laying phase, at the end of each 21-day period, the variables evaluated were feed intake (g/bird/day), laying percentage (%/bird/day), egg mass (g/bird/day), and feed conversion (kg of feed/kg of egg).

Egg quality

To evaluate egg quality during the laying phase, all eggs from each plot were collected, identified, and evaluated one day a week based on the variables: percentages (%) of yolk, albumen, and shell, Haugh Units (HU), specific gravity (g/cm³), and shell thickness (mm). For quality analyses, three eggs per plot were selected, all within the average weight calculated for that plot.

Initially, to calculate the specific gravity (SG) of the eggs were weighed in air and water using a semi-analytical scale of 0.01g sensitivity, according to the methodology described by FREITAS et al. (2004). The eggs were then broken on a glass surface to measure the height of the albumen using a depth micrometer. The albumen height and egg weight data were used to calculate the HU through the equation $HU = 100 \log (H + 7.57 - 1.7 W^{0.37})$, where H = albumen height and W = egg weight (HAUGH, 1937). After measuring the albumen height, it was separated from the yolk, which was then removed and weighed. To obtain the percentage, the yolk weight was divided by the egg weight and multiplied by 100.

After breaking the eggs, the shells were separated, washed, and dried for 72 hours. Once dry, they were weighed on a semi-analytical scale of 0.01 g sensitivity. To obtain the percentage, the shell weight was divided by the egg weight and multiplied by 100. The albumen percentage was obtained by difference, where %Albumen = 100 - (%yolk + %shell).

Eggshell thickness was measured by a digital caliper with 0.01mm divisions at the larger pole, smaller pole, and equatorial region of the egg, with the shell thickness obtained by the arithmetic mean of the values obtained in the three regions.

Incubation parameters

During the experiment, 3 incubations were performed in the 7th, 12th, and 15th experimental periods, when all eggs were collected for 10 days and sent to the hatchery, where they were selected for incubation, conducting candling with the disposal of cracked, broken, and irregularly shaped eggs (round and elongated). The selected eggs were properly identified and stored in a controlled temperature environment at 18 ºC.

The day after the last collection day, all stored eggs were brought to ambient temperature for eight hours, weighed on a semi-analytical scale of 0.01g sensitivity, placed in pre-identified incubator trays according to the treatments, and taken to an incubator with temperature of 38 ºC where they remained for 15 days. After this period, the eggs were placed in polyethylene nets and transferred to the hatcher at 36.8 ºC until hatching, which occurred on the 17th day of incubation.

Data from all incubations were combined to evaluate the parameters of average weight of incubated eggs (g/egg), which was obtained by the arithmetic mean considering the total weight of the eggs in the plot and the number of eggs incubated; average weight of the quail at birth (g/bird), obtained by weighing all quails on a semi-analytical scale of 0.01 g sensitivity immediately after hatching; hatching rate (%), calculated through the equation:

(number of quails/ number of eggs incubated) x 100; hatchability (%), calculated by the equation: (number of quails / number of fertile eggs) x 100; and fertility (%) calculated by: (number of fertile eggs / number of eggs incubated) x 100.

Statistical analysis

Data were subjected to analysis of variance through the procedure ANOVA of the SAS software version 9.2 (Statistical Analyses System - SAS, 2000), considering the model for a completely randomized design in a 3x2 factorial scheme, with three feeding programs and two strains. The statistical model adopted was: $Yijk = \mu + \alpha i + \beta j + (\alpha\beta ij) + Eijk$, in which Yijk is the the record of each observation; μ is the overall mean of the experiment; αi is the effect of the feeding program; βj is the effect of the strains; αβij is the effect of interaction between the factors; and Eijk is the experimental error. The means were compared by the Student-Newman-Keuls test at 5% probability.

RESULTS AND DISCUSSION

Performance during the grower phase

Evaluating the performance of the quails from 14 to 42 days (Table 3), it was observed that there was no significant effect of interaction between feeding program and strains on the evaluated variables. Conversely, the feeding program significantly affected feed intake, weight gain, feed conversion, final average weight, and uniformity between birds fed *ad libitum* and those fed with the controlled daily amounts stipulated in this research. However, birds fed with a 10% restriction showed lower feed intake and, consequently, lower weight gain and average weight at the end of the grower phase when compared to those from other feeding programs, with no significant difference in feed conversion and uniformity. Regarding the strain, it was observed that S2 quails showed body weight at 14 and 42 days significantly higher than S1, but there was no effect on the other variables.

At the beginning and end of the grower phase, the S2 quails had a body weight 1.92% and 1.76% higher, respectively, than the birds from S1, which proves the difference in growth potential between the strains evaluated. This occurred because the S2 quails came from the breeding program of Universidade Federal do Ceará, whose objective is to develop heavier quail strains for slaughter, with potential above that of the common meat-type quail strains commercially available.

