Characterization in the Egg Quality of Three Species of Phasianidae Birds

Putra WPB[1]*, Kırıkçı K[2], Arslan E[2]

[1]*Research Center for Applıed Zoology - National Research and Innovation Agency, Bogor, West Java, Indonesia 16911*
[2]*Department of Anımal Breeding, Faculty of Veterinary, Selçuk University, Konya, Turkey 42130*
**E-mail: widya.putra.lipi@gmail.com*

(received 23-12-2022; revised 18-01-2023; accepted 30-08-2023)

ABSTRAK

Putra WPB, Kırıkçı K, Arslan E. 2023. Karakterisasi kualitas telur pada tiga spesies unggas Phasianidae. JITV 28(4):244-250. DOI: http://dx.doi.org/10.14334/jitv.v28i4.3081.

Ayam Partridge Batu (*Alectoris graeca*), ayam Pegar (*Phasianus colchicus*) dan puyuh Jepang (*Coturnix japonica*) merupakan tiga jenis spesies unggas dari famili Phasianidae yang dipelihara untuk produksi daging dan telur di negara Republik Turki. Penelitian ini bertujuan untuk melakukan karakterisasi kualitas telur yang berasal dari ayam Partridge Batu (RP), ayam Pegar (CP) dan puyuh Jepang (JQ). Parameter yang diukur pada telur yaitu berat telur (EW), indeks bentuk (SI), indeks yolk (YI), indeks albumen (AI), berat kerabang (SW), haugh unit (HU),berat yolk (YW), berat albumen (AW), rasio yolk (YR), rasio albumen (AR) dan rasio kerabang (SR). Sebanyak 372 butir telur unggas terdiri dari 100 butir telur partridge, 200 butir telur pheasant dan 72 butir telur puyuh digunakan pada peneitian ini. Analisis Diskriminan Kanonik (ADK) dan Analisis Klaster Hirarki (AKH) digunakan pada penelitian untuk karakterisasi tiga jenis telur berdeda menggunakan program SPSS 16.0. Hasil penelitian menunjukkan bahwa 9 parameter telur yaitu EW, AR, YI, SI, YW, AW, YR, AI, HU dan SR merupakan variabel pembeda pada ketiga jenis telur yang diteliti. Hasil analisis menunjukkan bahwa nilai korelasi kanonik (R) yang diperoleh termasuk tinggi yaitu 0.98 (Fungsi 1) dan 0.79 (Fungsi 2). Jarak Mahalonobis (D^2) tertinggi dan terendah masing-masing sebesar15.28 (RP - CP) dan 27.94 (CP - JQ). Disimpulkan bahwa unggas Phasianidae pada penelitian ini memiliki sifat kualitas telur yang berbeda dan dapat digunakan untuk penciri spesies.

Kata Kunci: ADK, AKH, Kualitas Telur, Mahalonobis, Unggas Phasianidae

ABSTRACT

Putra WPB, Kırıkçı K, Arslan E. 2023. Characterization in the egg quality of three species of Phasianidae birds. JITV 28(4):244-250. DOI: http://dx.doi.org/10.14334/jitv.v28i4.3081.

Rock partridge (*Alectoris graeca*), Common pheasant (*Phasianus colchicus*), and Japanese quail (*Coturnix japonica*) are three poultry species from the Phasianidae family birds that are kept for meat and egg production in the Republic of Turkey. This research was carried out to characterize the egg quality of Rock partridge (RP), Common pheasant (CP), and Japanese quail (JQ). The eggs parameter of egg weight (EW), shape index (SI), yolk index (YI), albumen index (AI), shell weight (SW), haugh unit (HU), yolk weight (YW), albumen weight (AW), yolk ratio (YR), albumen ratio (AR) and shell ratio (SR) were measured for data analysis. A total of 372 eggs, including 100 eggs of partridges, 200 eggs of pheasant, and 72 eggs of quail were used in this study. A Canonical Discriminant Analysis (CDA) and Hierarchical Cluster Analysis (HCA) were used in this study to characterize three different types of eggs using SPSS. 16.0 package. The results showed that nine egg parameters of AR, YI, SI, YW, AW, YR, AI, HU, and SR are identified as discriminant variables for three egg types. The results showed that the canonical correlation (R) value in this study was high, *i.e.*, 0.98 (Function 1) and 0.79 (Function 2). The Mahalonobis distance (D^2) in this study ranged from 15.28 (RP - CP) to 27.94 (CP - JQ). In conclusion, the Phasianidae poultries in this study have different egg quality traits and can be used as the species marker.

