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Comparison of growth and developmental stability traits of Japanese quails reared in conventional and enriched cages

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Abstract: This study was carried out to determine the effects of different rearing systems on some performance and welfare characteristics in Japanese quail. For this purpose, a total of 630 birds were housed in battery-type conventional cages, conventional floor cages and enriched floor cages. There were statistically significant differences between the experimental groups and the sexes in terms of the average body weight of the quails at 42 and 56 days of age (both P<0.01). Accordingly, it was determined that the average body weight of the quails raised in the conventional battery cages were higher than those raised both in the conventional and enriched floor cages. Gompertz growth curve model parameters of β_0, β_1, β_2 were estimated as 262.05, 3.76, 0.050 for birds housed in battery-type conventional cages, 228.12, 3.57, 0.042 for birds housed in conventional floor cages, and 252.53, 3.86, 0.045 for birds housed in enriched floor cages, respectively. Among the bilateral traits, the highest mean value of relative asymmetry was found for wing length of birds reared in conventional battery type cages (P<0.01). As a result, it was determined that quails raised in conventional battery type cages are more advantageous for economic production. However, it may be recommended to use enrichment objects for an animal welfare oriented production system.
Keywords: Animal welfare, bilateral symmetry, enriched cage, growth curve.

Konvansiyonel ve Zenginleştirilmiş Kafeslerde Yetiştirilen Japon Bıldırcınlarında Büyüme ve Gelişim Dengesi Özelliklerinin Karşılaştırılması

Özet: Bu çalışma farklı yetiştirme koşullarının bıldırcınların bazı performans ve refah özelliklerine etkilerini belirlemek amacıyla gerçekleştirilmiştir. Bu amaçla toplam 630 Japon bıldırcını batarya tipi konvansiyonel kafeslerde, konvansiyonel yer kafeslerinde ve zenginleştirilmiş yer kafeslerinde barındırıldı. Çalışmada kullanılan bıldırcınların canlı ağırlık ortalamaları bakımından hem deneme grupları hem de cinsiyetler arasında istatistiksel olarak önemli farklılıklar belirlenmiştir (P<0.01). Buna göre konvansiyonel katlı kafeste yetiştirilen bıldırcınların canlı ağırlık ortalamalarının hem yer kafesinde yetiştirilenlerden, hem de zenginleştirilmiş kafeste yetiştirilenlerden daha yüksek olduğu belirlenmiştir. Gompertz büyüme eğrisi modeli parametreleri olan β_0, β_1, β_2 ortalamaları sırasıyla konvansiyonel kafes için 262,05, 3,76, 0,050, yer kafesi için β_0, β_1, $\beta_2$parametre ortalamaları ise sırasıyla 228,12, 3,57, 0,042 ve zenginleştirilmiş kafes için β_0, β_1, $\beta_2$parametre ortalamaları sırasıyla 252,53, 3,86 ve 0,045 olarak bulunmuştur. Bilateral özelliklerden kanat uzunluğu için en yüksek oransal asimetri ortalamaları konvansiyonel batarya tipi kafeste saptanmıştır (P<0,01). Sonuç olarak konvansiyonel katlı kafeslerde yetiştirilen bıldırcınların ekonomik üretim için daha avantajlı olduğu belirlenmiştir. Fakat hayvan refahı odaklı bir üretim için ise zenginleştirme objelerinin kullanılması tavsiye edilebilir.
Anahtar sözcükler: Büyüme eğrisi, hayvan refahı, iki yönlü simetri, zenginleştirilmiş kafes.

Introduction

In order to reduce the stress level and create welfare in poultry, it is recommended that the birds be housed in areas similar to their natural habitats and to add some environmental enrichment objects to the area where they can exhibit their natural behaviors. Environmental enrichment is defined as changing the environment offered to animals in order to improve biological functions and increase behavioral opportunities (7, 8). Environmental enrichment is a widely used technique to improve animal welfare and has a wide range of behavioral and physiological implications. In the cage and floor systems where poultry are housed, nest, perches, sand bath, walking path, playing equipment, relaxing sound or lighting equipment can be used as environmental enrichment elements (39).