Regarding the feeding program, controlling feed intake in breeding broilers is an essential tool for maintaining the growth curve within standards to achieve the maximum productive potential of the birds, as they have a high capacity for feed intake and, when fed *ad libitum*, tend to develop productive and reproductive problems associated with high body weight (AWOBAJO et al., 2007). According to ETCHES (1998), LEESON & SUMMERS (2009), and SCANES (2015), excessive body weight in adult birds is associated with the accumulation of body fat, which can interfere with production and release of key hormones such as

Table 3 - Performance of meat-type breeding quails from 14 to 42 days of age subjected to different feeding programs.

Parameters	--------Feeding Program (FP)---------			---Quail Strain (QS)---		--SEM---	----------P-value----------		
	P1	P2	P3	S1	S2		FP	QS	FP x QS
Weight at 14d (g/bird)	73.50[a]	73.98[a]	73.87[a]	73.07[b]	74.50[a]	0.175	0.2352	<.0001	0.7851
Feed intake (g/bird)	721.32[a]	712.97[a]	656.13[b]	693.43[a]	700.19[a]	5.720	<.0001	0.0760	0.0778
Weight gain (g/bird)	187.66[a]	187.04[a]	173.14[b]	181.05[a]	184.18[a]	1.505	<.0001	0.0848	0.8864
Feed conversion (g/g)	3.85[a]	3.82[a]	3.79[a]	3.83[a]	3.80[a]	0.017	0.4503	0.4016	0.6970
Weight at 42d (g/bird)	261.16[a]	261.02[a]	247.00[b]	254.12[b]	258.67[a]	1.523	<.0001	0.0142	0.8576
Uniformity at 42d (%)	89.17[a]	95.00[a]	90.00[a]	89.45[a]	93.33[a]	1.412	0.2066	0.1784	0.9614

P1: *Ad libitum*; P2: Controlled daily; P3: 10% restriction of P2; S1: Strain 1; S2: Strain 2; SEM: Standard error of the mean;
[a,b] Means followed by different letters in the same row are statistically different according to the SNK test ($P < 0.05$).

estrogen, progesterone, and luteinizing hormone (LH), all essential for ovulation and egg formation. It can also lead to hepatic lipidosis, impairing the production of essential egg components and compromising laying capacity. Additionally, it may cause insulin resistance, negatively affecting egg formation and the energy required to maintain consistent laying. Furthermore, excessive fat accumulation in the abdominal cavity can compress the reproductive organs and hinder the proper functioning of the oviduct, making egg passage and laying more difficult.

In this perspective, the absence of a significant difference in feed intake between birds fed *ad libitum* and those receiving controlled daily amounts indicates that quails from both strains still did not show an appetite capable of increasing daily feed intake when given the opportunity to feed *ad libitum*, as occurs in growing breeding broilers. It is worth noting that the feed intake of birds subjected to the *ad libitum* feeding program was only 1.16% higher than that determined for birds subjected to the restricted feeding program stipulated for growing birds.

The results obtained for weight gain and weight at the 42 days of age of the quails fed different feeding programs clearly reflect the effects of feed intake on bird growth, highlighting the importance of providing an adequate amount of feed for growth. Thus, by restricting the amount of feed offered, nutrient intake reduces, consequently reducing body growth. Therefore, there was an expectation that treatments with feed restriction could result in lighter birds at the end of the growth phase, which was observed only for birds fed with 10% feed restriction.

Conversely, this effect was not observed for birds that received daily controlled feeding and, therefore, it is important to highlight that the magnitude of the impact of feed restriction in decreasing weight gain and body weight at the end of the grower phase depends on the level of feed restriction imposed (HASSAN et al., 2003; BURAGOHAIN, 2013; GRIESER et al., 2017), since a healthy animal's organism is capable of promoting adjustments in physiological and metabolic mechanisms to ensure that the demand for nutrients for body growth is met when feed restriction is not severe. The observed effects on birds fed with feed restriction have also been reported by other researchers for growing meat-type quails (GRIESER et al., 2017) and growing Japanese quails (GEBHARDT-HENRICH & MARKS, 1995; OCAK & ERENER, 2005; HASSAN et al., 2003; BURAGOHAIN, 2013).

