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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Comparison of Hatching Results, Growth Traits, and Slaughter-Carcass Characteristics of Japanese Quails Classified by Hatching Egg Weight

Kuluçkalık Yumurta Ağırlığına Göre Sınıflandırılan Japon Bıldırcınlarında Kuluçka Sonuçları, Büyüme Özellikleri ve Kesim-Karkas Özelliklerinin Karşılaştırılması

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Abstract

The aim of this study is to determine the hatching characteristics, growth performance and slaughter-carcass traits of Japanese quails obtained from hatching quail eggs divided into four classes (G1: less than 8 g, G2: between 8-10 g, G3: between 10-12 g, and G4: heavier than 12 g) according to egg size. The animal material of the study consisted of chicks (60 birds were used in each group) obtained from a total of 525 eggs simultaneously obtained from a Japanese quail parent flock (random mated, not previously selection applied, at 16 weeks of age). The mean values of fertility in G2 and G3 were found to be higher than those of the other groups (P<0.05). There were no differences between the egg weight groups for either early or late embryonic mortality means. Also, there was no difference between the groups in terms of hatchability. Quail chicks obtained from light eggs had the lowest average (96.43%) in terms of chick quality determined by the Tona score method (P<0.05). A positive-linear relationship was found between egg weight and chick weights, and chick weight averages increased as egg size increased (P<0.05). According to the results of the profile analysis performed using weekly body weight values, the chick weight difference between egg weight classes was also reflected in the growth profiles. The growth profile of quails obtained from heavy class eggs were higher than the others (P<0.05). The mean values of asymptotic weight parameter and body weight at inflection point of Gompertz growth model were higher in quails obtained from heavy eggs (both P<0.05). There was no difference between the experimental groups in terms of carcass yield and percentages of carcass parts, but the lowest abdominal fat ratio was found in the G1 group (P<0.05). As a result, it can be thought that the use of higher weight hatching eggs in the incubation of Japanese quails raised for meat yield will provide economic benefits.

Keywords: Egg weight, Egg size, Tona score, Gompertz growth curve, Fertility

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Öz

Bu çalışmanın amacı, yumurta büyüklüğüne göre dört sınıfa ayrılan (G1: 8 g'dan düşük, G2: 8-10 g arası, G3: 10-12 g arası ve G4: 12 g'dan ağır) kuluçkalık bıldırcın yumurtalarından elde edilen Japon bıldırcınlarının kuluçka özelliklerini, büyüme performanslarını ve kesim-karkas özelliklerini belirlemektir. Araştırmanın hayvan materyali, bir Japon bıldırcın ebeveyn sürüsünden (rastgele çiftleştirilmiş, daha önce seleksiyon uygulanmamış, 16 haftalık yaşta) eş zamanlı olarak toplanan 525 yumurtadan elde edilen civcivlerden (her grupta 60 bıldırcın) oluşmaktadır. G2 ve G3'te döllülük ortalamaları diğer gruplara göre daha yüksek bulunmuştur (P<0.05). Erken ve geç dönem embriyonik ölüm ortalamaları için yumurta ağırlık grupları arasında fark bulunmamıştır. Benzer şekilde çıkış gücü açısından da gruplar arasında fark bulunmamıştır. Tona skor yöntemi ile belirlenen civciv kalitesi açısından hafif yumurtalardan elde edilen bıldırcın civcivleri en düşük ortalamaya (%96.43) sahip olmuştur (P<0.05). Yumurta ağırlığı ile civciv ağırlıkları arasında pozitif-doğrusal bir ilişki bulunmuş ve civciv ağırlık ortalamaları yumurta ağırlığı arttıkça artmıştır (P<0.05). Haftalık canlı ağırlık değerleri kullanılarak yapılan profil analizi sonuçlarına göre yumurta ağırlık sınıfları arasındaki civciv ağırlık farkı büyüme profillerine de yansımıştır. Ağır sınıf yumurtalardan elde edilen bıldırcınların büyüme profili diğerlerine göre daha yüksek bulunmuştur (P<0.05). Ağır yumurtalardan elde edilen bıldırcınlarda, Gompertz büyüme modelinin bükülme noktasındaki canlı ağırlık ve asimptotik ağırlık parametresi ortalama değerleri daha yüksek olarak tahmin edilmiştir (her ikisi de P<0.05). Deneme grupları arasında karkas randımanı ve karkas parçalarının oranları açısından fark bulunmazken, en düşük abdominal yağ oranı G1 grubunda bulunmuştur (P<0.05). Sonuç olarak et verimi için yetiştirilen Japon bıldırcınlarının kuluçkasında daha yüksek ağırlıkta kuluçkalık yumurtaların kullanılmasının ekonomik fayda sağlayacağı düşünülebilir.

Anahtar Kelimeler: Yumurta ağırlığı, Yumurta büyüklüğü, Tona skoru, Gompertz büyüme eğrisi, Döllülük

1. Introduction

Incubation is one of the most important elements of commercial poultry production. There are many environmental and genetic factors that affect healthy embryo development, high hatchability, and high-quality chick numbers. One of them is the weight of hatching eggs (Çelik et al., 2015; Narinç and Aydemir, 2021a). It is known that there is a positive and strong relationship between increasing body size and egg weight in poultry, both within and between species. Egg weight and yolk content are also associated with incubation period, early development degree, and yolk reserves needed by the hatchling (Wilson, 1991).

