Genetic parameter estimates of chick quality, growth, and carcass characteristics in Japanese quail

D. Narinç1, E. Aydemir2

1Department of Animal Science, Faculty of Agriculture, Akdeniz University, Antalya-Turkey
2Department of Animal Science, Faculty of Agriculture, Akdeniz University, Antalya-Turkey

ABSTRACT: The aim of this study was to estimate the heritabilities of chick quality and growth traits and their genetic relationships with some slaughter traits. Chick quality was determined using both Tona and Pasgar score methods. All birds were slaughtered at 8 weeks of age to measure carcass yield (CY), and percentage of breast (BY), leg (LY), abdominal fat (AFY). Heritability estimates for chick quality scores of Tona and Pasgar were found 0.08, and 0.09, respectively. Heritability estimates for growth curve parameters and inflection point coordinates of the Gompertz model were low to moderate, with values ranging from 0.17 to 0.26. Low heritability estimates for CY, BY, LY, and WY were found 0.04, 0.14, 0.09, and 0.07, respectively. Genetic and phenotypic correlations between chick quality and BW-growth traits were determined low and statistically non-significant (P>0.05). Similarly, genetic and phenotypic relationships between chick quality and carcass yield, and between chick quality and percentages of carcass parts were found low and statistically non-significant (P>0.05). As a result, it is possible to say that applying multitrait selection, including chick quality, will not affect other yield characteristics positively or negatively. However, in virtue of the chick quality is a very low heritable trait, environmental improvement of chick quality trait may be considered rather than genetic improvement.

Keywords: Chick quality, Genetic correlation, Heritability, Pasgar score, Tona score

Corresponding Author:
Doğan Narinç, Department of Animal Science, Faculty of Agriculture, Akdeniz University, Antalya-Turkey
E-mail address: dnarinc@akdeniz.edu.tr

Date of initial submission: 28-08-2020
Date of acceptance: 04-12-2020
INTRODUCTION

Thank to the genetic improvement studies carried out in the last 50 years, there have been significant developments in the rapid growth, muscle development and feed utilization characteristics of the fast-growing genotypes. In the selection studies carried out for many years, more than 25 traits from the ultimate pH of breast meat to angle of sternum have been used for the development of broilers. Environmental improvement such as feed quality, rearing systems, thermal conditions, air quality, equipment technology, and flock management gained importance in this period. Today, all environmental conditions at every stage of broiler production in poultry houses are under control. As a result of all these genetic and environmental improvements, the products with two kilograms of carcass weight at the age of 40 days are obtained and offered on the market. In addition to all these genetic and environmental features, one-day-old chick quality determined by various methods is also important because it directly affects the amount of salable chick (Leksrisompong et al., 2007; Tona et al., 2003). However, chick quality traits have never been incorporated in breeding indexes of applied genetic improvement schemes.

Starting broiler production with chicks of high quality reduces losses and increases profitability during the fattening period. All of the studies in which chick quality is measured by quantitative and qualitative methods are concerned with the effects of environmental factors on yield characteristics, and studies discussing the phenotypic relationships between chick quality and yield traits. Chick quality, like other quantitative characteristics, is affected by both genetic and environmental factors. Environmental factors affecting chick quality can be listed as age, nutrition and health status of breeder flock, egg storage conditions, position, and rotation of eggs, and thermal conditions in incubator. In the literature, there is no study focusing on the heritability of chick quality, and genetic relationships between other yield characteristics and chick quality. This study aims to estimate the heritability of chick quality and genetic correlations between yield characteristics and chick quality. Japanese quail, a commercially important and model animal for other poultry, was used in the study.

MATERIAL AND METHODS

The experiment was conducted at the Animal Science Department, Akdeniz University, Turkey. The care and use of animals were in accordance with laws and regulations of Turkey and approved by the Ministry of Food, Agriculture and Livestock (decision number 22875267-325.04.02-E.3706253) and Animal Experiments Local Ethics Committee of Akdeniz University (decision number B.30.2.AKD.0.05.07.00/59). Japanese quail (Coturnix coturnix Japonica) was used as animal material in the research. A total of 42 male and 126 female breeders were used at the Akdeniz University livestock facilities in order to create a base population which had not been selected before. The breeder females were housed in cages with five floors and ten individual compartments on each floor, with a stocking density of 275 cm²/bird in individual pens. The breeder flock was formed in the family structure. Families consisted of 3 females and 1 male to avoid full and half-sib mating, and males were shifted through the 3 female cages daily. A breeder diet containing 2,800 kcal of ME/kg and 19% CP/kg was given. All adult birds were kept under constant artificial lighting for 18 h/d. Eight hundred and sixty-seven chicks randomly selected from hatchlings obtained from 1200 hatching eggs of the base population were used as experimental animals.