The uniformity of the growing group is a priority factor for laying birds, as it directly impacts production and productivity of the birds in the laying phase, and the feeding program is fundamental to achieving adequate uniformity levels. Thus, considering that no significant differences were observed in the uniformity values at 42 days of birds subjected to different feeding programs and all values were above 80%, it can be inferred that the different programs used were adequate to obtain uniform birds at the end of the grower phase. It is worth noting that there was no bird mortality during the application of different feeding programs (14 to 42 days of age). This result indicated that the feeding condition imposed during the implementation of different feeding programs was satisfactory in this aspect. However, GEBHARDT-HENRICH & MARKS (1995) reported that mortality at the end of the grower phase was twice as high for birds subjected to 30% restriction compared to birds fed *ad libitum*. Results obtained by HASSAN et al. (2003) with quails subjected to 30% feed restriction in the initial phase and TROCINO et al. (2020) with broiler chickens subjected to 20% feed restriction showed increase of the stress manifesting intense feather pecking behavior and increased competition among birds. In the present research, it was observed that although birds subjected to 10% restriction were more competitive in seeking feed at feeding time, no lesions or feather loss that would indicate a problem were observed.

Sexual maturity

Data on feed intake and weight gain of breeding birds from 42 days old until the date of the first egg and sexual maturity parameters, age, weight of birds and weight of the egg at the first egg indicated that there was no significant effect of interaction between feeding program and strain (Table 4). These variables were also not significantly influenced by the strain itself; however, the feeding program during the grower phase significantly influenced the average age of birds at the first egg, where the birds subjected to a 10% feed restriction of the controlled daily amount took about four days longer to start egg production compared to birds subjected to other feeding programs, which did not differ from each other.

It is agreed that the weight of females at the end of the grower phase affects sexual maturity, so underweight birds may delay the start of laying (GEBHARDT-HENRICH & MARKS, 1995; HASSAN et al., 2003; TEIXEIRA et al., 2012), which was confirmed for the birds in the present research since those subjected to a 10% restriction of the controlled daily amount had lower weight at 42 days old. This is explained by the fact that

Table 4 - Sexual maturity indicators of meat-type breeding quails subjected to different feeding programs during the grower phase.

Parameters	------Feeding Program (FP)------			-Quail Strain (QS)-		--SEM--	----------P-value----------		
	P1	P2	P3	S1	S2		FP	QS	FP x QS
----------42d until maturity----------									
Feed intake (g/bird)	357.31[a]	369.09[a]	446.62[a]	364.58[a]	415.36[a]	22.823	0.2160	0.2497	0.1635
Weight gain (g/bird)	62.14[a]	61.68[a]	71.59[a]	66.82[a]	63.46[a]	2.989	0.3173	0.5738	0.2231
----------At the 1st egg----------									
Body weight (g/bird)	323.30[a]	322.70[a]	318.60[a]	320.93[a]	322.13[a]	2.916	0.7809	0.8408	0.1780
Age at 1st egg (days)	51.90[b]	52.20[b]	55.80[a]	53.13[a]	53.45[a]	0.582	0.0074	0.7461	0.4489
Egg weight of the 1st egg (g)	10.93[a]	11.56[a]	10.59[a]	10.90[a]	11.14[a]	0.237	0.2560	0.6108	0.4078

P1: *Ad libitum*; P2: Controlled daily; P3: 10% restriction of P2; S1: Strain 1; S2: Strain 2; SEM: Standard error of the mean;
[a,b] Means followed by different letters in the same row are statistically different according to the SNK test ($P < 0.05$).

sexual development and egg production are directly related to nutritional status and the accumulation of body reserves. Birds with lower body weight tend to reach sexual maturity later, as they need more time to accumulate sufficient nutrients to sustain the reproductive process. Therefore, feed restriction not only limits growth, but also affects the availability of energy resources for the onset of ovulation.

The absence of a significant difference in the average body weight of birds from different treatments at the first egg highlights the importance of weight for the start of egg production of the evaluated strains. Therefore, for birds restricted by 10% to start laying, it was necessary more time to reach the necessary weight. The absence of a significant difference in body weight at sexual maturity between restricted and *ad libitum*-fed quails was also reported by HASSAN et al. (2003). According to SUN et al. (2006), although the age at first laying was significantly different between *ad libitum*-fed birds and those with feed restriction, the total carcass protein amount was very similar at the first laying, indicating the importance of protein mass necessary for sexual maturity.

It is noteworthy that in the period from 42 days of age until the first egg, although there was no significant difference, the delay in starting production implied a higher amount of feed consumed and weight gain of feed-restricted birds compared to the others. This fact may be associated with compensatory growth presented by birds subjected to feed restriction in an attempt to compensate for growth since after 42 days of age all birds started to receive *ad libitum* feeding. According to GEBHARDT-HENRICH & MARKS (1995), compensatory growth in two strains of Japanese breeding quails after the release of feed restriction was remarkable, so that two weeks after the end of feed restriction, restricted quails no longer had significantly lower body weight than *ad libitum*-fed ones. Similar results were reported by BURAGOHAIN (2013) and FIDAN & KAYA (2014) for Japanese quails subjected to feed restriction from two to five weeks of age phase.