Oral Toplu et al. (2007) reported that eggs that are smaller and larger than normal should not be used in order to obtain optimum hatchability. Sarı et al. (2010) and Hegab and Hanafy (2019) reported that the fertility and hatchability were higher in the heavy egg size group in Japanese quails. Sarı et al. (2010) reported that both early and late embryonic deaths increased as egg weight decreased. Petek et al. (2005) and Sari et al. (2010) found that the mortality value of quail chicks obtained from small eggs was also higher than other egg size groups. Elibol and Brake (2008) observed that fertility decreased as age of breeder flock and egg weight increased. This effect was partially explained by a relationship between breeder age and egg weight. Iqbal et al. (2016) divided broiler breeder eggs into three groups and claimed that the best results in terms of fertility, hatchability and embryonic mortality were obtained from small size eggs. Ulmer Franco et al. (2010) reported that low hatchability and high late embryonic mortality were observed in eggs larger than the average eggs of broiler breeders. On the other hand, Gahri et al. (2015) claimed that there was no difference between the groups classified according to egg weight in terms of fertility and hatchability in broiler hatching eggs.

In many studies, it has been reported that there is a positive and strong relationship between egg weight and hatch weight (Abiola et al., 2008; Alabi et al., 2012; Iqbal et al., 2016; Karaman and Bulut, 2018). In some studies (Petek et al., 2003; Alkan et al., 2008; Çağlayan and İnal 2006), it has been suggested that there is a positive-linear relationship between egg weight and weekly body weight values at the post-hatch period, and that the weight at the end of fattening is also affected by this. Abiola et al (2008) divided the hatching eggs into three different categories and reported that the carcass yield of broiler chickens hatched from heavy eggs was higher than the other groups, while the abdominal fat ratio of chickens in the small size egg group was the lowest. There are also studies reporting results contrary to these findings. Researchers claimed that heavy chicks obtained from heavy eggs tend to lose these characteristics with age (Yıldırım and Yetişir, 1998; Gürcan and Çobanoğlu, 2012; Duman and Şekeroğlu, 2017; Karaman and Bulut, 2018).

When the literature reports on the subject are examined, it is seen that there are conflicting results about the relationship between egg weight, hatching, growth and slaughter carcass characteristics in different poultry species. The aim of this study is to determine the hatching characteristics, growth performance and slaughter-carcass traits of Japanese quails obtained from hatching quail eggs divided into four classes (less than 8 g, between 8-10 g, between 10-12 g and heavier than 12 g) according to egg size.

2. Materials and Methods

The experiment was conducted at the Animal Science Department, Faculty of Agriculture, Akdeniz University, Turkey. The care and use of animals were in accordance with laws and regulations of Turkey and approved by Ministry of Food, Agriculture and Livestock and Animal Experiments Local Ethics Committee of Akdeniz University (decision number 2020.04.117). The animal material of the study consisted of chicks obtained from a total of 525 eggs simultaneously obtained from a Japanese quail parent flock (random mated, not previously selected, at 16 weeks of age). A total of four egg weight groups were formed in the study. Eggs were classified according to their weight as being less than 8 g (G1), 8-10 g (G2), 10-12 g (G3) and heavier than 12 g (G4). The number of eggs in the experimental groups was 101, 135, 166 and 123, respectively. The hatching eggs were placed in a commercial incubator and maintained at a constant temperature of 37.5 °C and 55% relative humidity for the first 15 days, and 37.2 °C temperature and 70% relative humidity for the last three days. The number of chicks hatched at the end of incubation, the number of fertile eggs, early and late embryonic deaths were determined (Aygün et al., 2012). 60 quail chicks from each experimental group were selected by chance, their wing numbers were attached, and body weight measurements were made. All hatched chicks were examined to score using Tona method for quality (Tona et al., 2003). Tona chick quality score is a qualitative scoring system that assess total score index of 100 based on a wide variety of visual parameters, such as activity, appearance, retracted yolk, eye condition, leg and feet condition, navel deformities and status, remaining egg membrane, beak condition, and remaining yolk (Narinç and Aydemir, 2021b). Individual body weight measurements of quails were made weekly. Quail chicks were housed in brooding cages (90 cm^2/quail) for the first three weeks, after sex determination in the third week, then they were transferred to fattening cages (160 cm^2/quail) and they were housed here until the slaughtering age of 42 day. A grower diet containing 24% CP and 2,900 kcal of ME/kg for the first 21 d, and a fattening diet containing 21% CP and 2,800 kcal of ME/kg were used. *Ad libitum* feeding, water and a 23-hours/day lighting program were applied from hatch to the end of the study.