The hatched chicks were kept until dry, and then the wing numbers were attached. Thanks to this process the pedigree records were created, weekly live weights and other measurements were performed by matching the pedigree records during the trial. After 420 h of incubation, all hatched chicks were examined by experienced operators to determine Tona and Pasgar chick quality score of chicks as previously described by Tona et al. (2003) and Boerjan (2002). Tona and Pasgar methods are qualitative scoring systems that assess total score index of 100 and 10, respectively, 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 (Tona et al., 2003; Boerjan 2002). Quail chicks were housed in brooding cages (90 cm²/quail) for 3 wk before being feather-sexed, then they were transferred to fattening cages (160 cm²/quail), and they were housed here until the slaughtering age of 56 days. 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/daylighting program were applied from hatch to the end of the study. The cumulative mortality was found 1.38% in the study.

At 8 weeks of age, the BW of all birds was de-
terminated 4 hours after feed withdrawal and slaughtered in an experimental processing plant. The birds were slaughtered, 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 (Narìnç et al., 2014). The 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 the same experienced operators. Cold carcass, breast, leg, wing, and total fat pad yields were calculated in relation to body weight at 8 weeks of age.

To obtain the estimates of individual growth curve parameters, all quail were weighed weekly from hatching to 8 weeks of age. The Gompertz non-linear regression model (1) was used to estimate the growth curve of each quail.

\[ y_t = \beta_0 e^{(-\beta_1 e^{-\beta_2 t})} \]  

where \( y_t \) is the weight at age \( t \), \( \beta_0 \) is the asymptotic (mature) weight parameter, \( \beta_1 \) is the scaling parameter (constant of integration) and \( \beta_2 \) is the instantaneous growth rate (per day) parameter (Akbaş and Yaylak, 2000; Narìnç et al., 2010b). The Gompertz model is characterized by an inflection point in a manner such that \( \beta_0/e \) of the total growth occurs prior to it and the remainder occurring after. The coordinates of the point of the inflection, age, and weight at inflection point (IPA and IPW, respectively), were obtained as follows:

\[ IPA = \ln(\beta_1)/\beta_2 \]  

\[ IPW = \beta_0/e \]

The descriptive statistics of TS, PS, BW6, BW8, \( \beta_0 \), \( \beta_1 \), IPT, IPW, CY, BY, LY, WY, and AFY are presented in Table 1. In addition, the results of the independent sample t-test conducted to determine the sex effect are also given in Table 1. The significant effects of sex of the birds were not observed for chick quality traits. But, there were significant differences between males and females for traits of BW6, BW8, \( \beta_0 \) parameter, IPT, and IPW, and all slaughter-carcass traits. Females showed higher mean values than males for BW6, BW8, \( \beta_0 \) parameter, IPT, IPW, AFY traits (P<0.05 for all mentioned characteristics). The coefficient of determination R2 of the estimated growth curves were found to be above 0.99.

The estimates of genetic parameters (heritabilities and genetic relationships) for chick quality traits and growth characteristics are presented in Table 2. Heritability estimates for slaughter-carcass traits are presented in Table 3. Also, the genetic correlations between chick quality traits and slaughter-carcass characteristics are presented in Table 3. There are phenotypic correlation coefficients between all traits and their statistical significances in Table 2 and Table 3. In the study, the genetic correlation estimates among all characteristics were found higher than the phenotypic correlation coefficients (Table 2 and Table 3).
Table 1. The descriptive statistics and effect of sex on studied traits

| Trait | N  | Mean | SE  | CV % | Min | Max | Sex Effect |
|-------|----|------|-----|------|-----|-----|------------|
| TS    | 855| 98.69| 0.17| 5.14 | 54.33| 100.00| NS¹       |
| PS    | 855| 9.80 | 0.02| 6.41 | 5.00 | 10.00|           |
| BW6 (g) | 858| 114.59| 1.25| 32.24| 35.15| 210.43| *        |
| BW8 (g) | 855| 150.71| 1.35| 26.43| 43.12| 234.02| *        |
| β₀₁ (g) | 855| 253.25| 2.45| 28.49| 54.34| 559.83| *        |
| β₁² (g) | 855| 0.038| 0.001| 39.22| 0.012| 0.126 |           |
| IPT ⁴ (d) | 855| 35.60| 0.48| 40.10| 9.49 | 119.11| *        |
| IPW ⁵ (g) | 855| 93.37| 0.92| 29.07| 19.99| 259.75| *        |
| CY (%) | 855| 74.86| 0.21| 8.08 | 61.93| 88.74| *        |
| BY (%) | 855| 28.52| 0.14| 14.24| 20.85| 41.14|           |
| LY (%) | 855| 17.20| 0.08| 2.28 | 3.33 | 41.14|           |
| WY (%) | 855| 5.36 | 0.02| 3.33 | 9.28 |      |           |
| AFY (%) | 855| 1.08 | 0.02| 5.33 | 0.08 | 2.94 |           |

TS= Tona score; PS= Pasgar score; BW6 and BW8= Body weight at 6 and 8 wk of age; β₀= Asymptotic BW parameter; β₁= Shape parameter; β₂= Instantaneous growth rate parameter; IPT and IPW = age and weight at inflection point, CY= Carcass yield, BY= Breast yield, LY= Leg yield, WY= Wing yield, AFY= Abdominal fat yield.