Accelerated growth after ending feed restriction favors obtaining the minimum body weight necessary for sexual maturity. However, according to OCAK & ERENER (2005), the ability of quails to achieve compensatory growth may be influenced by the quail strain and the severity, time, and duration of feed restriction. In this context, it can be inferred that although, there is a difference in body weight between the evaluated strains, they responded similarly to the feeding programs during the grower phase, and the magnitude of the restriction (10% of the controlled daily) allowed the birds to reach sexual maturity a few days after the *ad libitum*-fed birds.

The effects of feeding programs on the sexual maturity of meat-type breeding quails are similar to those reported in the literature for breeding Japanese quails. GEBHARDT-HENRICH & MARKS (1995) observed a delay in sexual maturity, so that *ad libitum*-fed birds had the first laying at 48 days of age, and birds subjected to 30% feed restriction of the *ad libitum* feed intake had the first laying at 59 days of age. HASSAN et al. (2003) reported that although there was no significant difference, birds subjected to 30% feed restriction delayed the onset of laying by 2 days (52.4 days) when compared to birds fed with 15% restriction (50.3 days) or *ad libitum* (50.3 days). However, birds subjected to 30% restriction had higher body weight at the first egg. There was also no difference in the weight of the first egg among feeding programs. OCAK & ERENER (2005) observed a two-day delay

in sexual maturity of Japanese quails subjected to 30% feed restriction when compared to those fed *ad libitum*. However, there was no significant difference in the weight of the first egg. FIDAN & KAYA (2014) observed that Japanese quails subjected to 15 and 30% restriction had three more days to start laying when compared to *ad libitum*-fed birds, without significant differences in these parameters, as well as for the weight of birds at maturity and the weight of the first egg. HERTAMAWATI et al. (2019) reported similarity in body weight at sexual maturity of Japanese quails subjected to 20% and 10% feed restriction compared to *ad libitum*-fed birds.

Performance during the laying phase

When evaluating the effect of different feeding programs during the grower phase on the performance of birds during the laying phase (Table 5), it was observed that there was no significant effect of interaction between feeding program and strain on the evaluated variables. There was also no significant difference between strains. However, for the different feeding programs, a significant difference was observed in feed intake, body weight, and bird mortality at the end of the laying phase, while egg production, average egg weight, egg mass, and feed conversion did not vary significantly.

According to the results, birds subjected to feed restriction during the grower phase showed lower feed intake during the laying phase when compared to birds fed with other feeding programs, which did not differ from each other. Restricted birds also showed the lowest body weight at the end of the laying phase, differing significantly only from birds fed with controlled daily amounts during the grower phase.

Considering that birds intended for egg production depend on daily energy and nutrient intake to meet their maintenance and productive requirements, according to NEME et al. (2006), it is expected that heavier birds at the end of the grower phase will present higher feed intake during the laying phase, since maintenance requirements are higher for heavier birds. Thus, the lower feed intake during the laying phase observed for restricted birds may be associated with the fact that these birds ended the grower phase (42 days of age) with lower body weight and maintained lower body weight throughout their productive cycle, without significant differences in egg production. Therefore, the feed intake presented by restricted birds during the grower phase was enough to ensure the same level of performance as birds from other programs, and thus, only by being smaller, restricted birds required less nutrient for maintenance, resulting in lower feed intake during the laying phase.

The absence of a significant influence of feed restriction during the grower phase on the laying percentage and egg weight during the laying cycle was also recorded by GEBHARDT-HENRICH & MARKS (1995), HASSAN et al. (2003), and FIDAN & KAYA (2014) for breeding Japanese quails.

For mortality, a significant difference was observed only between *ad libitum*-fed birds compared to birds restricted by 10% of the controlled daily feed intake, with lower mortality for restricted birds. Mortality in breeding broiler hens during the production phase has been associated, among other factors, with overweight birds, leading to fat accumulation (AWOBAJO et al., 2007).

Egg quality

For the parameters of egg characteristics and quality (Table 6), it was observed that there was

Table 5 - Performance during the laying phase of meat-type breeding quails subjected to different feeding programs during the grower phase.