To obtain the estimates of individual growth curve parameters, all quail were weighed weekly from hatching to 6 weeks of age. The Gompertz non-linear regression model (Eq. 1) was used to estimate growth curve of each quail (Narinç et al., 2010a; Narinç et al., 2017).

$$y_t = \beta_0 e^{(-\beta_1 e^{-\beta_2 t})} \qquad \text{(Eq.1)}$$

where y_t is the weight at age t, β_0 is the asymptotic (mature) weight parameter, β_1 is the scaling parameter (constant of integration) and β_2 is the instantaneous growth rate (per day) parameter (Akbaş and Yaylak, 2000; Narinç et al., 2010a). 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 (IPA and IPW, respectively), were obtained as follows (Eq 2,3):

$$IPW = \beta_0/e \qquad \text{(Eq.2)}$$

$$IPA = \ln(\beta_1)/\beta_2 \qquad \text{(Eq.3)}$$

At 6 weeks of age, the body weights of all birds were determined 4 hours after feed withdrawal and slaughtered in an experimental processing plant. The birds were manually cut, bled out, scalded (55°C, 2 min), defeathered with equipment, manually eviscerated, and the abdominal fat pad (from the proventriculus surrounding the gizzard down to the cloaca) was taken, chilled in an ice-water tank, and drained (Narinç et al., 2013). Next day, after carcass dissection, breast with bone and the remaining abdominal fat on cold carcasses were weighed using an electronic digital balance with a sensitivity of 0.01 g. Slaughter and dissection were performed by same experienced operators. Cold carcass, breast, leg, wing, and total fat pad yields were calculated in relation to body weight at 6 weeks of age.

Profile analysis technique, which is one of the multivariate analysis of variance (MANOVA) methods, was used to test the difference between groups in terms of growth samples according to weekly individual body weight values (Sabuncuoğlu et al., 2018). The nonlinear regression analyses for Gompertz growth curves of birds were performed using NLIN procedure of SAS 9.4 statistics software. The descriptive statistics, Shapiro Wilk normality tests, and hypothesis tests of the traits were obtained using UNIVARIATE and GLIMMIX procedures of SAS 9.4 statistics software (SAS Ins., 2009).

3. Results and Discussion

The average values of fertility, embryonic mortality, hatchability, chick quality and hatch weight of quails, and the results of variance analyses are given in *Table 1*. The mean values of eggs in G2 and G3 were found to be higher than those of the other groups in terms of fertility (P<0.05). Sarı et al. (2010) found the fertility rate higher in the heavy egg groups than the light egg groups in Japanese quails. In the study conducted by Petek et al. (2005), it was reported that there was no difference in terms of fertility characteristics between egg weight groups classified as small, medium, large, and jumbo. Researchers reported that the average fertility of eggs in these groups was 86.54%, 90.03%, 90.05% and 92.12%, respectively. Similarly, Mirahmetoğlu and Çelen (2017) divided quail eggs into three groups as smaller than 11 g and larger than 11.9 g, and reported that there was no difference in fertility rate between the experimental groups. There are many factors that affect fertility. These include breeder flock age, genotype, health status, feed content, rearing type, incubation conditions, egg storage period and conditions (Okur and Şamlı, 2013; Narinç and Aydemir, 2021a). Some studies investigated the effects of both breeder age and egg weight on fertility. In the study carried out by Sarı et al. (2010), it was determined that as the age of the parents increased, fertility decreased, and on the contrary, as the egg weight increased, fertility increased. In our study, eggs of quails at a fixed age (16 weeks of age) were evaluated, and the weight difference is only due to the genetic structure of the birds. In this case, it can be thought that optimum weight eggs should be used for maximum fertility.

Table 1. The hatching results, and results of variance analysis

Group	Fertility	EEM	LEM	Hatchability	Tona Score	Hatching Weight
G1	86.87[b]	9.27	9.36	81.37	96.43[b]	5.26[d]
G2	91.25[a]	8.92	9.11	81.97	98.24[a]	6.65[c]
G3	92.46[a]	9.12	8.75	82.13	98.74[a]	7.90[b]
G4	87.71[b]	9.01	9.13	81.86	98.56[a]	8.94[a]
SEM	0.16	0.05	0.06	0.09	0.11	0.06
P Value	0.001*	0.644	0.540	0.332	0.034*	0.000*

*P<0.05, EEM: Early embryonic mortality, LEM: Late embryonic mortality, [a-d]: Different letters in the same column indicate statistical difference

There were no differences between the egg weight groups for either early or late embryonic mortality means (both P>0.05). In the study, early embryonic mortality was between 8.92% and 9.27%, and late embryonic mortality was between 8.75% and 9.36% (*Table 1*). Iqbal et al. (2016) and Gahri et al. (2015), who classified broiler breeder eggs into three groups according to their weight, reported that the highest mean values of embryonic mortality were in large eggs. However, Othman et al. (2014) claimed that the lowest late embryo mortality was in large eggs in the results of their study, which divided Japanese quail hatching eggs into three classes. Oral Toplu et al. (2007), who found similar to our results, reported that there were no differences between the groups in terms of early and late embryonic mortality in quail hatching eggs divided into three egg weight groups. In many similar studies (Çağlayan and İnal, 2006; Çağlayan et al., 2009; Duman and Şekeroğlu, 2017; Karaman and Bulut, 2018; Kırıkçı et al., 2018), it has been reported that egg weight classes have no effect on embryo mortality.