Key Words: CDA, HCA, Egg Quality, Mahalonobis, Phasianidae birds

INTRODUCTION

Egg production is an essential trait in poultry because of its high economic value. Generally, two poultry species of chicken (*Gallus domesticus*) and Japanese quail (*Coturnix japonica*) were kept for meat and egg production in most countries. Despite chicken and quail, two other poultry species, Rock partridge (*Alectoris graeca*) and Common pheasant (*Phasianus colchicus*), were kept for meat and egg production in the Republic of Turkey. According to the IUCN Red List, Common pheasants have the conservation status of Least Concern (Braasch et al. 2011). Meanwhile, the Rock partridge has the conservation status of Near Threatened globally and Vulnerable in Italy (Fontaneto et al. 2022). Despite habitat loss, the decrease in the Rock partridge population can be caused by parasitic helminths of *Cheilospirura hamulosa* (Fanelli et al. 2020). Hence, the

breeding program for both bird species for economic purposes is vital to protect them in the wild habitat from extinction.

Rock partridge and Common pheasants are classified as Phasianidae family birds (Shen et al. 2014). The average body weight in mixed-sex Rock partridge at 12 weeks of age was 421.57±4.88 g (Putra & Kırıkçı 2021). Meanwhile, the average body weight in Common pheasant at 13 weeks of age was 1053.00±58.97 g in males and 825.00±74.25 g in females (Kokoszynski et al. 2012). Compared to Rock partridge and Common pheasant, the average body weight of Japanese quail was shown to be lowest, *i.e.*, 203.48±25.21 g in males and 228.21±26.44 g in females (Khalil et al. 2006). Therefore, Rock partridge and Common pheasant can be kept for meat production (Hofbauer et al. 2010; Franco & Lorenzo 2013; Wen et al. 2020).

Interestingly, the quality of milk and eggs can be used to characterize the livestock breed (Haygert-Velho 2018; Putra et al. 2021). A Canonical Discriminant Analysis (CDA) and Hierarchical Cluster Analysis (HCA) are two statistical methods that are used to evaluate livestock animals (Ali et al. 2013). Both statistical analyses represent a valid method to simplify the considerable amount of information available regarding the poultry Farms' routines. An example is cluster analysis, which allows grouping and discriminating between groups, where the Euclidean distances, a measure of similarity, define that the means of nearer observations are in the same group, while the most distant are in separate groups (Todde et al. 2016). In addition, both statistical methods have been used to characterize eggs in poultry (Michalczyk & Kurczab 2018; Putra et al. 2021; Ariza et al. 2021). Presently, a study to discriminate many Phasianidae birds based on egg quality traits has yet to be reported. The egg characteristics can be used for avian species identification (Buss & Keiss 2009) and for determining the Euclidean genetic distance (Putra et al. 2021). Unfortunately, there are few studies on egg characterization in Phasianidae birds. Alaşahan & Günlü (2012) have worked to observe the egg quality traits in partridge, pheasant, quail, and chicken without characterization analysis. Hence, this study aimed to characterize the egg quality of three Phasianidae birds (Rock partridge, Common pheasant, and Japanese quail) and determine the Euclidean genetic distance with their egg quality. The results of this study can be used as early information to observe the similarity of egg characteristics in three species of Phasianidae birds.

MATERIALS AND METHODS

Egg sample and research site

Three species of Phasianidae birds, *i.e.*, Rock partridge (*Alectoris graeca*), Common pheasant (*Phasianus colchicus*), and Japanese quail (*Coturnix japonica*), were involved in this study, as shown in Figure 1. A total of 372 eggs consisting of 100 eggs of Rock partridge (RP), 200 eggs of Common pheasant (CP), and 72 eggs of Japanese quail (JQ) were used in this study for the egg quality analysis. All Phasianidae birds were kept at the Selçuk University Faculty of Veterinary Science Hümeyra Özgen Research and Application Center Farm, Republic of Turkey. The egg collection was performed during the laying period of RP (40-44 weeks of age), CP (44-48 weeks of age), and JQ (10-14 weeks of age).