¹ NS= Non-significance, P>0.05. *=Statistically significance, P<0.05.

Table 2. Heritability estimates (on diagonal), genetic correlation estimates (below diagonal) and SE (in parentheses), phenotypic correlations (above diagonal) and P values (in parentheses) of chick quality and growth traits (N=855 for all traits)

| TS | PS  | BW6 | BW8 | β₀ | β₁ | β₂ | IPT | IPW |
|----|-----|-----|-----|----|----|----|-----|-----|
|    | 0.08| 0.03| 0.08| 0.00| -0.04| 0.00| -0.01| 0.01|
| TS | (0.02)| (0.388)| (0.466)| (0.889)| (0.209)| (0.916)| (0.075)| (0.845)|
|    | 0.82| 0.09| 0.02| 0.05| 0.02| -0.03| -0.01| 0.03|
| PS | (0.01)| (0.605)| (0.315)| (0.486)| (0.367)| (0.685)| (0.367)| 0.05|
|    | 0.14| 0.06| 0.46| 0.55| 0.05| 0.02| 0.69*| -0.60*|
| BW6| (0.03)| (0.01)| (0.001)| (0.549)| (0.876)| (0.001)| (0.001)| 0.225|
|    | 0.13| 0.09| 0.69| 0.51| 0.34*| -0.18*| 0.68*| -0.61*|
| BW8| (0.01)| (0.01)| (0.005)| (0.002)| (0.001)| (0.001)| (0.001)| (0.691)|
|    | 0.38| 0.35| 0.31| 0.35| 0.17| 0.35*| -0.57*| 0.66*|
| β₀ | (0.03)| (0.02)| (0.02)| (0.02)| (0.008)| (0.001)| (0.001)| (0.001)|
|    | 0.56| 0.28| -0.21| -0.21| -0.08| 0.27| -0.08| 0.40*|
| β₁ | (0.02)| (0.03)| (0.03)| (0.03)| (0.05)| (0.02)| (0.221)| (0.001)|
|    | -0.08| -0.22| 0.88| 0.84| -0.17| -0.07| 0.26| -0.93*|
| β₂ | (0.05)| (0.03)| (0.02)| (0.03)| (0.04)| (0.02)| (0.001)| (0.001)|
| IPT | 0.28| 0.32| -0.85| -0.65| 0.20| 0.33| -0.95| 0.26|
|    | (0.02)| (0.01)| (0.04)| (0.03)| (0.01)| (0.05)| (0.04)| (0.03)|
| IPW | 0.39| 0.35| 0.29| 0.43| 0.97| -0.06| -0.20| 0.24|
|    | (0.02)| (0.01)| (0.04)| (0.03)| (0.01)| (0.05)| (0.04)| (0.03)|

TS= Tona score; PS= Pasgar score; BW6 and BW8= Body weight at 6 and 8 wk of age; β₀= Asymptotic BW parameter; β₁= Shape parameter; β₂= Instantaneous growth rate parameter; IPT and IPW = age and weight at inflection point.
The mean values of Tona score and Pasgar Score (98.69 and 9.80) were in agreement with those reported for broiler chickens by Willemse et al. (2008), Van de Ven et al. (2012), and Bergouge et al. (2015), which range from 95.6 to 90.4 and 9.84 to 9.52, respectively. In the current study, the mean values of chick quality scores of birds were higher than those published by Tona et al. (2004) and Sözcü and İpek (2015) who reported Tona scores of 90.4-68.9 and Pasgar scores of 8.9-7.1 in broiler chickens. Chick quality varies considerably in studies conducted depending on factors affecting chick quality. In the studies where optimum conditions were provided, the Tona score and Pasgar score were over 90 and 9, respectively. In this study, chick quality scores obtained for Japanese quails were found to be compatible with the averages obtained under optimum conditions in these studies.