In the study, the average values of hatchability in all groups were found between 81.37% and 82.13% (*Table 1*). There was no statistical difference between egg weight groups in terms of hatchability (P>0.05), which represents the ratio of chicks hatched from fertile eggs. Similarly, Çağlayan and İnal (2006) and Oral Toplu et al. (2017) in quails, Gahri et al. (2015) in broilers, and Kırıkçı et al. (2018) in partridges divided the breeder eggs into various weight classes, and reported that there was no difference between the egg weight groups in terms of hatchability. There are conflicting reports in the literature regarding the relationship between egg weight and hatchability in poultry. Many researchers (Elibol and Brake, 2008; Alkan et al., 2008; Çağlayan et al., 2009; Sarı et al., 2010; Iqbal et al., 2016) who classified quail and chicken eggs according to their weight reported that the highest average hatchability was in light eggs. Abiola et al. (2008) and Alabi et al. (2012) reported that the highest hatchability rate in hatching chicken eggs was in the medium weight class. On the contrary, Petek et al. (2005) and Hegab and Hanafy (2019) found the highest hatchability rate in quail hatching eggs in the high egg weight groups. The reasons for these different results may be the genetic improvement status of the birds, the storage conditions and duration of hatching eggs, and breeder flock age.

Chick quality is a characteristic that directly determines the number of saleable chicks and can be measured by both qualitative (Tona, Pasgar) and quantitative methods (various morphological measurements). Chick quality primarily depends on breeder age due to changes in hatching egg weight and egg quality characteristics (İpek and Sözcü, 2013). As the breeder flock age increases, egg and yolk weight increase and shell thickness decreases (Peebles et al. 2000). As the breeder age increases, the chick weight also increases, but the quality of the chick declines (Tona et al., 2004). Because of this dilemma, it is thought that the chick quality determined by qualitative methods is more consistent than quantitative methods (Narinç and Aydemir, 2021b). In this study, chicks obtained from light eggs had the lowest average (96.43%) in terms of chick quality determined by the Tona score method (P<0.05). Elibol and Brake (2008), who divided broiler breeder eggs into three categories as small, medium, and large according to their weight classes, reported that the rates of second quality chicks were 2.86%, 2.13%, and 2.03%, respectively. The researchers found that the quality of chicks from light hatching eggs was poor, which is in agreement with the findings of this study.

In the study, a linear relationship was found between egg weight categories and chick weights (*Table 1*), and chick weight averages increased as egg category increased (P<0.05). Similar results have been obtained in many studies on the subject (Yıldırım and Yetişir, 1998; Petek et al., 2003; Çağlayan and İnal, 2006; Oral Toplu et al., 2007; Abiola et al., 2008; Alkan et al., 2008; Alabi et al., 2012; Gahri et al., 2015; Iqbal et al., 2016; Duman and Şekeroğlu, 2017; Iqbal et al., 2017; Karaman and Bulut, 2018; Kırıkçı et al., 2018; Hegab and Hanafy, 2019). In some of these studies, it has been reported that heavy chicks obtained from heavy eggs maintain these advantages until the end of fattening (Petek et al., 2003; Çağlayan and İnal, 2006; Abiola et al., 2008; Alkan et al., 2008). In some studies, it has been reported that the difference in hatch weight disappears over time and the slaughter weight is not affected by egg weight size. According to the results of the profile analysis performed using weekly body weight values in our study, the chick weight difference between egg weight classes was also reflected in the growth profiles (*Table 2*). Statistical differences were found between the growth profiles of quails and the growth profile of quails obtained from heavy class eggs were higher than the others (P<0.05).

Table 2. The mean values of weekly body weight, and results of profile analysis

Sequential Week	G1	G2	G3	G4	SE	P Value[1]
1-7	17.82[c]	20.31[b]	19.51[b]	22.68[a]	0.39	0.000*
7-14	31.19[c]	37.81[b]	37.12[b]	44.94[a]	0.80	0.000*
14-21	48.80[c]	59.57[b]	55.65[b]	66.50[a]	1.04	0.000*
21-28	77.24[c]	95.78[b]	96.61[b]	110.19[a]	1.40	0.000*
28-35	108.11[c]	127.61[b]	132.57[b]	148.73[a]	1.62	0.000*
35-42	131.12[d]	155.01[c]	165.58[b]	178.78[a]	1.62	0.000*
Overall[2]						0.001*

*P<0.05, [1] MANOVA results, [2] Profile analysis result (P value of Lawley–Hotelling Trace), [a-d]: Different letters in the same row indicate statistical difference

Table 3. The parameters of Gompertz growth curve

Group	β_0	β_1	β_2	IPW	IPA
G1	202.45[d]	3.87	0.051	74.70[c]	26.62
G2	212.91[c]	3.93	0.058	78.56[c]	23.77
G3	256.28[b]	3.99	0.052	94.57[b]	25.34
G4	269.63[a]	3.84	0.052	99.50[a]	25.75
SEM	4.12	0.21	0.001	1.56	0.57
P Value	0.000	0.245	0.365	0.000	0.124