Management of bird

Typical pheasant eggs were used from matings of 90 females and 15 male pheasants of 44 wk of age. The pheasants were mated inside four semi-open shelters (a 4 × 5 m open section and a 4 × 4 m closed section) as one male: 6 female ratio. Artificial lighting was used 16 hours light in a day. Birds were fed with ration ad libitum, including 18% HP and 2,850 MJ/kg of ME, and water was provided from automatic nipples. Rock partridge eggs were used from mating 72 rock partridges (24 male and 48 female) of 44 wk of age. The partridges were mated as one male and two females in open cages (1.2 m x 6.0 m x 1.2 m). Artificial lighting was used 16 hours a day. An ad libitum ration, including 24% CP and 2,850 MJ/kg of ME was provided, and water was supplied via automatic nipples. Quail eggs were used from matings of 120 quails (40 male and 80 female) at 15 weeks of age. Quails were housed in battery cages with 130 cm^2 space per bird as one male and two females and exposed to a 16 h light daily. Commercial quail layer rations containing 17% crude protein (CP) and 2800 kcal/kg metabolizable energy (ME) were provided for quails. The ration and water were available ad libitum.

Egg quality

Eleven egg quality traits of egg weight (EW), shape index (SI), yolk index (YI), albumen index (AI), shell weight (SW), haugh unit (HU), yolk weight (YW), albumen weight (AW), yolk ratio (YR), albumen ratio (AR) and shell ratio (SR) were measured in this study using animal weighing scale (g) and digital caliper (mm). Therefore, SI, YI, AI, HU, YR, AR, and SR measurements were calculated using equations according to Alkan et al. (2015) and Wijedasa et al. (2020) as follows:

$$SI(\%) = \left(\frac{widht\ of\ egg}{length\ of\ egg}\right) x\ 100$$

$$YI(\%) = \left(\frac{height\ of\ yolk}{diameter\ of\ yolk}\right) x\ 100$$

$$AI(\%) = \left(\frac{albumen\ height}{albumen\ diameter}\right) x\ 100$$

$$HU = 100\ x\ Log[(AW + 7.57 - 1.70) x\ EW\ x\ 0.37]$$

$$YR(\%) = \left(\frac{YW}{EW}\right) x\ 100$$

$$AR(\%) = \left(\frac{AW}{EW}\right) x\ 100$$

$$SR(\%) = \left(\frac{SW}{EW}\right) x\ 100$$

Data analysis

The descriptive statistics of egg quality traits were computed with General Linear Model (GLM) using a mathematical model as follows:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

Where Y_{ij} is the response variable of the jth observation in the group, μj is the overall mean, σ_i is the effect of the ith group, and e_{ij} is random for the jth error. Thus, a Canonical Discriminant Analysis (CDA) was performed to calculate Mahalanobis distance (D^2), tolerance (T), Wilk's lambda (λ) values, and the discriminator variables.

After that, the CDA was applied with the backward-stepping automatic elimination method for the variables, with F value entry = 3.84 and F value removal = 2.71 (Depison et al. 2021). The T value (0 to 1) was computed to detect the level of correlation among variables in the discriminant function. Suppose a variable is highly correlated with one or more of the others. In that case, the T value is minimal, and the resulting estimates of the discriminant function coefficients may be unstable (Asamoah-Boaheng & Sam 2016). The Hierarchical Cluster Analysis (HCA) was used for clustering in each breed with the squared Mahalonobis (D^2) distance (Oliveira et al. 2018). The HCA in this study was performed using the morphometric measurements with the nearest-neighbor method and computed using the SPSS 16.0 computer program.