There have been a number of studies of the effects of particular enrichment types on poultry performance and behavior.It has been reported by many researchers that environmental enrichment practices in broiler chickens have no effect on body weight gain, feed efficiency and carcass characteristics (5, 22, 37). Jones (16) reported that the level of fear was reduced in broilers raised in the enriched environment, and the adaptation ability of birds against different objects increased. Martrenchar et al. (23) reported that the aggressive pecking behavior was reduced in turkeys raised in an enriched environment. In another study investigating the effect of environmental enrichment and music stimulation on behavior in broilers, it was reported that the fear behavior towards different objects was significantly lower (15).

Studies on environmental enrichment in poultry have generally been carried out in chickens (9, 22, 37, 39). There are limited number of studies on environmental enrichment practices in Japanese quail (26, 36). In developed countries, 80% of the total poultry production is obtained from chicken species while 20% of the production is from other poultry species. For this reason, it is necessary to work on the breeding practices of minor poultry species such as goose, duck, partridge and quail to improve the product quality. The commercial production of quails is intensively carried out due to the fact that quails reach sexual maturity and slaughter age in a very short time, they are reared in large numbers per unit area due to their small size and they are resistant to diseases. In addition, Japanese quails have been used as model animals in various scientific studies for years (29). The production, which is made without distinguishing the meat or egg yield in quails, is carried out both in battery cages and in the deep litter system. However, there are a limited number of studies on rearing systems which promote behaviors that are important for metabolic and mental health in quails and their relationship with productivity. Miller and Mench (26), who examined the effects of different environmental enrichment methods on behavior and productivity in Japanese quails, reported that live weight was not affected by environmental enrichment. In another study conducted by Miller and Mench (25), Japanese quails were reared in trial units with four different enriched environments, and the effects of these housing types on aggressiveness, feather pecking, feather loss, feed wasting and some performance characteristics were investigated. In a study using conventional battery cage and enriched cage (36), some behavioral characteristics of Japanese quails were compared. The aim of this study is to compare growth and developmental stability characteristics of Japanese quails housed in different rearing system. Thus, it was targeted to determine the effect of an enriched environment on growth and developmental stability characteristics of Japanese quails.

Materials and Methods

The care and use of animals were in accordance with laws and regulations of Turkey and approved by Ministry of Food, Agriculture and Livestock (decision number 22875267-325.04.02-E.3211771) and Animal Experiments Local Ethics Committee of Akdeniz University. The study was conducted using three in-time replicates over the course of 56 days. A total of 630 randombred Japanese quail (*Coturnix coturnix Japonica*) chicks were hatched at Avian Sciences facility of Akdeniz University. Chicks with wing numbers were randomly distributed at one day old among 2 battery type cages (conventional battery cages=CBC) and 4 floor pens with deep litter (2 conventional floor pens=CFP, 2 enriched floor pens=EFP). Weekly live weights and developmental stability measurements were performed by matching individual records during the trial. A total of 240 chicks assigned to the conventional environment treatment were housed in the fattening type of battery cages (12.63 kg BW/m^2 at slaughter age). A total of 240 chicks assigned to the conventional environment treatment were housed in the floor pen cages with deep litter (12.63 kg BW/m^2 at slaughter age). A total of 150 chicks assigned to the enriched environment were placed in the floor pen cages with deep litter (6.87 kg BW/m^2 at slaughter age). Chicks in the floor groups (CFP and EFP) were placed on 4-cm fresh wood-shavings litter in an environmental chamber. Chicks in the cage group (CBC) were placed in a 2-cage stainless steel battery (five levels of two cages, cup-type automatic waterers and trough feeders). Perches, sandboxes, walking paths, nail and beak scrubbers and various game objects were used as enrichment equipment in the EFC trial units.