*P<0.05, β_0, β_0, β_0: Gompertz model parameters, IPW: Weight of point of inflection, IPA: Age at point of inflection [a-d]: Different letters in the same column indicate statistical difference

The results of Gompertz growth curve analyzes performed using weekly body weight data of quails in the experimental groups are given in *Table 3*. The coefficients of determination in all nonlinear regression analyzes were found to be between 0.992 and 0.998 (not included in any table). In this case, it was determined that the Gompertz growth curve model was quite sufficient to explain the quail data. The mean values of mature (asymptotic) weight parameter (β_0) of the Gompertz growth model were estimated as 202.45, 212.91, 256.28, and 269.63 g for G1, G2, G3, and G4 respectively (*Table 3*). A positive linear relationship was determined between the β_0 parameter of the Gompertz model and egg weight classes, and an increase in the mature weight parameter was determined as the egg size increased (P<0.05). To our best knowledge, there is no study in the literature that analyzed growth using nonlinear regression models in poultry from eggs separated by weight class. In studies in which the growth of Japanese quails was examined with the Gompertz model, the mature weight parameter was found in the range of 208.30-265.78 g (Akbaş and Oğuz, 1998; Narinç et al., 2010b; Alkan et al., 2009; Kaplan and Gürcan, 2018; Narinç and Genç, 2021). In the study, β_0 parameter averages (241.57-260.23 g) obtained from all three experimental groups were found to be compatible with mature weight parameter values reported in the literature.

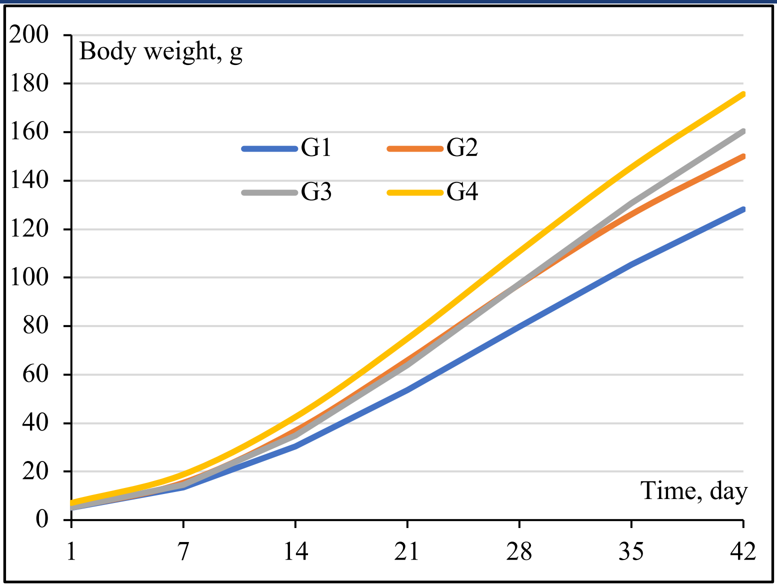

Figure 1. Growth curves estimated by the Gompertz model by experimental groups

The growth curves of the quails in the experimental groups drawn with the Gompertz model are presented in *Figure 1.* In the study, no statistical differences were found between the experimental groups in terms of shape parameter (β_1) and instantaneous growth rate parameter (β_2) of the Gompertz function (both P>0.05). In the study, the integration coefficient parameter (β_1) of the Gompertz growth function for quail growth samples was estimated in the range of 3.84-3.99. The results obtained were found to be compatible with the estimated values (3.65-4.00) for randomly mating flocks that were not selected by many researchers (Akbaş and Oğuz, 1998; Balcıoğlu et al., 2005; Alkan et al., 2009; Narinç et al., 2010a; Narinç and Genç, 2021). Small values for β_2 parameter indicate late maturation and high adult weight. On the other hand, high β_2 values represent early maturation and lower adult weight (Akbaş and Yaylak, 2000). In the study, the β_2 parameter of the Gompertz model was found to be between 0.051 and 0.058. These values are in line with the results (0.046-0.065) reported by many researchers (Beiki et al., 2013; Gürcan et al., 2017; Kaplan and Gürcan, 2018; Narinç and Genç, 2021; Narinç and Sabuncuoğlu, 2022) fitting growth in Japanese quails using the Gompertz model.

A statistical difference was found between the egg weight groups in terms of the body weight of the inflection point of the sigmoid Gompertz model (P<0.05). The highest mean value (99.50 g) of point of inflection weight was observed in the G4 group, while the G1 quails had the lowest mean value (74.70 g) of the body weight of the inflection point. This supports the view that chicks hatching from heavy eggs maintain their superior body weight values. In addition, no statistical difference was found in the experimental groups in terms of the inflection point age of the Gompertz model. The estimated inflection point ages in the experimental groups were between 23.77 days and 26.62 days. In the study, the estimated values for the inflection point age of the Gompertz model in quails in different groups were found to be compatible with the results (21.20-27.88 days) of many studies (Alkan et al., 2009; Kaplan and Gürcan, 2018; Narinç and Sabuncuoğlu, 2022).