RESULTS AND DISCUSSION

Egg quality

The egg qualities of three Phasianidae poultries in the present study are presented in Table 1. According to Table 1, RP and CP birds have similar AI and SR measurements. Meanwhile, RP and JQbirds have similar SI measurements. Wijedasa et al. (2020) obtained a lower value of HU (81.46±1.43) and EW (9.47±5.64 g) in JQ birds than in the present study. In addition, Alaşahan & Günlü (2012) obtained a lower value of HU in RP (80.34±0.62), CP (80.55±0.56) and JQ (82.88±0.39) birds rather than the present study. Ashraf et al. (2016) obtained lower EW (26.94±5.37 g), YI (32.27±0.86%), and AR (49.30±3.97) values in CP birds rather than in the present study. Kırıkçı et al. (2005) reported that the HU and EW values in different egg colors of CP birds were 83.96±1.41 and 28.10±0.63 g (white); 79.91±2.68 and 26.71±0.62 g (blue); 82.12±0.86 and 31.89±0.34 g (brown); 81.41±0.57 and 31.16±0.23 g

Table 1. Means (±SD) of egg quality in three species of Phasianidae birds

Parameter	Phasianidae birds		
	Rock partridge (N = 100)	Common pheasant (N = 200)	Japanese quail (N = 72)
Egg weight (g)	22.43±1.69[a]	31.03±2.26[b]	12.49±1.06[c]
Shape index	77.04±4.28[a]	80.69±3.14[b]	77.43±3.61[a]
Yolk index	47.88±5.39[a]	43.19±4.77[b]	38.52±3.51[c]
Albumen index	1.56±0.29[a]	1.47±0.30[a]	2.34±0.63[b]
Shell weight (g)	2.34±0.28[a]	3.22±0.38[b]	1.24±0.25[c]
Haugh unit	85.14±4.13[a]	82.52±4.48[b]	84.39±8.29[a]
Yolk weight (g)	8.41±0.97[a]	10.20±1.00[b]	3.91±0.45[c]
Albumen weight (g)	11.68±1.43[a]	17.58±1.86[b]	7.35±0.71[c]
Yolk ratio	37.55±4.07[a]	32.96±3.37[b]	31.36±2.76[c]
Albumen ratio	52.01±4.11[a]	56.73±5.14[b]	58.85±2.86[c]
Shell ratio	10.44±1.03[a]	10.40±1.09[a]	9.94±2.00[c]

[a,b,c] = superscript of differ significantly (P<0.05); N= Number of bird; SD= Standard deviation

Table 2. Factor selected by stepwise discriminant analysis to discriminate three species of Phasianidae birds

Variable	Tolerance	F to Remove	Min. D^2	Wilk's λ
Egg weight	0.02	13.30	25.38	0.02
Albumen ratio	0.03	7.69	25.67	0.02
Yolk index	0.91	38.10	26.03	0.02
Shape index	0.95	7.69	25.69	0.02
Yolk weight	0.04	5.91	27.00	0.02
Albumen weight	0.02	4.02	26.30	0.02
Yolk ratio	0.04	17.11	26.92	0.02
Albumen index	0.50	59.49	26.98	0.02
Haugh unit	0.48	39.80	26.96	0.02
Shell ratio	0.80	21.19	25.64	0.02

Table 3. Percentage (%) of individual classification per bird species based on discriminant analysis

Birds species	Predicted group membership (N)			Total (N)
	Rock partridge	Common pheasant	Japanese quail	
Rock partridge	100.0 (100)	0.0 (0)	0.0 (0)	100.0 (100)
Common pheasant	2.0 (4)	98.0 (196)	0.0 (0)	100.0 (200)
Japanese quail	0.0 (0)	0.0 (0)	100.0 (72)	100.0 (72)

N= Number of bird

Table 4. The squared Mahalonobis distance (D^2) among three species of Phasianidae birds

Birds species	Rock partridge	Common pheasant	Japanese quail
Rock partridge	1.00	15.28	22.79
Common pheasant		1.00	27.94
Japanese quail			1.00

Alectoris graeca *Phasianus cochiucus* *Coturnix japonica*

Figure 1. Phenotypic characteristics of Rock partridge (A), common pheasant (B), and Japanese quail (C)