The mean values of BW at 6 and 8 weeks of age were detected at 114.59 and 150.71 g, respectively. Comparable results (91.63 to 114.76 g) have been reported for body weight at 6 weeks of age by Aggrey et al. (2003), Tarhyel et al. (2012), Raji et al. (2014), and Rocha et al. (2020). In another study conducted by Daikwo et al. (2013), it was found that the live weight at 8 weeks of age was 133.76 g. However, some researchers (Akbaş and Yaylak, 2000; Balçırğolu et al., 2005; Narinç et al., 2014b) reported much higher mean values for body weight (170.9-184.4 g) even at six weeks of age in random-bred control lines. Minvielle (2004) reported that discrepancies among studies in the literature are attributed to the adaptation of these birds to cage conditions from immigrant life and the genetic improvement that has been applied. Sex differences for BW6 and BW8 in Japanese quail have been reported previously by Aggrey et al. (2003) and Narinç et al. (2010a), who reported that the body weights of females were heavier.

The mean value of $\beta_0$ parameter (253.25 g) was in agreement with the mean values reported by Beiki et al. (2013) and Narinç et al. (2014a). Similarly, the mean values for $\beta_0$ parameter of Gompertz function in Japanese quails were estimated in the range of 242-276 g by Karabağ et al. (2017), Hyankova et al. (2001), and Kızılkaya et al. (2005). The estimations of integration coefficient parameter ($\beta_1$) of the Gompertz model for growth of Japanese quail were found to be 3.39 and 3.31 by Akbaş and Yaylak (2000) and Narinç et al. (2010a), which is in agreement with the mean value (3.25) of $\beta_1$ parameter in this study. The mean value of instantaneous growth rate parameter ($\tilde{\beta}$) was found to 0.038 and this value is in agreement with the values (from 0.032 to 0.046) reported by Akbaş and Yaylak (2000), Narinç et al. (2014a), and Alkan et al. (2009).

As a result of studies conducted by various researchers (Alkan et al., 2009; Akbaş and Oğuz, 1998; Kaplan and Gürcan, 2018), quite different results (ranged from 15 to 35 days of age) have been found for the age at inflection point of the growth curve. The results for IPW have been reported by Alkan et al. (2009), Kızılkaya et al. (2006), and Kaplan and Gürcan (2018) that ranged from 88.13 to 105.84 g.

### DISCUSSION

Table 3. Heritability estimates (on diagonal), genetic correlation estimates (below diagonal) and SE (in parentheses), phenotypic correlations (above diagonal) and p values (in parentheses) of chick quality and slaughter traits (N=855 for all traits)

|     | TS  | PS  | CY   | BY   | LY   | WY   | AFY  |
|-----|-----|-----|------|------|------|------|------|
| TS  | 0.08| 0.81*| -0.03| -0.05| -0.02| 0.03 | 0.03 |
|     | (0.02)| (0.001)| (0.768)| (0.257)| (0.816)| (0.374)| (0.881) |
| PS  | 0.82| 0.09| -0.02| -0.03| -0.03| 0.01 | 0.07 |
|     | (0.01)| (0.02)| (0.254)| (0.128)| (0.375)| (0.278)| (0.554) |
| CY  | -0.05| -0.12| 0.04| 0.66*| 0.70*| 0.38*| 0.28*|
|     | (0.03)| (0.04)| (0.05)| (0.001)| (0.001)| (0.001)| (0.000) |
| BY  | -0.11| -0.14| 0.14| 0.46*| 0.11*| -0.07|    |
|     | (0.06)| (0.03)| (0.03)| (0.001)| (0.041)| (0.356)|    |
| LY  | -0.12| -0.12| 0.78| 0.42| 0.09| 0.32*| 0.13 |
|     | (0.05)| (0.05)| (0.03)| (0.03)| (0.03)| (0.001)| (0.094) |
| WY  | -0.07| -0.08| 0.61| 0.10| 0.57| 0.07| 0.12 |
|     | (0.04)| (0.03)| (0.03)| (0.03)| (0.03)| (0.04)| (0.196) |
| AFY | 0.22| 0.31| 0.33| 0.18| 0.33| 0.27| 0.21 |
|     | (0.03)| (0.03)| (0.04)| (0.01)| (0.01)| (0.01)| (0.01) |

TS= Tona score; PS= Pasgar score; CY= Carcass yield, BY= Breast yield, LY=Leg yield, WY= Wing yield, AFY= Abdominal fat yield.

Table 3.

**DISCUSSION**

The mean values of Tona score and Pasgar Score (98.69 and 9.80) were in agreement with those reported for broiler chickens by Willemse et al. (2008), Van de Ven et al. (2012), and Bergouge et al. (2015), which range from 95.6 to 90.4 and 9.84 to 9.52, respectively. In the current study, the mean values of chick quality scores of birds were higher than those published by Tona et al. (2004) and Sözcü and İpek (2015) who reported Tona scores of 90.4-68.9 and Pasgar scores of 8.9-7.1 in broiler chickens. Chick quality varies considerably in studies conducted depending on factors affecting chick quality. In the studies where optimum conditions were provided, the Tona score and Pasgar score were over 90 and 9, respectively. In this study, chick quality scores obtained for Japanese quails were found to be compatible with the averages obtained under optimum conditions in these studies.