Chicks in all chambers were brooded at 32 °C on days 1 to 5, 29 °C on days 6 to 10, 27 °C on days 11 to 17, and 21 °C thereafter. Both chambers shared the same ventilation system, and the ventilation rate was equal for both groups. Water and a corn-soybean meal quail ration (24% CP, 2900 kcal ME/kg) formulated to meet or exceed the minimum NRC standards for all ingredients were provided ad libitum. The lights were on for 24 h/d through day 5, and for 23 h/d thereafter.

Four bilateral traits (face, wing, shank diameter, shank length) were measured in millimeters by using calipers to determinate the developmental stability in Japanese quail at 56 days of age. The recorded morphological traits were right (R) and left (L) lengths and diameters of shank (metatarsus), right (R) and left (L) lengths of wing (radius), and face lengths. Relative asymmetry (RA) of bilateral traits was defined as $(|L-R|/((L+R))/2)\times 100$. A series of steps (30) were followed before identifying exhibited asymmetry as fluctuating asymmetry. First, the presence of directional asymmetry (normal distribution with a mean of not zero) and antisymmetry (nonnormal distribution) was tested by inspection of the distribution of signed right minus left differences (R−L). The presence of directional asymmetry was tested for using one sample t-test. Departures from normality were assessed using Shapiro Wilktest. If differences in (R−L) exist, asymmetry should be leptokurtically distributed: the greater the magnitude of differences, the greater the leptokurtosis. Second, the fluctuating asymmetry and measurement errors are normally distributed about a mean of zero (9).

To obtain the estimates of individual growth curve parameters, all quail were weighed weekly from hatching to 8 weeks of age. In many studies fitted to model of the growth samples of Japanese quails, it was determined that the best model in terms of goodness of fit criteria was the Gompertz model (3, 11, 19, 31, 33). For this reason, the Gompertz non-linear regression model (I) was used to estimate growth curve of each quail.

$$\boldsymbol{y_t = \beta_0 e^{(-\beta_1 e^{-\beta_2 t})}} \text{ (I)}$$

where $\boldsymbol{y_t}$ is the weight at age *t*, $\boldsymbol{\beta_0}$ is the asymptotic (mature) weight parameter, $\boldsymbol{\beta_1}$ is the scaling parameter (constant of integration) and $\boldsymbol{\beta_2}$ is the instantaneous growth rate (per day) parameter (4, 31, 33). The Gompertz model is characterized by an inflection point in a manner such that β_0/e of the total growth occurs prior to it and the remainder occurring after. The coordinates of the point of inflection, age and weight at inflection point (IPW and IPA, respectively), were obtained as follows:

$$\boldsymbol{IPW = \beta_0 / e} \text{ (II)}$$

$$\boldsymbol{IPA = ln(\beta_1)/\beta_2} \text{ (III)}$$

The nonlinear regression analyses for growth curves of birds were performed using NLIN procedure of SAS 9.3 statistics software. The descriptive statistics, Shapiro Wilk normality tests and hypothesis tests of the traits were obtained using UNIVARIATE procedure of SAS 9.3 statistics software. Data was subjected to two-way ANOVA to test the effects of treatment groups and gender on weekly body weights, individual growth curve parameters, and values of relative asymmetry using the GLM procedure of the SAS 9.3 statistics software. Means were compared using Duncan's multiple range test. The level of significance for all statistical analyses was based on $P < 0.01$.

Results

The descriptive statistics and results of statistical analyses (analyses of variance and Duncan multiple range tests) for body weight at 42 and 56 days of age, parameters of Gompertz growth curve and its point of inflection coordinates were presented by treatment groups and gender in Table 1. In studies using Japanese quails and in commercial production, generally six and eight week periods are accepted as the fattening period. Therefore, in

Table 1. The results of statistical analysis for traits of body weight and growth curve by treatment groups and gender.