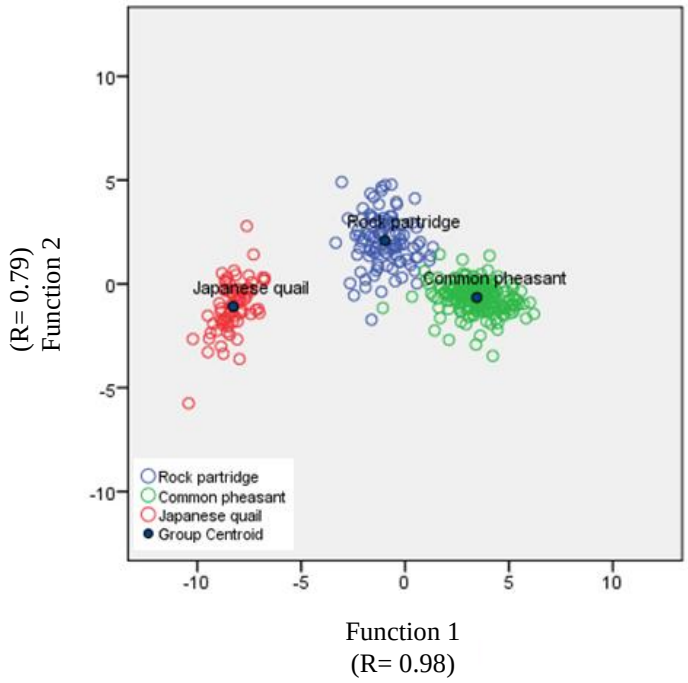

Figure 2. The canonical discriminant plot in the egg quality traits to discriminate three species of Phasianidae birds

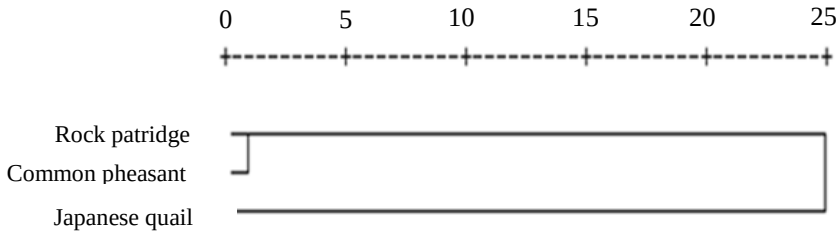

Figure 3. Dendogram distance among three species of Phasianidae birds based on egg quality traits

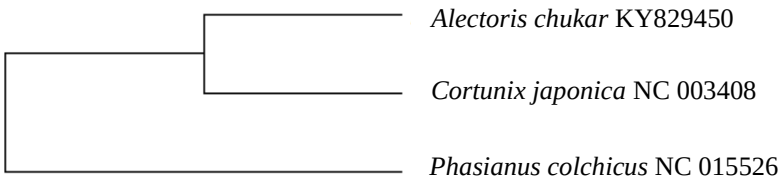

Figure 4. Dendogram among three species of Phasianidae birds based on mitogenome DNA from GenBank database (https://www.ncbi.nlm.nih.gov)

(olive green), respectively. Hence, the HU value of CP birds was higher than in a previous study reported by Kırıkçı et al. (2005). Despite this, the EW of CP birds in the present study was close to the eggs of CP with brown and olive green colors. The egg quality in birds can be affected by nutrient, environmental, and genetic factors.

Canonical discriminant analysis

In this study, the egg quality traits were described as the discriminant variable (Table 2). In addition, ten discriminant variables were able to discriminate three Phasianidae poultries with the canonical correlation (R) of 0.98 (function 1) and 0.79 (function 2), as shown in Figure 2. Hence, ten discriminant variables were able to classify RP (100%), CP (98%), and JQ (100%) birds into their original Phasianidae poultry group (Table 3). The D^2 value among Phasianidae poultries was 15.28 (RP and CP birds), 22.79 (RP and JQ birds), and 27.94 (CP and JQ birds), as shown in Table 4. Hence, RP and CP birds were grouped into a similar cluster based on HCA with egg quality, as shown in Figure 3. Meanwhile, the JQ bird was grouped into a separate cluster. Putra et al. (2021) reported that three egg qualities of yolk diameter, volume, and surface area were the discriminant variables