Parameters	------Feeding Program (FP)-----			--Quail Strain (QS)--		--SEM--	----------P-value----------		
	P1	P2	P3	S1	S2		FP	QS	FP x QS
Feed intake (g/bird/day)	32.06^{a}	31.40^{ab}	30.82^{b}	31.36^{a}	31.49^{a}	0.193	0.0332	0.7166	0.5161
Laying (%/bird/day)	78.28^{a}	74.94^{a}	76.70^{a}	75.83^{a}	77.44^{a}	0.809	0.2614	0.3291	0.5642
Egg weight (g)	12.94^{a}	13.02^{a}	12.76^{a}	12.87^{a}	12.95^{a}	0.046	0.0772	0.3869	0.8900
Egg mass (g/bird/day)	10.13^{a}	9.75^{a}	9.79^{a}	9.75^{a}	10.03^{a}	0.107	0.2883	0.2088	0.4831
Feed conversion (g/g)	3.17^{a}	3.22^{a}	3.16^{a}	3.22^{a}	3.15^{a}	0.029	0.6753	0.2189	0.6238
Bird weight at 51 weeks (g/bird)	350.27^{ab}	354.26^{a}	340.59^{b}	350.29^{a}	346.52^{a}	2.266	0.0319	0.3637	0.2328
Mortality (%)	350.27^{ab}	7. 58^{ab}	4.17^{b}	7.83^{a}	8.39^{a}	1.041	0.0460	0.8411	0.8488

P1: *Ad libitum*; P2: Controlled daily; P3: 10% restriction of P2; S1: Strain 1; S2: Strain 2; SEM: Standard error of the mean;
^{a,b} Means followed by different letters in the same row are statistically different according to the SNK test ($P < 0.05$).

no significant effect of interaction between feeding program and strain on the evaluated variables. There was also no significant difference between feeding programs or between strains.

As with performance variables during the laying phase, no significant effects of feeding program were observed on the components and quality of the eggs, indicating that there was no residual effect of the feed received by the birds during the grower phase on the evaluated variables. Conversely it is known that protein, amino acids, and linoleic acid are the most important nutritional factors in laying feed that affect egg weight and, consequently, the proportion of egg components (LEESON & SUMMERS, 1997). Since all birds received the same laying feed in this study, the nutrients ingested by birds from all feeding programs were certainly sufficient to keep the components and quality of the eggs stable.

It is worth noting that the values obtained in this research for egg characteristics and quality indicators agree with the literature, as according to MÓRI et al. (2005), European quail eggs have an average weight of 13.12g, specific gravity of 1.073, 29.93% yolk, 61.97% albumen, and 8.10% shell. Furthermore, the absence of a significant effect of feed restriction programs during the grower phase of meat-type breeding quails on egg quality has been reported (UKACHUKWU & AKPAN, 2007).

A study conducted by SAIBABA et al. (2021) demonstrated that at the beginning of the experiment, the feed restriction did not have a significant impact on HU values compared to the control group (*ad libitum*). However, over time, the group subjected to feed restriction began to show improvements in HU values, indicating better protein quality in the eggs compared to the control group. This improvement suggested that while the initial feed restriction did not affect egg quality, the restricted feeding approach eventually contributed to the production of superior quality eggs, particularly in older birds.

Incubation parameters

Regarding the incubation parameters of breeding quail eggs, the results (Table 7) showed that there was no significant effect of interaction between feeding program and strain on the evaluated variables. There was also no significant difference between feeding programs or between strains in terms of the average weight of incubated eggs, weight of chicks at birth, fertility, hatching rate, and hatchability. The fertility of breeding birds plays an effective role in the results obtained in egg incubation. Thus, the relationship between bird weight and fertility has been a concern, justifying the use of restriction programs during the grower phase to achieve adequate weight standards throughout the production cycle (BENSON et al., 2022). Thus, the results indicated that the higher body weight of *ad libitum*-fed quails during the grower phase was not sufficient to compromise their fertility.

Fertility has a direct effect on the hatching rate, as there is no embryonic development in infertile eggs. Therefore, obtaining chicks from fertile eggs incubated can be better evaluated by obtaining hatchability rates, which can be affected by factors related to incubation conditions and the quality of eggs produced by the breeding birds. Thus, generally, changes in incubation parameters have been observed when there is a change in the size or components of incubated eggs. Therefore, the absence of a significant difference in hatchability can be associated with the similarity in egg size, proportion of their components, and internal and shell quality.

The results obtained for reproductive performance variables agree with those reported by

Table 6 - Internal and external quality of fertile eggs from meat-type breeding quails subjected to different feeding programs during the grower phase.

Parameters	-------Feeding Program (FP)------			--Quail Strain (QS)--		--SEM--	----------P-value----------		
	P1	P2	P3	S1	S2		FP	QS	FP x QS
Specific density (g/cm³)	10.698	10.696	10.691	10.699	10.691	0.0002	0.3641	0.0831	0.2847
Haugh unit	93.93	94.01	93.95	93.83	94.10	0.124	0.9676	0.3100	0.3478
Albumen (%)	62.05	61.72	61.92	62.05	61.74	0.095	0.3652	0.1111	0.8736
Yolk (%)	29.95	30.25	30.12	29.93	30.28	0.098	0.4808	0.0940	0.9752
Shell (%)	8.00	8.03	7.96	8.02	7.98	0.028	0.6264	0.5652	0.5391
Shell thickness (mm)	0.22	0.22	0.22	0.22	0.21	0.0011	0.5658	0.1618	0.9203

P1: *Ad libitum*; P2: Controlled daily; P3: 10% restriction of P2; S1: Strain 1; S2: Strain 2; SEM: Standard error of the mean.