Treatment		BW 42 (g)	BW 56 (g)	β_0	β_1	β_2	IPA (days)	IPW (g)
CBC		131.09±1.78[a]	169.58±2.17[a]	262.05±8.15[a]	3.76±0.04[a]	0.050±0.001[a]	27.88±0.75[c]	83.93±2.62[c]
CFC		112.18±2.04[c]	155.89±2.49[c]	228.12±7.12[c]	3.57±0.04[b]	0.042±0.001[b]	34.37±0.86[a]	96.41±3.00[a]
EFC		125.73±2.51[b]	163.72±3.07[b]	252.53±10.06[b]	3.86±0.05[a]	0.045±0.001[ab]	32.97±1.06[a]	92.91±3.70[a]
Sex								
♀		126.84±1.78[a]	168.24±2.17[a]	253.00±7.11	3.76±0.04	0.046±0.001	31.44±0.75	93.08±2.62
♂		119.16±1.70[b]	157.88±2.08[b]	242.14±6.82	3.71±0.03	0.045±0.001	32.04±0.72	89.09±2.51
Interaction								
CBC	♀	136.40±2.46	176.61±3.01	269.70±11.49	3.82±0.05	0.050±0.001	28.24±1.04	88.56±3.63
	♂	125.77±2.56	162.55±3.13	254.41±11.56	3.70±0.05	0.049±0.001	27.53±1.08	79.30±3.78
CFC	♀	114.07±2.87	159.11±3.51	240.72±9.87	3.60±0.06	0.042±0.001	34.50±1.21	99.23±4.23
	♂	110.28±2.89	152.66±3.53	215.53±10.27	3.54±0.06	0.041±0.001	34.24±1.22	93.60±4.25
EFC	♀	130.04±3.75	169.01±4.58	248.58±15.01	3.85±0.07	0.046±0.002	31.58±1.58	91.46±5.52
	♂	121.43±3.35	158.43±4.09	256.48±13.40	3.87±0.07	0.044±0.002	34.36±1.41	94.36±4.93
Source of Variation					P values			
Treatment		<0.001*	<0.001*	0.005*	<0.001*	<0.001*	<0.001*	0.005*
Sex		0.002*	0.001*	0.271	0.286	0.389	0.563	0.271
TreatmentxSex		0.443	0.515	0.406	0.511	0.900	0.384	0.406

CBC= Conventional battery cages, CFC= Conventional floor cages, EFC= Enriched floor cages, BW42 and BW56= Body weight at 42 and 56 days of age; β_0= Asymptotic BW parameter; β_1= Shapeparameter; β_2= Instantaneous growth rate parameter; IPT and IPW = age and weight at inflection point, *=Statistically significance, $P<0.01$, [a,b]= Means with in the same effect and column with no common superscript differ ($P<0.01$).

this study, live weight averages of both ages were focused on. The average body weights of the quails housed in conventional battery cages at 42 and 56 days of age were found as 131.09 g and 169.58 g, respectively, while the average body weights of those raised in the floor cages were 112.18 g and 155.89 g, and 143.80 g and 163.72 g for those grown in the enriched floor pens. The highest live weights at 42 and 56 days of age were measured in quails housed in a battery-type cage (P<0.01). Females had higher averages than males in terms of live weight values for both weeks (P<0.01). The coefficients of determination were found between 0.9978 and 0.9999 in the growth curve analyzes performed individually for all quails. In terms of the mature weight parameter (β_0) of the Gompertz growth curve model, similar to the live weight averages, CBC group had a higher mean value (P<0.01), while no significant difference was found between female and male quails in terms of this parameter (P>0.01). Similar situations were valid for the other parameters of Gompertz growth model and the mean values of weight and time of the inflection point. The growth curves obtained as a result of the analysis with Gompertz model using the live weights of the quails in the experimental groups, and the graphs of these growth curves plotted according to the sex in each experimental group were presented in Figure 1.

The mean values and statistical analysis results for the relative asymmetry measurements of the face, wing, shank length and diameter determined at 56 days of age in Japanese quails were presented according to the experimental groups and sexes in Table 2. A statistically significant difference was found only for the wing in terms of the relative asymmetry averages of the bilateral traits (P<0.01). In the study, the mean value of relative asymmetry for the wing was found to be 10.85% in quails reared in battery type cages, and it was higher than the average values (CFC: 6.68% and EFC: 7.87%) of those raised on the floor pens (P<0.01). In the study, no significant difference was found between genders in terms of relative asymmetry values determined for bilateral characteristics.