to differentiate White Leghorn, Lohmann Brown, and Ataks chicken breeds. Ariza et al. (2021) reported that partridge has close relatedness with chicken based on egg quality traits. Hence, partridges are a potential bird for egg production in Turkey. In this study, a phylogenetic analysis with the mitogenome DNA sequence of *Alectoris chukar* (GenBank: KY829450), *Phasianus colchicus* (GenBank: NC015526), and *Coturnix japonica* (GenBank: NC003408) was performed to evaluate the findings in the present study. According to the mitogenome DNA sequence, partridge and quail have a close genetic relationship and are grouped into a similar cluster, as shown in Figure 4. Meanwhile, the pheasant was grouped into a separate cluster. Kimball et al. (1999) obtained a similar finding that *Coturnix coturnix* and *Alectoris sp.* have a close genetic relationship based on the mitochondrial Cytochrome-b (Cyt-b) gene.

CONCLUSION

The egg quality traits can be used to differentiate three species of Phasianidae birds, *i.e.*, Rock partridge (*Alectoris chukar*), Common pheasant (*Phasianus colchicus*) and Japanese quail (*Coturnix japonica*). The egg quality traits of Rock Partridge and Common Pheasant were closed. However, a study with the mitogenome DNA revealed that Japanese quail and partridge have a similar maternal lineage. Hence, genetically, Japanese Quails are the closest kinship to Rock partridge. Nonetheless, the egg quality of Rock partridges was close to that of Common pheasant. In the future, Rock partridge and Common pheasant can be managed in poultry farming for meat and egg production.

REFERENCES

Ali AA, Ullah MA, Ejaz MA. 2013. Evaluation of livestock data using multivariate analysis techniques. Pak J Life Soc Sci. 11:208-211.

Alkan S, Galiç A, Karsli T, Karabağ K. 2015. Effects of egg weight on egg quality traits in partridge (*Alectoris chukar*). J Appl Anim Res. 43:450-456. DOI:10.1080/09712119.2014.980419.

Alaşahan S, Günlü A. 2012. Determination of egg quality characteristics of different poultry species with digital image analysis. Kafkas Univ Vet Fak Derg. 18:976-986.

Ariza AG, Arbulu AA, Gonzalez FJN, Bermejo JVD, Vallejo MEC. 2021. Discriminant canonical analysis as a validation tool for multivariety native breed egg commercial quality classification. Foods. 10:632. DOI:10.3390/foods10030632.

Asamoah-Boaheng M, Sam EK. 2016. Morphological characterization of breeds of sheep: a discriminant analysis approach. Springer Plus 5:1-12. DOI:10.1186/s40064-016-1669-8.

Ashraf S, Javid A, Ashraf M, Akram M, Malik S, Irfan, Altaf M. 2016. Influence of egg weight on egg quality parameters and growth traits in Ring Necked pheasant (*Phasianus colchicus*) in captivity. J Anim Plant Sci. 26:331-338.

Braasch T, Pes T, Michel S, Jacken H. 2011. The subspecies of the common pheasant *Phasianus colchicus* in the wild and captivity. Int J Galliformes Conserv. 2:6-13.

Buss A, Keiss O. 2009. Method for identification of avian species by eggshell microstructure. Act Univ Latviensis. 753:89-98.

Depison, Putra WPB, Gushairiyanto, Alwi Y, Suryani H. 2021. Morphometrics characterization of Thin-tail sheep in lowland and highland areas. Trop Anim Sci J. 44:386-398. DOI:10.5398/tasj.2021.44.4.386.

Fanelli A, Tizzani P, Ferroglio E, Belleau E. 2020. *Cheilospirura hamulosa* in the Rock partridge (*Alectoris graeca saxatilis*): epidemiological patterns and prediction of parasite distribution in France. Diversity. 12:484. DOI:10.3390/d12120484.

Fontaneto D, Viola P, Pizzirani C, Chiesa S, Rossetti A, Amici A, Lucentini L. 2022. Mismatches between morphology and DNA in Italian Partridges may not be explained only by recent artificial release of farm-reared birds. Anim. 12:541. DOI:10.3390/ani12050541.