The carcass characteristics of quails obtained from eggs classified according to their size, determined by slaughtering at the end of the 42-day fattening period, are presented in *Table 4*. The cold carcass yields of quails in G1, G2, G3 and G4 groups were 70.14%, 69.88%, 70.08%, and 69.84%, respectively. No difference was observed between the experimental groups in terms of carcass yield (P>0.05). Duman and Şekeroğlu (2017), who divided the breeder broiler eggs into three weight groups, reported that there was no difference between the groups in terms of carcass yields of chickens slaughtered at the end of the experiment. Alabi et al. (2012), who obtained similar results, divided the hatching eggs of a domestic chicken breed into three groups, and reported that there was no difference between the carcass yields of the chicks at the end of fattening. The finding for carcass yield in our study is consistent with the results reported by Duman and Şekeroğlu (2017) and Alabi et al. (2012).

Table 4. The mean values of slaughter-carcass traits, and results of variance analysis

Group	Carcass (%)	Abdominal Fat (%)	Breast (%)	Leg (%)	Wing (%)
G1	70.14	0.89[c]	26.32	15.96	6.12
G2	69.88	1.11[b]	26.42	16.08	6.25
G3	70.08	1.15[b]	26.76	15.88	6.14
G4	69.84	1.43[a]	26.81	15.81	6.31
SEM	0.22	0.08	0.18	0.12	0.10
P Value	0.322	0.012*	0.654	0.755	0.486

*P<0.05, [a-d]: Different letters in the same column indicate statistical difference

The averages determined for the abdominal fat ratio (proportioned to slaughter weight) in the study were 0.89%, 1.11%, 1.15%, and 1.43% in the G1, G2, G3, and G4 groups, respectively (*Table 4*). Among the experimental groups, the highest abdominal fat ratio (1.43%) was obtained from the quails in the G4 group, while the abdominal fat ratio (0.89%) of the quails in the G1 group was the lowest (P<0.05). Abiola et al. (2008), reporting a concordant result, found that broiler chickens hatched from small eggs had the lowest abdominal fat percentage at the end of the fattening period.

There were no differences between egg weight groups in terms of the mean values of breast, thigh, and wing percentage, which are other important parts of the carcass (all P>0.05). Similar to our findings, Alabi et al. (2012) and Duman and Şekeroğlu (2017) who examined the slaughter-carcass characteristics of broiler chickens obtained from hatching eggs divided into classes, also reported that no differences between treatment groups were determined for breast, thigh and wing characteristics.

4. Conclusions

As a result of the incubation of hatching quail eggs divided into weight classes, it was determined that the best results were obtained from eggs with optimum size (G2 and G3 groups) according to fertility and chick quality characteristics. No negative results were encountered in heavy eggs in terms of hatchability and embryo deaths. Besides, the highest values in terms of hatch weight, weekly body weight values and general growth were determined in quails obtained from heavy eggs (G1 group). As a result, it can be recommended to use heavy hatching eggs in order to obtain better performance from quails planned to be reared for fattening.

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References

Abiola, S., Meshioye, O. O., Oyerinde, B. O., Bamgbose, M. A. (2008). Effect of egg size on hatchability of broiler chicks. *Archivos de Zootecnia* 57 (217): 83-86.

Akbaş, Y., Oğuz, I. (1998). Growth curve parameters of lines of Japanese quail (Coturnix coturnix japonica), unselected and selected for four-week body weight. *Archiv fuer Gefluegelkunde* 62 (3):104-109.

Akbas, Y., & Yaylak, E. (2000). Heritability estimates of growth curve parameters and genetic correlations between the growth curve parameters and weights at different age of Japanese quail. *Archiv fuer Gefluegelkunde* 64 (4):141-146.

Alabi, O. J., Ng'ambi, J. W., Norris, D., Mabelebele, M. (2012). Effect of egg weight on hatchability and subsequent performance of Potchefstroom Koekoek chicks. *Asian Journal of Animal and Veterinary Advances* 7 (8): 718-725.

Alkan, S., Mendeş, M., Karabağ, K., Balcıoğlu, M. S. (2009). Effect of short-term divergent selection for 5-week body weight on growth characteristics of Japanese quail. *Archiv fuer Gefluegelkunde* 73 (2):124-131.

Alkan, S., Karabağ, K., Galic, A., Balcıoğlu, M. S. (2008). Effects of genotype and egg weight on hatchability traits and hatching weight in Japanese quail. *South African Journal of Animal Science* 38 (3): 231-237.

Aygün, A., Sert, D., Copur, G. (2012). Effects of propolis on eggshell microbial activity, hatchability, and chick performance in Japanese quail (*Coturnix coturnix japonica*) eggs. *Poultry Science* 91 (4): 1018-1025.

Balcıoğlu, M. S., Kızılkaya, K., Yolcu, H. I., Karabağ, K. (2005). Analysis of growth characteristics in short-term divergently selected Japanese quail. *South African Journal of Animal Science* 35 (2): 83-89.