The symmetry conditions determined at the age of 8 weeks for the face, wing, shank length and shank diameter of the Japanese quails in the experimental groups are presented in Table 3. In terms of symmetry status determined according to Shapiro Wilk and One Sample T-test results, antisymmetry for face length and wing length and directional symmetry for shank length and diameter were determined in CBC group. While fluctuating asymmetry was determined only for the face length among the bilateral traits of the CFC group quails, it was determined that the symmetry status was directional for the other bilateral characteristics. While the fluctuating asymmetry conditions were determined for wing and shank length traits of quails housed in the enriched floor cage, antisymmetry for the face length and directional asymmetry for shank diameter were determined.

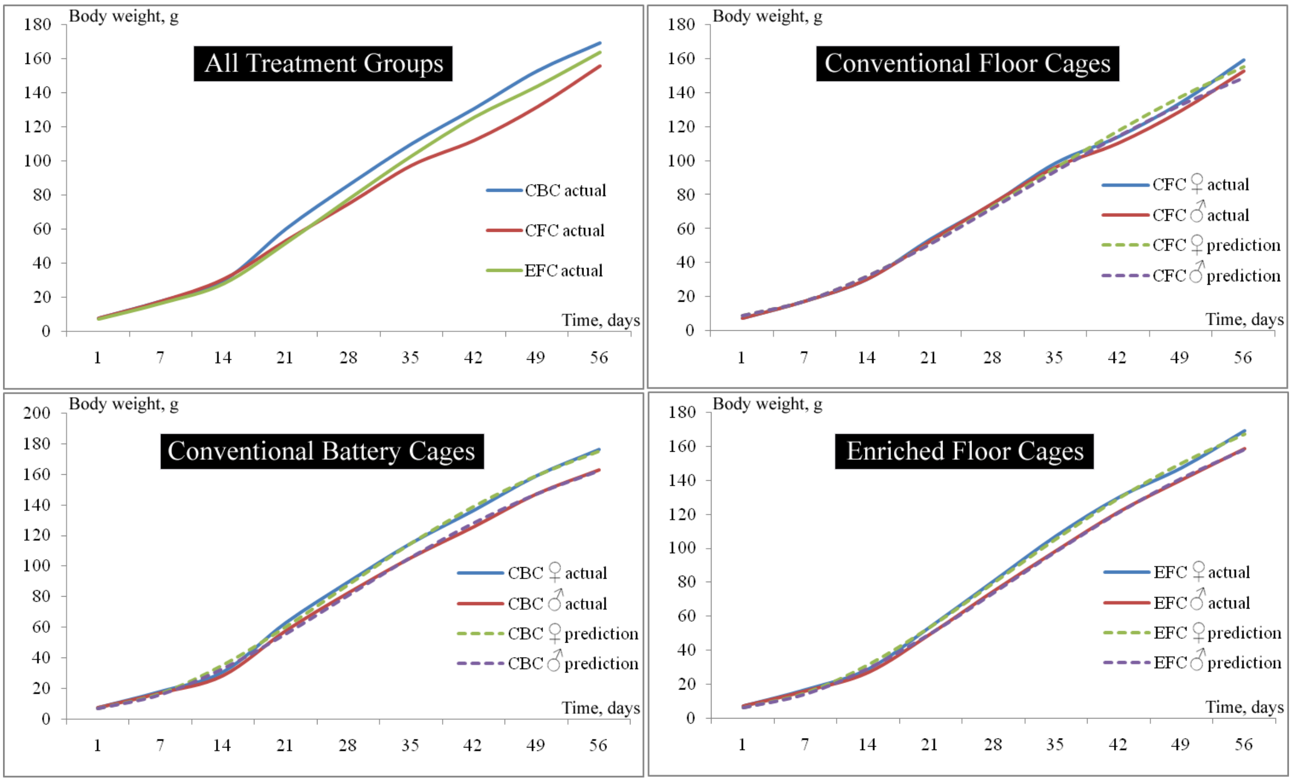

Figure 1. Growth curves by treatment groups.

