Ordu Üniversitesi Bilim ve Teknoloji Dergisi
Ordu Üniv. Bil. Tek. Derg.

Ordu University Journal of Science and Technology
Ordu Univ. J. Sci. Tech.

E-ISSN: 2146-6459 2021;11(2):140-151 Araştırma Makalesi / Research Article
https://doi.org/10.54370/ordubtd.996530

Effects of Egg Shape Index on Egg Quality in Partridges

Sezai Alkan[1], İsmail Türker[2]

[1]Ordu University, Faculty of Agriculture, Department of Animal Science, Ordu
[2]Uşak University, Faculty of Agriculture, Department of Animal Science, Uşak

Geliş Tarihi / Received Date: 16.09.2021 Kabul Tarihi / Accepted Date: 04.10.2021

Abstract

The aim of this study is to investigate the effects of the egg shape index on egg quality traits in Partridge (*Alectoris Chukar*). For this purpose, the eggs were classified as three different groups in terms of egg shape index which are ≤ 75, < 76 -77 > and ≥ 78 and 114, 56 and 73 eggs were used in the groups, respectively. Albumen ratio, albumen weight, yolk weight, yolk/albumen ratio and Haugh unit were significantly affected by egg shape index in this research. On the other hand, egg weight, egg volume, shell surface area, eggshell thickness, unit surface eggshell weight, shell ratio, albumen index, yolk index, yolk ratio and eggshell weight traits were not affected by egg shape index. It was determined that there was a significant relationship between egg shape index and albumen ratio, albumen weight, yolk weight, yolk/albumen ratio and Haugh unit in this study. According to the findings, eggshape index is an important factor affecting egg quality.

Keywords: alectoris chukar, egg, egg quality traits, egg shape index, correlation

Kınalı Kekliklerde Yumurta Şekil İndeksinin Yumurta Kalitesine Etkileri

Özet

Bu araştırmada, Kınalı Kekliklerde (*Alectoris Chukar*) yumurta şekil indeksinin yumurtanın iç ve dış kalite özelliklerine olan etkilerinin belirlenmesi amaçlanmıştır. Bu amaçla, yumurtalar şekil indeksi bakımından ≤ 75, < 76 -77 > ve ≥78 olmak üzere üç farklı gruba ayrılmıştır ve gruplarda sırasıyla 114, 56 ve 73 adet yumurta kullanılmıştır. Araştırmada ak oranı, ak ağırlığı, sarı ağırlığı, sarı-ak oranı ve Haugh birimi yumurta şekil indeksi tarafından önemli derecede etkilenmiştir. Buna karşın, yumurta ağırlığı, yumurta hacmi, kabuk yüzey alanı, kabuk kalınlığı, birim yüzey kabuk ağırlığı, kabuk oranı, ak indeksi, sarı indeksi, sarı oranı ve kabuk ağırlığı özellikleri yumurta şekil indeksi tarafından etkilenmemiştir. Yumurta şekil indeksi ile ak oranı, ak ağırlığı, sarı ağırlığı, sarı/ak oranı ve Haugh birimi arasından önemli ilişki olduğu belirlenmiştir. Bulgulara göre, yumurta şekil indeksi yumurta kalitesini etkileyen önemli bir faktördür.

Anahtar Kelimeler: kınalı keklik (alectoris chukar), yumurta, yumurta kalite özellikleri, yumurta şekil indeksi, korelasyon

Sorumlu Yazar / Corresponding Author: Sezai Alkan sezaialkan61@gmail.com

Introduction

There are many breeds of partridge, both wild and domesticated, in the world, and the most commonly used partridge in commercial production is *Alectoris Chukar*. Since partridge is a seasonal poultry species, the egg laying period is short. The spawning period starts in the spring season when the weather starts to warm up and ends at the end of the summer season when the weather starts to cool (April-August). Partridges grown in intensive conditions begin to reach sexual maturity at the age of approximately 16 weeks. However, the age of sexual maturity in the wild ranges from 8 to 12 months, as partridges hatch in spring and summer. Therefore, both the late age to start spawning and the short spawning period cause the products obtained from partridges to be more valuable (Alkan et al., 2007; Sarıca et al., 2003;). Partridges play an important role in maintaining the natural balance by eating maggots, insects, and even harmful grasses that harm plants cultivated by humans, such as wheat, barley and oats. Although Turkey is rich in geographical areas where partridges can live, the number of partridges is not at the desired or expected level. Although there are many reasons for this situation, the most important reasons are uncontrolled and unconscious hunting, destruction of habitats, excessive agricultural spraying, and fertilization, and problems in the protection of local gene resources (Alkan et al., 2007; Alkan et al., 2008; Çetin et al., 2000; Günlü et al., 2001).