Beiki, H., Pakdel, A., Moradi-Shahrbabak, M., Mehrban, H. (2013). Evaluation of growth functions on Japanese quail lines. *The Journal of Poultry Science* 50 (1): 20-27.

Çağlayan, T., İnal, Ş. (2006). Bıldırcınlarda kuluçkalık yumurta ağırlığının kuluçka sonuçları ile büyüme ve yaşama gücüne etkisi. *Eurasian Journal of Veterinary Sciences* 22 (1-2): 11-19.

Çağlayan, T., Garip, M., Kırıkçı, K., Günlü, A. (2009). Effect of egg weight on chick weight, egg weight loss and hatchability in rock partridges (*A. graeca*). *Italian Journal of Animal Science* 8 (4): 567-574.

Çelen, M. F., Mirahmetoğlu, Ç. (2017). Japon bıldırcınlarında (*Coturnix coturnix japonica*) kuluçkalık yumurta ağırlığı ve kuluçkanın son döneminde oksijen eklenmesinin kuluçka sonuçları ve çıkış sonrası performansa etkileri. *Batman Üniversitesi Yaşam Bilimleri Dergisi* 7 (2/2): 137-148.

Çelik, Ş., İnci, H., Şengül, T., Söğüt, B. (2015). Bıldırcın yumurtalarında bazı kalite özellikleri ile tüy rengi arasındaki ilişkinin diskriminant analizi ile incelenmesi. *Journal of Tekirdağ Agricultural Faculty* 12 (3): 47-56.

Duman, M., Şekeroğlu, A. (2017). Effect of egg weights on hatching results, broiler performance and some stress parameters. *Brazilian Journal of Poultry Science* 19 (2): 255-262.

Elibol, O., Brake, J. (2008). Effect of egg weight and position relative to incubator fan on broiler hatchability and chick quality. *Poultry Science* 87 (9): 1913-1918.

Gahri, H., Gader, N., Farzam, D. (2015). Effect of egg weight of broiler breeder on egg characteristics and hatchery performance. *International Journal of Biosciences* 6 (1): 42-48.

Gürcan, E. K., Çobanoğlu, Ö. (2012). Japon Bıldırcınlarında (Coturnix coturnix japonica) çıkım ağırlığı ve boyu ile canlı ağırlık performansı arasındaki ilişkiler. *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi* 22 (2): 85-90.

Gürcan, E. K., Çobanoğlu, Ö., Kaplan, S. (2017). Flexible alternatives to models widely used for describing growth in Japanese quail. *Journal of Animal & Plant Sciences* 27 (1): 48-56.

Hegab, I. M., Hanafy, A. M. (2019). Effect of egg weight on external and internal qualities, physiological and hatching success of Japanese quail eggs (*Coturnix coturnix japonica*). *Brazilian Journal of Poultry Science* 21 (3): 1-8.

Iqbal, J., Khan, S. H., Mukhtar, N., Ahmed, T., Pasha, R. A. (2016). Effects of egg size (weight) and age on hatching performance and chick quality of broiler breeder. *Journal of Applied Animal Research* 44 (1): 54-64.

Iqbal, J., Mukhtar, N., Rehman, Z. U., Khan, S. H., Ahmad, T., Anjum, M. S., Pasha, R.H., Umar, S. (2017). Effects of egg weight on the egg quality, chick quality, and broiler performance at the later stages of production (week 60) in broiler breeders. *Journal of Applied Poultry Research* 26 (2): 183-191.

İpek, A., Sözcü, A. (2013). Broiler chick quality and scoring methods. *Uludağ Üniversitesi Ziraat Fakültesi Dergisi* 27 (2): 131-137.

Kaplan, S., Gürcan, E. K. (2018). Comparison of growth curves using non-linear regression function in Japanese quail. *Journal of Applied Animal Research* 46 (1): 112-117.

Karaman, M., Bulut, M. (2018). Japon Bıldırcınlarında Kuluçkalık Yumurta Ağırlığının Kuluçka ve Kuluçka Sonrası Performans Özelliklerine Etkisi. *KSÜ Doğa Bilimleri Dergisi* 21 (1): 13-19.

Kırıkçı, K., Mustafa, Ç., Başer, E., Akbulut, N. K., Bilgiç, M. A. (2018). Kınalı kekliklerde yumurta ağırlığının kuluçka sonuçları üzerine etkisi. *Bahri Dağdaş Hayvancılık Araştırma Dergisi* 7 (1): 1-6.

Narinç, D., Aksoy, T., Karaman, E. (2010a). Genetic parameters of growth curve parameters and weekly body weights in Japanese quails (*Coturnix coturnix japonica*). *Journal of Animal and Veterinary Advances* 9 (3): 501-507.

Narinç, D., Karaman, E., Firat, M. Z., Aksoy, T. (2010b). Comparison of non-linear growth models to describe the growth in Japanese quail. *Journal of Animal and Veterinary Advances* 9 (14): 1961-1966.