Table 2. The results of statistical analysis for relative asymmetry means of bilateral traits by treatment groups and gender.

Treatment		Face Length (%)	Wing Length (%)	Shank Length (%)	Shank Diameter (%)
CBC		9.49±0.46	10.85±0.46^{a}	5.60±0.31	15.71±0.84
CFC		7.59±0.84	6.68±0.85^{b}	5.25±0.57	15.06±1.54
EFC		8.14±0.58	7.87±0.59^{b}	4.71±0.39	17.98±1.07
Sex					
♀		8.39±0.54	8.51±0.54	5.23±0.37	16.88±0.99
♂		8.42±0.51	8.43±0.52	5.14±0.35	15.62±0.95
Interaction					
CBC	♀	8.71±0.62	10.74±0.62	5.79±0.42	14.31±1.14
	♂	10.27±0.67	10.96±0.68	5.41±0.46	17.11±1.23
CFC	♀	8.46±1.26	7.50±1.28	4.61±0.86	18.27±2.32
	♂	6.72±1.10	5.87±1.11	5.88±0.75	11.86±2.02
EFC	♀	8.00±0.80	7.27±0.81	5.28±0.54	18.06±1.47
	♂	8.28±0.85	8.46±0.86	4.14±0.57	17.90±1.56
Source of Variation		P values			
Treatment		0.061	<0.001*	0.208	0.167
Sex		0.962	0.920	0.863	0.359
Treatment x Sex		0.211	0.391	0.220	0.032

CBC= Conventional battery cages, CFC= Conventional floor cages, EFC= Enriched floor cages, *=Statisticallysignificance, P<0.01, ^{a,b}= Means with in the same effect andcolumn with no common superscript differ (P<0.01).

Table 3. Asymmetry status in bilateral traits according to treatment groups.

Treatment	Criteria	Face Length	Wing Length	Shank Length	Shank Diameter
CBC	Shapiro Wilk	0.005*	0.006*	0.099	0.314
	One Sample T-test	0.597	<0.001*	<0.001*	<0.001*
	Status	Antisymmetry	Antisymmetry	Directional Asymmetry	Directional Asymmetry
CFC	Shapiro Wilk	0.349	0.373	0.686	0.110
	One Sample T-test	0.057	<0.001*	<0.001*	<0.001*
	Status	Fluctuating Asymmetry	Directional Asymmetry	Directional Asymmetry	Directional Asymmetry
EFC	Shapiro Wilk	0.005*	0.379	0.558	0.964
	One Sample T-test	0.676	0.086	0.014	0.003*
	Status	Antisymmetry	Fluctuating Asymmetry	Fluctuating Asymmetry	Directional Asymmetry

CBC= Conventional battery cages, CFC= Conventional floor cages, EFC= Enriched floor cages, *=Statistically significance, P<0.01.

Discussion and Conclusion

The mean values of body weight in all birds at 6 and 8 weeks of age were found between 112.18 g and 143.80 g, and between 155.89 g and 169.58 g, respectively. Similar results (from 91.63 to 114.76 g) for 6 weeks of age have been reported by Aggrey et al. (2), Raji et al. (38) and Rocha et al. (40). Yalçın et al. (45) and Daikwo et al. (10) who reported the average body weight of eight weeks in accordance with the results of this study, reported that these values ranged between 133.76 and 182.00 g. In a study conducted by Sadjadi and Becker (41), live weights of males and females at 8 weeks of age were determined as 107 g and 114 g, respectively. On the contrary, live weight values at 6 weeks of age were found to be quite high (from 181.52 g to 231.6 g) in studies conducted by some researchers (1, 6, 28, 43). Minvielle (27) reported that the reasons for the weekly live weight values of Japanese quail to be very different are the result of the adaptation of these birds to cage conditions from immigrant life and effects of genetic improvement studies. The difference in body weight of male and female quails in favor of females is a species-specific dimorphism opposite to that of other birds. A similar situation has been reported by Akbaş and Yaylak (4).