The mean values of BW at 6 and 8 weeks of age were detected at 114.59 and 150.71 g, respectively. Comparable results (91.63 to 114.76 g) have been reported for body weight at 6 weeks of age by Aggrey et al. (2003), Tarhyel et al. (2012), Raji et al. (2014), and Rocha et al. (2020). In another study conducted by Daikwo et al. (2013), it was found that the live weight at 8 weeks of age was 133.76 g. However, some researchers (Akbaş and Yaylak, 2000; Balçırğolu et al., 2005; Narinç et al., 2014b) reported much higher mean values for body weight (170.9-184.4 g) even at six weeks of age in random-bred control lines. Minvielle (2004) reported that discrepancies among studies in the literature are attributed to the adaptation of these birds to cage conditions from immigrant life and the genetic improvement that has been applied. Sex differences for BW6 and BW8 in Japanese quail have been reported previously by Aggrey et al. (2003) and Narinç et al. (2010a), who reported that the body weights of females were heavier.

The mean value of $\beta_0$ parameter (253.25 g) was in agreement with the mean values reported by Beiki et al. (2013) and Narinç et al. (2014a). Similarly, the mean values for $\beta_0$ parameter of Gompertz function in Japanese quails were estimated in the range of 242-276 g by Karabağ et al. (2017), Hyankova et al. (2001), and Kızılkaya et al. (2005). The estimations of integration coefficient parameter ($\beta_1$) of the Gompertz model for growth of Japanese quail were found to be 3.39 and 3.31 by Akbaş and Yaylak (2000) and Narinç et al. (2010a), which is in agreement with the mean value (3.25) of $\beta_1$ parameter in this study. The mean value of instantaneous growth rate parameter ($\tilde{\beta}$) was found to be 0.038 and this value is in agreement with the values (from 0.032 to 0.046) reported by Akbaş and Yaylak (2000), Narinç et al. (2014a), and Alkan et al. (2009).

As a result of studies conducted by various researchers (Alkan et al., 2009; Akbaş and Oğuz, 1998; Kaplan and Gürcan, 2018), quite different results (ranged from 15 to 35 days of age) have been found for the age at inflection point of the growth curve. The results for IPW have been reported by Alkan et al. (2009), Kızılkaya et al. (2006), and Kaplan and Gürcan (2018) that ranged from 88.13 to 105.84 g.
The percentages of carcass, breast, leg, wing, and abdominal fat were 74.86, 28.52, 17.20, 5.36, 1.08 %, respectively, which were higher than those previously reported by Narinç et al. (2010c), Lotfi et al. (2011), Nariñ et al. (2013), and Raji et al. (2014). The significant effects of the sex of the birds were observed for all slaughter-carcass traits. The average percentages of slaughter-carcass traits (BY, LY, and WY), except AFY, were higher in males compared with females. Similar sex differences for slaughter-carcass characteristic in Japanese quail have already been reported for BY, LY, and WY (Narinç et al., 2010c; Shokoohmand et al., 2007; Khaldari et al., 2010).

Heritability estimates for the chick quality traits measured using Tona and Pasgar methods were found to be 0.08 and 0.09, respectively (Table 2). There are no studies on scientific literature for the genetic structure of chick quality traits of poultry species. In terms of chick quality, 4.06% of the phenotypic variance for the Tona score and 4.48% of the total variance for the Pasgar score could be explained by genetic factors, while the remaining environmental variance rates were 95.94% and 95.52%, respectively. This situation supports the view reported by Tona et al. (2005) that “although there are many genetic and environmental factors affecting chick quality, environmental factors have a larger share”.

Heritabilities for BW at 6 and 8 weeks of age were estimated at 0.46 and 0.56, respectively (Table 2). Consistent with the findings in the current study, many researchers found high heritabilities (0.40-0.69) for both traits (Akbaş and Yaylak, 2000; Nariñ et al., 2010b; Sezer 2007; Taraco et al., 2019; Sari et al., 2011). The estimates of heritability for the Gompertz model parameter β₀ (0.17), β₁ (0.27), β₂ (0.26), and live weight (0.26) and age (0.19) at an inflection point of growth function were close to those reported in a previously published study in Japanese quail (Akbaş and Yaylak, 2000). Akbaş and Yaylak (2000) reported that the heritability estimates for β₀, β₁, β₂ parameters and point of inflection coordinates (IPT and IPW) of Gompertz model were low to moderate (0.18, 0.33, 0.32, 0.32 and 0.18, respectively).