Table 7 - Incubation parameters of eggs from meat-type breeding quails subjected to different feeding programs during the grower phase.

Parameters	-------Feeding Program (FP)-------			--Quail Strain (QL)--		--SEM--	----------P-value----------		
	P1	P2	P3	S1	S2		FP	QS	FP x QS
Egg weight (g)	13.00	13.04	12.86	12.89	13.04	0.048	0.2602	0.1341	0.7278
Chick weight (g)	9.00	8.87	8.86	8.85	8.97	0.049	0.4264	0.2242	0.1849
Hatching (%)	59.48	56.04	60.52	57.16	60.20	2.312	0.7409	0.5423	0.7172
Hatchability (%)	70.78	66.60	73.14	70.19	70.15	1.975	0.4290	0.9924	0.5270
Fertility (%)	82.88	82.69	82.45	80.61	84.74	1.559	0.9941	0.2042	0.3177

P1: *Ad libitum*; P2: Controlled daily; P3: 10% restriction of P2; S1: Strain 1; S2: Strain 2; SEM: Standard error of the mean.

other researchers. HASSAN et al. (2003) and FIDAN & KAYA (2014) did not observe a significant effect of up to 30% feed restriction during the grower phase of breeding Japanese quails on the weight, fertility, and hatchability of incubated eggs.

Regarding the influence of the hen on chick weight at birth, this effect is associated with the size of incubated eggs and the availability of nutrients for embryonic development. Thus, considering that the weight and components of incubated eggs did not vary significantly due to the evaluated factors, the absence of a significant effect on chick weight at birth can be considered expected. SANTOS et al. (2015) related the increase in the size of incubated eggs from meat-type breeding quails to the increase in chick weight at birth.

CONCLUSION

Regardless of the strains evaluated, *ad libitum* or daily controlled feeding between 14 and 42 days old does not compromise growth performance, sexual maturity, egg production and quality, as well as reproductive performance, while restricting the feed by 10% of the controlled daily feed in the grower phase reduces body weight, delays sexual maturity, and leads to lower feed intake, without compromising egg production or quality. In addition, the feed restriction programs reduced mortality during the laying cycle. Thus, *ad libitum* or daily controlled feeding programs are the best strategies to be adopted in the formation of the breeding group of meat-type quails; however, restricted feeding programs imply a greater demand for daily labor.

ACKNOWLEDGMENTS

The authors thank the Brazilian agencies: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), located in Brasilia, Brazil, for the productivity in research scholarship and the Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the support. Financing Code 001.

DECLARATION OF CONFLICT OF INTEREST

There are no conflicts of interest to be declared.

AUTHORS' CONTRIBUTIONS

All authors contributed equally to the conception and writing of the manuscript. All authors critically reviewed the manuscript and approved the final version.

BIOETHICS AND BIOSECURITY COMMITTEE APPROVAL

The study was approved by the Ethics Committee on Animal Use of the Universidade Federal do Ceará, under protocol CEUA nº 2510202101 and is in accordance with the Ethical Principles of Animal Experimentation adopted by the Brazilian College of Animal Experimentation.

REFERENCES

ABBAS, Y. et al. Effect of different feed restriction regimes on growth performance and economic efficiency of Japanese quails. **The Journal of Animal & Plant Sciences**, v.25, n.4, p.966-670, 2015. Available from: <https://www.thejaps.org.pk/docs/v-25-04/08.pdf>. Accessed: Sept. 22, 2024.

AWOBAJO, O. K. et al. The mortality rate of two different breeds of broilers after brooding stage to maturity. **Middle-East Journal of Scientific Research**, Ogum, Nigéria, v.2, n.1, p.37-42, 2007. Available from: <https://idosi.org/mejsr/mejsr2(1)/7.pdf>. Accessed: Apr. 28, 2024.

BENSON, A. P. et al. Effect of early photostimulation at 15-weeks of age and everyday spin feeding on broiler breeder performance. **Poultry Science**, v.101, n.6, p.101872, 2022. Available from: <https://doi.org/10.1016/j.psj.2022.101872>. Accessed: Apr. 27, 2024. doi: 10.1016/j.psj.2022.101872.

BURAGOHAIN, R. Effects of feed restriction on compensatory growth period, nutrient digestibility and economics of Japanese quails

(Coturnix coturnix japonica). **International Multidisciplinary Research Journal**, Vidyanagar, India, v.3, n.1, p.4-7, 2013. Available from: <https://updatepublishing.com/journal/index.php/imrj/article/view/1657>. Accessed: Apr. 28, 2024.