In this study, the quails in the battery-type cage were heavier than the other groups in terms of the average values at 6 and 8 weeks of age. However, when the floor cages were compared among themselves, it was observed that the quails in the enriched ones at both weeks of age had higher live weight averages. Miller and Mench (26) argued that as a potential result of environmental enrichment there should be an increase in growth and other yield traits. However, in their study, it was determined that none of the various environmental enrichment practices had a positive or negative effect on growth. Jones (18) claimed that environmental enrichment practices that reduce problematic behaviors can increase productivity. However, there are very limited and empirical literature reports for this view in poultry. Jones et al. (17) reported that environmental enrichment using new objects increased body weight gain and feed conversion rate in broilers and laying hens. In the studies conducted by Von Borell et al. (44) and Mendl et al. (24), it was revealed that the averages of aggression, fear, and stereotype behaviors were higher in impoverished environments, and they were associated with poor growth and low yield traits. However, in a study conducted by Nicol (35), it was reported that intermittent music and new objects did not affect performance characteristics in broilers. There are very different results in the literature on the subject. In this study, remarkable differences found in the weekly average body weight of the quails in the enriched floor pens compared to the quails housed in the conventional ground cages.

In studies investigating the growth of Japanese quails with the Gompertz model, the adult weight parameter (β_0) was estimated by Akbaş and Oğuz (3), Narinç et al. (32), Fırat et al. (11), and Kaplan and Gürcan (19) in the range of 208.3-287.7 g. In the study, the averages of the β_0 parameter obtained from all three experimental groups were found between 228.12 and 262.05 g, consistent with the adult weight parameter values reported in the other studies. In addition, Grieser et al. (14) reported that the β_0 parameter in a flock selected to increase live weight was estimated in the range of 275-369 g, and the β_0 parameter for quails from different genotypes in the same study was estimated between 131 and 215 g. Environmental and genetic manipulations greatly affect growth curve parameters. In the study, the integration coefficient parameter (β_1) of Gompertz growth curve model was estimated between 3.57 and 3.86 for growth samples of Japanese quails. Similarly, this parameter was estimated as 3.89 and 3.82 in nonselected-randombred Japanese quail flocks by Akbaş and Oğuz (3) and Kızılkaya et al. (20), respectively. The β_2 parameter representing the instantaneous growth rate was estimated in the range of 0.042-0.050. These means were consistent with the values (0.039-0.046) reported by Aggrey et al. (2) and Raji et al. (38). Estimating small values for the β_2 parameter indicates late maturity and high adult weight. On the other hand, high β_2 values represent early maturity and lower adult weight (32). The ages and weights of the inflection point of the Gompertz growth curve model of all quails in the study were between 27.88 and 34.37 days, and between 83.93 and 96.41 g, respectively. According to the results of many studies in which growth samples of Japanese quails were analyzed with the Gompertz function, the values obtained for the inflection point age of the curve were reported to be between 14.76-34.58 days of age. In these studies, it was reported that the growth curve inflection point weight was between 76.22-124.56 g (3, 19, 32, 38). The mean values for the age and weight of inflection point of Gompertz growth curve determined for the Japanese quails in this study were found to be compatible with the averages reported in these studies.

As in weekly live weights, a statistically significant difference was found between the experimental groups in terms of the β_0 parameter of the Gompertz growth curve which represents the asymptotic body weight. The mean value of β_0 parameter of quails raised in conventional battery cages was higher than the other experimental groups ($P<0.05$). In addition, the mean value of β_0 parameter of the quails housed in the enriched floor cages was also higher than the average of those housed in the conventional floor pens ($P<0.05$). Statistically significant differences were found between the experimental groups in terms of the mean values of the β_1 parameter which is a biological constant, and the β_2 parameter which represents the instantaneous growth rate of the Gompertz growth curve model ($P<0.05$ for both). In the current literature, there is no study on the analysis of the effects of environmental enrichment applications on the growth of poultry using non-linear regression models. In addition, Genç et al. (13) who carried out the growth curve analyzes using Gompertz function in Japanese quails housed in different types of cages (individual and colony) and in different stocking densities, reported that the average value of β_0 parameter of the quails housed in individual cages was higher. In the same study, it was reported that inflection point age and weight were also affected by both cage type and stocking density. The fact that environmental manipulations caused differentiation in the growth curves of quails in the study conducted by Genç et al. (13) was found to be compatible with the results of this study.