Narinç, D., Aksoy, T., Karaman, E., Aygun, A., Firat, M. Z., Uslu, M. K. (2013). Japanese quail meat quality: Characteristics, heritabilities, and genetic correlations with some slaughter traits. *Poultry Science* 92 (7): 1735-1744.

Narinc, D., Narinç, N. Ö., Aygün, A. (2017). Growth curve analyses in poultry science. *World's Poultry Science Journal* 73 (2): 395-408.

Narinç, D., Aydemir, E. (2021a). Chick quality: an overview of measurement techniques and influencing factors. *World's Poultry Science Journal* 7 (2): 313-329.

Narinç, D., Aydemir, E. (2021b). Genetic parameter estimates of chick quality, growth, and carcass characteristics in Japanese quail. *Journal of the Hellenic Veterinary Medical Society* 72 (4): 1-8.

Narinç, D., Genç, B. A. (2021). Genetic parameter estimates of fear, growth, and carcass characteristics in Japanese quail. *Turkish Journal of Veterinary and Animal Sciences* 45 (2): 272-280.

Narinç, D., Sabuncuoğlu, K. (2022). Comparison of growth and developmental stability traits of Japanese quails reared in conventional and enriched cages. *Ankara Üniversitesi Veteriner Fakültesi Dergisi* 69 (1): 33-41.

Okur Ağma A., Şamlı, H. E. (2013). Effects of storage time and temperature on egg quality parameters and electrical conductivities of eggs. *Journal of Tekirdağ Agricultural Faculty* 10 (2): 78-82.

Oral Toplu, H., Dereli Fidan, E., Nazligül, A. (2007). Japon bıldırcınlarında kuluçkalık yumurta ağırlığı ve depolama süresinin kuluçka özellikleri ve civciv çıkış ağırlığı üzerine etkileri. *Erciyes Üniversitesi Veteriner Fakültesi Dergisi* 4 (1): 11-16.

Othman, R. A., Amin, M. R., & Rahman, S. (2014). Effect of egg size, age of hen and storage period on fertility, hatchability, embryo mortality and chick malformations in eggs of Japanese quail (*Coturnix coturnix japonica*). *IOSR Journal of Agriculture and Veterinary Science* 7 (1): 101-106.

Peebles, E. D., Gardner, C. W., Brake, J., Benton, C. E., Bruzual, J. J., & Gerard, P. D. (2000). Albumen height and yolk and embryo compositions in broiler hatching eggs during incubation. *Poultry Science* 79 (10): 1373-1377.

Petek, M., Baspinar, H., Oğan, M. (2003). Effects of egg weight and length of storage on hatchability and subsequent growth performance of quail. *South African Journal of Animal Science* 33 (4): 242-247.

Petek, M., Başpınar, H., Oğan, M. M., Balcı, F. M. (2005). Effects of egg weight and length of storage period on hatchability and subsequent laying performance of quail. *Turkish Journal of Veterinary and Animal Sciences* 29 (2): 537-542.

Sabuncuoğlu, K. M., Korkmaz, F., Gürcan, E. K., Narinç, D., Şamlı, H. E. (2018). Effects of monochromatic light stimuli during embryogenesis on some performance traits, behavior, and fear responses in Japanese quails. *Poultry Science* 97 (7): 2385-2390.

Sarı, M., Tilki, M., Saatci, M., Işik, S., Önk, K. (2010). Japon bıldırcınlarında (*Coturnix coturnix japonica*) ebeveyn yaşı, yumurta ağırlığı ve şekil indeksinin kuluçka özellikleri ve yaşama gücü üzerine etkisi. *Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi* 24 (2): 93-97.

SAS Institute Inc., 2009. SAS / STAT User's Guide, Version 9. 4th ed. SAS Institute Inc., Cary, NC.

Tona, K., Bamelis, F., De Ketelaere, B., Bruggeman, V., Moraes, V. M., Buyse, J., Onagbesan, O., Decuypere, E. (2003). Effects of egg storage time on spread of hatch, chick quality, and chick juvenile growth. *Poultry Science* 82 (5): 736-741.

Tona, K., Onagbesan, O., De Ketelaere, B., Decuypere, E., Bruggeman, V. (2004). Effects of age of broiler breeders and egg storage on egg quality, hatchability, chick quality, chick weight, and chick posthatch growth to forty-two days. *Journal of Applied Poultry Research* 13 (1): 10-18.

Ulmer-Franco, A. M., Fasenko, G. M., Christopher, E. O. D. (2010). Hatching egg characteristics, chick quality, and broiler performance at 2 breeder flock ages and from 3 egg weights. *Poultry Science* 89 (12): 2735-2742.

Wilson, H. R. (1991). Interrelationships of egg size, chick size, posthatching growth and hatchability. *World's Poultry Science Journal* 47 (1): 5-20.

Yıldırım, İ., Yetişir, R. (1998). Effects of hatching egg weight and parental age on the hatching weight and 6th week live weight in Japanese quail (*Coturnix coturnix japonica*). *Turkish Journal of Veterinary and Animal Sciences* 22 (4): 315-320.