The current estimate (0.04) of the heritability of carcass percentage was close to previously reported low estimates for Japanese quail which range from 0.12 to 0.21 (Lotfi et al., 2011; Sari et al., 2011; Daikwo et al., 2013; Akbernejad et al., 2015). In the present study, heritabilities for BY, LY, and WY were found at 0.14, 0.09, and 0.07, respectively (Tablo 3). These estimates were in agreement with estimates reported by Vali et al. (2005), Akşit et al. (2003), Lotfi et al. (2011) ranged from 0.09 to 0.19. The estimated heritability for AFY (0.21) was low to moderate. In other studies involving quail, low to moderate heritabilities (0.23-0.29) were also reported for AFY trait (Akşit et al., 2003; Nariñ et al., 2010c; Lotfi et al., 2011). However, Nariñ et al. (2013) and Le Bihan Duval et al. (1998) reported higher heritability estimates for AFY in Japanese quail and chickens, which range from 0.35 to 0.84.

In the present study, the genetic correlation coefficients among all characteristics were estimated higher than the phenotypic correlation coefficients (Table 2 and Table 3). Cheverud (1988) reported that genetic correlation estimates were slightly larger than their phenotypic counterparts. The correlation patterns were strikingly similar in all studies using data sets based on appropriate effective sample sizes. Hence, Cheverud (1988) claimed that most of the difference between phenotypic and genetic correlation estimates was the imprecise estimates of genetic correlations.

The coefficients of phenotypic and genetic correlation between the Tona and Pasgar chick quality traits were 0.81 and 0.82, respectively. A positive and strong relationship between chick quality scores showed that these measurements were performed consistently and accurately. Positive and strong genetic and phenotypic correlations between weekly live weights (BW6 and BW8) were estimated to be 0.99 and 0.91, respectively (Table 2). These estimates were in agreement with estimates reported by Sezer (2007), Akbaş et al. (2004), and Sari et al. (2011) and ranged from 0.80 to 0.96. The genetic relationships between the β₀-β₁, β₀-β₂ parameters of the Gompertz model were negatively estimated. The low value of the parameter β₀ and long growing period resulted in high mature weight in birds as a consequence of the correlation between parameters β₀ β₂. These results were in agreement with similar research findings (Akbaş and Oğuz, 1998; Akbaş and Yaylak, 2000; Nariñ et al., 2010b). Genetic correlations between parameter β₀, β₂, and weekly live weights were positive, and genetic correlations between β₁ and weekly live weights were negative. These estimates were similar to those reported by Akbaş and Oğuz (1998), Akbaş and Yaylak (2000), and Nariñ et al. (2014a). This is the fact that an increase in the asymptotic (mature) body weight results in a decrease in the parameter β₂, which denotes the average rate of maturing.
ble 2, there were negative genetic correlations (-0.85 and -0.83) between body weight traits and IPT. These results agreed with the estimates of Mignon-Grasteau et al. (2000) who found a strong negative relationship (-0.60) between BW and IPT traits. Genetic correlations between IPT and IPW were estimated to be positive. Similar findings for these genetic correlations Nariç et al. (2010b) have also been reported.

Phenotypic and genetic relationships between chick quality traits determined by Tona and Pasgar methods in one-day-old chicks and yields of cold carcass and carcass parts were found to be low (genetic correlations between -0.14 and 0.13, phenotypic correlations between -0.05 and 0.05) and statistically insignificant. Phenotypic and genetic correlations between whole carcass yield, breast yield, thigh yield, wing yield were generally statistically significant and positive and generally moderate (Table 3). It was determined that the highest phenotypic and genetic correlations were between cold carcass and breast and thigh (0.61-0.78). Lotfi et al. (2011) reported similarly that the genetic relationships between cold carcass yield and percentage of breast and, between cold carcass yield, and the percentage of abdominal fat were 0.46 and 0.43, respectively.

CONCLUSION
Considering the results obtained from the study, it is not possible to say that Tona and Pasgar chick quality scores in Japanese quail have important genetic and phenotypic relationships with most yield characteristics. Since the chick quality is both low heritable trait and low genetic correlated trait with other yield characteristics, there is no requirement to be included directly in the selection index in a poultry breeding scheme, where improvement of the chick quality is also taken into account. In virtue of the chick quality is a very low heritable trait, environmental improvement of chick quality trait may be considered rather than genetic improvement.

ACKNOWLEDGEMENTS
This work was supported by The Scientific Research Projects Coordination Unit of Akdeniz University. Project Number: FYL-2019-4758.

CONFLICT OF INTEREST
The authors declared that there is no conflict of interest.