In terms of the relative asymmetry values, only one difference was found between the groups for wing length characteristics ($P<0.05$). Accordingly, the mean value of relative asymmetry (10.85%) of the quails housed in the conventional battery cages was higher than the averages (6.68% and 7.87%, respectively) of those housed in conventional and enriched floor cages. There are contradictions regarding the application of the procedure to reveal the relationship of developmental stability-welfare in poultry using symmetry of bilateral traits. Garcia (12) claimed that stress in poultry can cause asymmetry in all parts of the body, but to reveal this, many bilateral traits need to be evaluated and these characteristics require correction because they are not numerically homogeneous. Besides, Knierim et al. (21) claimed that fluctuating asymmetry is specific of a trait and that correction can prevent the detection of bilateral characteristics sensitive to symmetry. One of the first studies to measure the developmental stability using bilateral symmetrical traits in Japanese quails was carried out by Nestor et al. (34), and the effects of long-term divergent selection for live weight on the balance of development were revealed. In the current study, no statistically significant difference was found in terms of the mean values of relative asymmetry for the length of face, wing, shank and shank diameter in female and male quails (P>0.05 for all). Although there is no study on the effect of environmental enrichment or alternative rearing systems on developmental stability in Japanese quails, there are some studies investigating the effect of some environmental manipulations on bilateral symmetry (30). Sarıca and Özdemir (42) revealed that quails exposed to heat stress lead to differences in terms of left-right difference averages of some bilateral traits (beak, finger, nostril and eye). Campo et al. (9) reported that chickens reared under conventional conditions had higher mean relative asymmetry than those raised in the alternative system, and they claimed that alternative breeding systems or environmental enrichment prevented the impairment of symmetry in bilateral traits. The results of both studies support that the quails that were enriched in this study had lower values in terms of proportional asymmetry values regarding the wing length than those raised in the battery type cage. The results of both studies support that the relative asymmetry values of the wing length of the EFC quails were lower than those grown in the battery type cage in current study.

The type of symmetry observed in the bilateral characteristics of creatures that are not exposed to genetic and environmental stress is fluctuating asymmetry (the mean of the difference between the right and left sides is equal to zero and has a normal distribution). Directional asymmetry (the mean of the difference between the right and left sides is not equal to zero and shows a normal distribution) occurs usually due to genetic stress. The situation defined as asymmetrical or antisymmetry (the differences between right and left sides do not show normal distribution) occurs as a result of environmental stress (21). In the study, a total of 4 symmetry types were determined regarding the length of face, wing, shank, and shank diameter in the quails of each experimental group (Table 3). Two fluctuating asymmetry, one directional asymmetry, and one antisymmetry were identified for the quails housed in the enriched floor cages. Two directional asymmetry and two antisymmetry were determined for the quails housed in the conventional battery cages. In the conventional floor cages, one fluctuating asymmetry and three directional asymmetries were detected. As it can be seen in Table 3, the fluctuating asymmetry type, which is the indicator of welfare, were mostly found in the enriched floor cages, while the highest detection in terms of antisymmetry, which is accepted as the indicator of environmental stress, was found in the quails raised in the conventional battery cages.

As a result, it is possible to obtain higher yields by using conventional battery cages in a production system where higher live weight is targeted and there are economic concerns. However, it was determined in this study that for a production meeting the criteria for goodanimal welfare, promising results can be obtained in case of using enriched floor cages. Even if it is not included in this study, it is thought that the use of some enrichment objects in conventional battery cages may produce positive results in terms of animal welfare, and more studies are needed on the subject.

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Ethical Statement

It was determined by Akdeniz University Animal Experiments Local Ethics Committee that this study does not need ethics committee approval with the document numbered B.30.2.AKD.0.05.07.00/50.

Conflict of Interest

The authors declared that there is no conflict of interest.

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