Franco D, Lorenzo JM. 2013. Meat quality and nutritional composition of Pheasants (*Phasianus colchicus*) reared in an extensive system. Br Poult Sci. 54:594-602. DOI:10.1080/00071668.2013.828195.

Haygert-Velho IMP, Conceicao MD, Cosmam LC, Alessio DRM, Busanello M, Sippert MR, Damiani C, Almeida AP, Velho JP. 2018. Multivariate analysis relating milk production, milk composition, and seasons of the year. An Acad Bras Ciênc. 90:3839-3852. DOI:10.1590/0001-3765201820180345.

Hofbauer P, Smulders FJM, Vodnansky M, Paulsen P, El-Ghareeb WR. 2010. A note on meat quality traits of pheasants (*Phasianus colchicus*). Eur J Wildl Res. 56:809-813.

Huang Z, Ke D. 2014. Structure and evolution of the Phasianidae mitochondrial DNA control region. Mitochondrial DNA. 27:350-354. DOI:10.3109/19401736.2014.895987.

Khalil HA, Hassanein AM, Mady ME, Gerken M. 2006. Effect of housing conditions on performance of Japanese quail (*Coturnix coturnix japonica*) under cold stress in winter. Egyptian J Anim Prod. 43:71-82. DOI:10.21608/ejap.2006.93094.

Kimball RT, Braun EL, Zwartjes PW, Crowe TM, Ligon JD. 1999. A molecular phylogeny of the pheasants and partridges suggests that these lineages are not monophyletic. Mol Phylogenet Evol. 11: 38-54. DOI:10.1006/mpev.1998.0562.

Kırıkçı K, Günlü A, Garip M. 2005. Some quality characteristics of Pheasant (*Phasianus colchicus*) eggs with different shell colors. Turk J Vet Anim Sci. 29: 315-318.

Kokoszynski D, Bernacki Z, Duszynski L. 2012. Body conformation, carcass composition and physicochemical and sensory properties of meat from pheasants of different origin. Czech J Anim Sci. 57:115-124. DOI:10.17221/5564-CJAS.

Michalczyk E, Kurczab R. 2018. Assessment of poultry eggs freshness using FTIR spectroscopy combined with HCA and PCA methods. Sci Tech Inov. 2:7-12.

Oliveira EJ, Savegnano RP, de Freitas LA, Freitas AP, Maia SR, Simili FF, Faro LE, da Costa RLD, Junior MLS, C. de Paz CP. 2018. Estimates of genetic parameters and cluster analysis for worm resistance and resilience in Santa Ines meat sheep. Pesq Agropec Braz. 53:1338-1345. DOI:10.1590/S0100-204X2018001200006.

Putra WPB, Kırıkçı K. 2021. The growth curve of body weight in mixed-sex Rock partridge (*Alectoris graeca*) kept in captivity. J Poult Res. 18:19-23. DOI:10.34233/jpr.901581.

Putra WPB, Ridho M, Nugraha I. 2021. Breeds characterization in three Turkish laying chicken breeds based on egg characteristics. Indonesi J Agric Res. 4:130-141. DOI:10.32734/injar.v4i2.6210.

Shen YY, Dai K, Cao X, Murphy RW, Shen XJ, Zhang YP. 2014. The updated phylogenies Phasianidae based on combined data of nuclear and mitochondrial DNA. PLOS ONE. 9:e95786. DOI:10.1371/journal.pone.0095786.

Todde G, Murgia L, Caria M, Pazzona A. 2016. A multivariate statistical analysis approach to characterize mechanization, structural and energy profile in Italian dairy farms. Energy Reports. 2:129-134. DOI:10.1016/j.egyr.2016.05.006.

Wen Y, Liu H, Liu K, Cao H, Mao H, Dong X, Yin Z. 2020. Analysis of the physical meat quality in partridge (*Alectoris chukar*) and its relationship with intramuscular fat. Poult Sci. 99:1225-1231. DOI:10.1016/j.psj.2019.09.009.

Wijedasa WMRM, Wickramasinghe YHST, Vidanarachchi JK, Himali SMC. 2020. Comparison of egg quality characteristics of different poultry species. J. Agric. Sci.12:331-342. DOI:10.5539/jas.v12n11p331.