REFERENCES

Aggrey SE, Ankra-Badu BA, Marks HL (2003) Effect of long-term divergent selection on growth characteristics in Japanese quail. Poult Sci 82:538-542.
Akbarnejad S, Zerehdaran S, Hassani S, Samadi F, Lotfi E (2015) Genetic evaluation of carcass traits in Japanese quail using ultrasonic and morphological measurements. Br Poult Sci 56:293-298.
Akbaş Y, Öğuz I (1998) Growth curve parameters of line of Japanese quail (Coturnix coturnix Japonica) unselected and selected for four-week body weight European Poultry Science; 62: 104-109.
Akbaş 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. Europ Poult Sci 64:141-146.
Akbaş Y, Takma Ç, Yaylak E (2004) Genetic parameters for quail body weights using a random regression model. South African Journal of Animal Science; 34: 104-109.
Aksit M, Öğuz I, Akbaş Y, Altan Y, Özdöğan M (2003) Genetic variation of feed traits and relationships to some meat production traits in Japanese quail (Coturnix coturnix Japonica). Europ Poult Sci 67:76-82.
Alkan S, Mendez M, Karabağ K, Balçoğlu MS (2009) Effects short term divergent selection to 5-week body weight on growth characteristics in Japanese quail. Europ Poult Sci 73:124-131.
Balçoğlu MS, Kızılkaya K, Yolcu HI, Karabağ K (2005) Analysis of growth characteristics in short-term divergently selected Japanese quail. S Afr J Anim Sci 35:83-89.
Beiki H, Pakdel A, Moradi-Shahrhabab M, Mehrbani H (2013) Evaluation of growth functions on Japanese quail lines. Poult Sci 50:20-27.
Bergoug H, Guinebretière M, Roulston N, Tong Q, Romanini CEB, Exadaktylos V, McGonnell IM, Demmers T, Garain P, Bahr C, Berckmans D, Eterradossi N, Michel V (2015) Relationships between hatch time and egg weight, embryo sex, chick quality, body weight and po-
dodermatitis severity during broiler rearing. Europ Poult Sci 79:1-10.
Borjian M (2002) Programs for single stage incubation and chick quality. Avian Poult Biol Rev 13:237-238.
Cheverud JM (1988) A comparison of genetic and phenotypic correlations. Evolution 42:958-968.
Daikwo SI, Momoh OM, Dim NI (2013) Heritability estimates of genetic and phenotypic correlations among some selected carcass traits of Japanese quail (Coturnix coturnix Japonica) raised in a sub-humid climate. J Biol Agr Health 3:60-65.
FAOSTat (2020) Statistics Data: the Food and Agriculture Organization of the United Nations. Official website. Retrieved from http://www.fao.org/faostat/en/#data
Hyankova L, Knizetova H, Dedkova L, Horta J (2001) Divergent selection shape of growth curve in Japanese quail 1. Responses in growth parameters and food conversion. Br Poult Sci 42:583-589.
Kaplan S, Gürçan EK (2018) Comparison of growth curves using non-linear regression function in Japanese quail. J Appl Anim Res 46:112-117.
Karabağ K, Alkan S, Karśli T (2017) Genetic changes in growth curve parameters in Japanese quail lines divergently selected for body weight. Europ Poult Sci 81:1-10.
Khaldari M, Pakdel A, Mehrbani Yeganeh H, Nejati JA, Berg P (2010) Response to selection and genetic parameters of body and carcass weights in Japanese quail selected for 4-week body weight. Poult Sci 89:1834-1841.
Kızılkaya K, Balçoğlu MS, Yolcu HI, Karabağ K (2005) The application of exponential method in the analysis of growth curve for Japanese quail. European Poult Sci 69:193-198.
Kızılkaya K, Balçoğlu MS, Yolcu HI, Karabağ K, Genç IH (2006) Growth curve analysis using nonlinear mixed model in divergently selected Japanese quails. Europ Poult Sci 70:181-186.
Le Bihan-Duval E, Mignon-Grasteau S, Millet N, Beaumont C (1998) Genetic analysis of a selection experiment on increased body weight and breast muscle weight as well as on lim-ted abdominal fat weight. Br Poult Sci 39:346-353.

Lektsirimpong N, Romero-Sanchez H, Plumstead PW, Brannan KE, Brake J (2007) Effect of elevated temperature during late incubation on body weight and organs of chicks. Poult Sci 86:2685-2691.

Lotfi E, Zerehdaran S, Ahani Azari M (2011) Genetic evaluation of carcass composition and fat deposition in Japanese quail. Poult Sci 90:2202-2208.

Mignon-Grasteau S, Piles M, Varona L, De Rochambeau H, Poivey JP, Blasco A, Beaumont C (2000) Genetic analysis of growth curve parameters for male and female chickens resulting from selection on shape of curve. J Anim Sci 78:2515-2524.