CARNEIRO, P. R. O. et al. Effect of different feed restriction programs on the performance and reproductive traits of broiler breeders. **Poultry Science**, v.98, n.10, p.4705-4715, 2019. Available from: <https://doi.org/10.3382/ps/pez181>. Accessed: Apr. 28, 2024. doi: 10.3382/ps/pez181.

ETCHES, R. J. **Reproduction in poultry**. Zaragoza: Acribia, S. A., 1998.

FIDAN, E. D.; KAYA, M. Effects of early feed restriction on some performance and reproductive parameters in Japanese quail (Coturnix coturnix japonica). **International Journal of Poultry Science**, Aydın, Turquia, v.13, n.6, p.323-328, 2014. Available from: <https://doi.org/10.3923/ijps.2014.323.328>. Accessed: Apr. 28, 2024. doi: 10.3923/ijps.2014.323.328.

FREITAS, E. R. et al. Comparison of methods to measure the specific gravity of laying hen eggs. **Pesquisa Agropecuária Brasileira**, Brasília, v.39, p.509-512, 2004. Available from: <https://doi.org/10.1590/S0100-204X2004000500014>. Accessed: Apr. 27, 2024. doi: 10.1590/S0100-204X2004000500014.

GEBHARDT-HENRICH, S. G.; MARKS, H. L. Effects of feed restriction on growth and reproduction in random-bred and selected lines of Japanese quail. **Poultry Science**, v.74, n.2, p.402-406, 1995. Available from: <https://doi.org/10.3382/ps.0740402>. Accessed: Apr. 28, 2024. doi: 10.3382/ps.0740402.

GRIESER, D. O. et al. Productive performance, body chemical composition, and deposition of 42-day-old quail for meat subjected to quantitative dietary restriction. **Semina: Ciências Agrárias**, Londrina, v.38, n.2, p.855-866, 2017. Available from: <https://doi.org/10.5433/1679-0359.2017v38n2p855>. Accessed: Apr. 29, 2024. doi: 10.5433/1679-0359.2017v38n2p855.

HASSAN, S. M. et al. Effect of early feed restriction on reproductive performance in Japanese quail (Coturnix coturnix japonica). **Poultry Science**, v.82, n.7, p.1163-1169, 2003. Available from: <https://doi.org/10.1093/ps/82.7.1163>. Accessed: Apr. 29, 2024. doi: 10.1093/ps/82.7.1163.

HAUGH, R. R. The Haugh unit for measuring egg quality. **United States Egg Poultry Magazine**, v.43, p.552-555, 1937. Accessed: Apr. 28, 2024.

HERTAMAWATI, R. T. et al. Reproductive performance of Japanese quail hens (Coturnix coturnix japonica) fed with feed restriction regimes during growth period. **Agricultural Science Digest-A Research Journal**, Malang, Indonesia, v.39, n.2, p.163-166, 2019. Available from: <https://doi.org/10.18805/ag.D-145>. Accessed: Apr. 29, 2024. doi: 10.18805/ag.D-145.

JAAP, R. G.; MUIR, F. V. Erratic oviposition and egg defects in broiler-type pullets. **Poultry Science**, v.47, n.2, p.417-423, 1968. Available from: <https://doi.org/10.3382/ps.0470417>. Accessed: Apr. 29, 2024. doi: 10.3382/ps.0470417.

LEESON, S.; SUMMERS, J. D. **Commercial poultry nutrition**. Nottingham university press, 2009.

LEESON, S.; SUMMERS, J. D. Feeding programs for broilers. **In Commercial Poultry Nutrition**. (3rd ed., p.207-298), 1997.

LEKSRISOMPONG, N. et al. Effect of feeder space during the growing and laying periods and the rate of feed increase at the onset of lay on broiler breeder female reproductive function. **Poultry Science**, v.93, n.7, p.1599-1607, 2014. Available from: <https://doi.org/10.3382/ps.2013-03277>. Accessed: Apr. 28, 2024. doi: 10.3382/ps.2013-03277.

MAHROSE, K. M. et al. Restricted feeding could enhance feed conversion ratio and egg quality of laying Japanese quail kept under different stocking densities. **Animal Biotechnology**, v.33, n.1, p.141-149, 2022. Available from: <https://doi.org/10.1080/10495398.2020.1810059>. Accessed: Sept. 22, 2024. doi: 10.1080/10495398.2020.1810059

MÓRI, C. et al. Desempenho e qualidade dos ovos de codornas de quatro grupos genéticos. **Revista Brasileira de Zootecnia**, v.34, p.864-869, 2005. Available from: <https://doi.org/10.1590/S1516-35982005000300018>. Accessed: Jun. 10, 2024. doi: 10.1590/S1516-35982005000300018.

NEME, R. et al. Curvas de crescimento e de deposição dos componentes corporais em aves de postura de diferentes linhagens. **Revista Brasileira de Zootecnia**, v.35, p.1091-1100, 2006. Available from: <https://doi.org/10.1590/S1516-35982006000400021>. Accessed: Apr. 29, 2024. doi: 10.1590/S1516-35982006000400021.

OCAK, N.; ERENER, G. The effects of restricted feeding and feed form on growth, carcass characteristics and days to first egg of Japanese quail (Coturnix coturnix japonica). **Asian-Australasian Journal of Animal Sciences**, v.18, n.10, p.1479-1484, 2005. Available from: <https://doi.org/10.5713/ajas.2005.1479>. Accessed: Apr. 28, 2024. doi: 10.5713/ajas.2005.1479.

RENEMA, R. A.; ROBINSON, F. E. Defining normal: comparison of feed restriction and full feeding of female broiler breeders. **World's Poultry Science Journal**, Edmonton, Canadá, v.60, n.4, p.508-522, 2004. Available from: <https://doi.org/10.1079/WPS200434>. Accessed: Apr. 29, 2024. doi: 10.1079/WPS200434.

ROBINSON, F. E. et al. The relationship between body weight and reproductive efficiency in meat-type chickens. **Poultry Science**, v.72, n.5, p.912-922, 1993. Available from: <https://doi.org/10.3382/ps.0720912>. Accessed: Apr. 29, 2024. doi: 10.3382/ps.0720912.

ROSTAGNO, H. S. et al. **Tabelas Brasileiras para aves e suínos**: composição de alimentos e exigências nutricionais (4th ed.). Viçosa: Universidade Federal de Viçosa, 2017.

SAIBABA, G. et al. Time-restricted feeding in commercial layer chickens improves egg quality in old age and points to lack of adipostat activity in chickens. **Frontiers in Physiology**, v.12, p.651738, 2021. Available from: <https://doi.org/10.3389/fphys.2021.651738>. Accessed: Aug. 29, 2024. doi: 10.3389/fphys.2021.651738.

SAKOMURA, N. K.; ROSTAGNO, H. S. **Métodos de pesquisa em nutrição de monogástricos**. Jaboticabal: Funep, 2007.

SANTOS, T. C. et al. Influence of European quail breeders age on egg quality, incubation, fertility and progeny performance. **Brazilian Journal of Poultry Science**, v.17, p.49-56, 2015. Available from: <https://doi.org/10.1590/1516-635x170149-56>. Accessed: Apr. 28, 2024. doi: 10.1590/1516-635x170149-56.

SAS Institute. **SAS User's Guide**: Statistics (8th ed.). Cary, NC: SCIRP, 2000.

SCANES, C. G. (Ed.). **Sturkie's avian physiology**. Elsevier, 2015.

SILVA, J. H. V.; COSTA, F. G. P. **Tabela para codornas japonesas e europeias** (2nd ed.). Jaboticabal: FUNEP-SP, 2009.

SUN, J. M. et al. The relationship of body composition, feed intake, and metabolic hormones for broiler breeder females. **Poultry Science**, v.85, n.7, p.1173-1184, 2006. Available from: <https://doi.org/10.1093/ps/85.7.1173>. Accessed: Jun. 6, 2024. doi: 10.1093/ps/85.7.1173.

SUNDER, G. S. et al. Energy restriction in broiler breeders during rearing and laying periods and its influence on body weight gain, conversion efficiency of nutrients, egg production and hatchability. **The Journal of Poultry Science**, Tsukuba, Japão, v.45, n.4, p.273-280, 2008. Available from: <https://doi.org/10.2141/jpsa.45.273>. Accessed: Apr. 29, 2024. doi: 10.2141/jpsa.45.273.

TEIXEIRA, B. B. et al. Quantitative traits in meat-type quail through two-trait analysis. **Ciência Rural**, v.42, p.2259-2264, 2012. Available from: <https://doi.org/10.1590/S0103-84782012005000102>. Accessed: Apr. 28, 2024. doi: 10.1590/S0103-84782012005000102.

TROCINO, A. et al. Effect of feed restriction on the behaviour and welfare of broiler chickens. **Animals**, v.10, n.5, p.830, 2020. Available from: <https://doi.org/10.3390/ani10050830>. Accessed: Aug. 28, 2024. doi: 10.3390/ani10050830.

UKACHUKWU, S. N.; AKPAN, U. O. Influence of level and duration of quantitative feed restriction on post-restriction egg-laying characteristics and egg quality of pullets. **International Journal of Poultry Science**, v.6, n.8, p.567-572, 2007. Available from: <https://doi.org/10.3923/ijps.2007.567.572>. Accessed: Apr. 29, 2024. doi: 10.3923/ijps.2007.567.572.