Minvielle F (2004) The future of Japanese quail for research and production World’s Poult Sci 60:500-507.

Narinç D, Karaman E, Firat MZ, Aksoy T (2010a) Comparison of non-linear growth models to describe the growth in Japanese quail. J Anim Vet Adv 9:1961-1966.

Narinç D, Aksoy T, Karaman E (2010b) Genetic parameters of growth curve parameters and weekly body weights in Japanese quails (Coturnix coturnix Japonica). J Anim Vet Adv 9:501-507.

Narinç D, Karaman E, Aksoy T (2010c) Estimation of genetic parameters for carcass traits in Japanese quail using Bayesian methods. S Afr J Anim Sci 40:342-347.

Narinç D, Aksoy T, Karaman E, Aygun A, Firat MZ, Uslu MK (2013) Japanese quail meat quality: characteristics heritabilities and genetic correlations with some slaughter traits. Poult Sci 92:1735-1744.

Narinç D, Karaman E, Aksoy T, Firat MZ (2014a) Genetic parameter estimates of growth curve and reproduction traits in Japanese quail. Poult Sci 93:24-30.

Narinç D, Karaman E, Aksoy T (2014b) Effects of slaughter age and mass selection on slaughter and carcass characteristics in 2 lines of Japanese quail. Poult Sci 93:762-769.

Raji AO, Alade NK, Duwa H (2014) Estimation of model parameters of the Japanese quail growth curve using Gompertz model. Arch Zoo-tech 63:429-435.

Rocha G, Del Vesco A, Santana T, Santos T, Cercquiera A, Zancanela V, Fernandes RPM, Oliveira Júnior G (2020) Lippia gracilis Schauer essential oil as a growth promoter for Japanese quail. Animal 1:1-9.

Sarı M, Tilki M, Saatci M (2011) Genetic parameters of slaughter and carcass traits in Japanese quail (Coturnix coturnix Japonica). Br Poult Sci 52:169-172.

Sarica, M., Yamak, U.S., Turhan, S., Boz, M.A., Saricagolu & Altop, A., 2014. Comparing slow-growing chickens produced by two- and three-way-crosses with commercial genotypes. 2. Carcass quality and blood parameters. Europ Poult Sci 78:1-14.

Sezer M (2007) Genetic Parameters estimated for sexual maturity and weekly live weights of Japanese quail (Coturnix coturnix Japonica). Asian-Australas J Anim Sci 20:19-24. Shokoolmand M, Emam JKN, Emami MA (2007) Estimation of heritability and genetic correlations of body weight in different age for three strains of Japanese quail. Int J Agric Biol 9:945-947.

Stozü A, Ipekoğlu A (2015) Quality assessment chicks from different hatcher temperatures with different scoring methods and prediction of broiler growth performance. J Appl Anim Res 43:409-416.

Taraco G, Gaya LG, Mota LF, Souza AR, Lima HJD, Silva MA (2019) Heritability and genotype-environment interactions for growth curve parameters in meat-type quail fed different threonine: lysine ratios from hatching to 21 d of age. Poult Sci 98:69-73.

Tarihyel R, Tanimomo BK, Hena SA (2012) Organ Weight: As Influenced By Color, Sex And Weight Group in Japanese Quail. Sci J Anim Sci 1:46-49.

Tona K, Bamelis F, De Ketelaere B, Bruggeman V, Moraes VMB, Buyse J, Onagbesan O, Decuyper E (2005) Effects of egg storage time on spread of hatch, chick quality, and chick juvenile growth. Poult Sci 82:736-741.

Tona K, Onagbesan O, Jego Y, Kamers B, Decuyper E, Bruggeman V (2004) Comparison of embryo physiological parameters during incubation, chick quality and growth performance of three lines of broiler breeders differing in genetic composition and growth rate. Poult Sci 83:507-513.

Tona K, Onagbesan O, Bruggeman V, Mertens K, Decuyper E (2005) Effects of turning duration during incubation on embryo growth utilization of albumen, and stress regulation. Poult Sci 84:315-320.

Vali N, Edriss MA, Rahmani HR (2005) Genetic parameters of body and some carcass trait in two quail strains. Int J Poult Sci 4:296-300.

Van de Ven LJF, Van Wagenberg AV, Uitdehaag KA, Koerkamp PG, Kemp B, Van den Brand H (2012) Significance of chick quality score in broiler production. Animal 6:1677-1683.

Willemsen H, Everaert N, Witters A, De Smit L, Debonne M, Verschueren F, Garain P, Berckmans D, Decuyper E, Bruggeman V (2008) Critical assessment of chick quality measurements as an indicator of posthatch performance. Poult Sci 87:2358-2366.