Today, economically it is very important to expand and develop hunting tourism, as well as mountain tourism, which has started to develop in the Aegean and Mediterranean regions, which are close to tourism regions, and in the Black Sea region as well in recent years. For this purpose, depending on the increasing number of tourists, the efforts to diversify and extend tourism over longer periods should be accelerated and these studies should be concluded as soon as possible. In addition to health, congress, spa, and winter tourism, hunting tourism should be included among the touristic activities. Partridges have an important place in hunting tourism in terms of providing material. Particular attention should be paid to partridge breeding in settlements in and around the forest, and efforts must be accelerated to increase the economic income from partridges for the people living there. In this way, the negative influence of these people living in or near the forest can be reduced (Günlü et al., 2001).

Egg shape index is the ratio of egg width to length and is an important criterion used to determine egg quality. The ideal shape index for hatching and commercial eggs is 74. Eggs with a shape index greater than 76 are round, those between 72-76 are normal, and those with a shape index less than 72 are elongated. Round and elongated eggs are weak-looking and not particularly suitable for egg trays. During the transportation of this type of eggs, more broken-cracked egg problems occur compared to the transportation of normal shaped eggs (Alkan et al., 2016; Türkoğlu & Sarıca, 2014).

In this study, the aim was to determine the relationship between the effects of shape index on internal and external quality traits and egg quality traits in Partridge (*A. Chukar*) eggs.

Materials and Methods

Materials

Partridge were fed with a diet containing 2850 kcal/kg metabolic energy and 24% crude protein during chick period, and 2800 kcal/kg metabolic energy and 21% crude protein during the growing and laying period ad libitium, while unlimited water was supplied until the end of the experiment (Table 1). Partridges aged 40-48 weeks were used in this study. Eggs obtained in between May and June were used in the study which were kept at room temperature for 24 hours without being examined for their internal and external quality traits.

Table 1. Composition and Calculated Content of Main Nutrients in The Diet

Name of the traits	Equation
Shape index	100 x (Egg width) / (Egg length)
Eggshell surface area (cm^2)	(3.155-0.013 x Egg width) x (Egg length x Egg width)
Unit surface eggshell weight (g/cm^2)	(Eggshell weight) / (Eggshell surface area)
Eggshell ratio (%)	100 x (Eggshell weight) / (Egg weight)
Albumen index	100 x (Albumen height) / (Albumen length + Albumen width) / 2)
Albumen weight (g)	Egg weight - (Yolk weight + Eggshell weight)
Albumen ratio (%)	100 x (Albumen weight) / (Egg weight)
Yolk index	100 x (Yolk height) / (Yolk diameter)
Yolk ratio (%)	100 x (Yolk weight) / (Egg weight)
Yolk – albumen ratio (%)	100 x (Yolk weight) / (Albumen weight)
Haugh unit	100 log [Albumen height - (1.7 x Egg weight $^{0.37}$) + 7.57]
Egg volume (cm^3)	0.913 x Egg weight
Eggshell thickness (mm)	(Sharp part + Blunt part + Equatorial part) / 3

Methods

The eggs were classified as three different groups in terms of egg shape index which are ≤ 75, < 76 -77 > and ≥ 78. For these groups, 114, 56 and 73 eggs were used, respectively (Alkan et al., 2016; Türkoğlu & Sarıca 2014). After being numbered, the eggs were weighed using an electronic balance with an accuracy of 0.01 g. The width and length of the eggs were measured with a digital caliper with a precision of 0.01 mm. Then, the eggs were broken one by one on a glass table and the yolk height and albumen height were measured with a tripod micrometer with a precision of 0.01 mm while a digital caliper with a sensitivity of 0.01 mm was used for measuring yolk diameter, albumen length and albumen width. The yolk was separated from the egg albumen with a spoon and weighed. The albumen weight was calculated by subtracting the yolk and shell weight from the total egg weight. After the eggshells were cleaned and kept in room temperature for 24 hours, the weights of the shells without the membrane were determined by weighing them. The average egg thickness was calculated by measuring the samples taken from the sharp, equatorial and blunt parts of the egg using a micrometer with a precision of 0.01 mm (Alkan et al., 2016). The given equations used to determine the other quality traits of eggs are given in Table 2 (Alkan et al., 2015; Narushin 2005; Sreenivasiah 2006; Yannakopoulos & Tserveni-Gousi 1986). The obtained data were analyzed using Minitab 17 package program and Tukey Multiple Comparison Test was used to determine the groups that make up the difference.

Table 2. Equations Used to Determine Egg Quality Traits

Starter feed		Grower feed	
Ingredient	(%)	Ingredient	(%)
Maize	53.6	Maize	57.32
Soybean meal	25.94	Soybean meal	19.35
Sunflower meal	10.0	Sunflower meal	9.0
Bone meal	8.0	Bone meal	9.0
Vegetable oil	1.85	Vegetable oil	1.14
Vitamin	0.20	Vitamin	0.40
Lysine	0.16	Lysine	0.19
Methionine	0.10	Methionine	0.14
Mineral	0.10	Mineral	0.20
Salt	0.05	Salt	0.10
		Limestone	3.16

Results and Discussion

The effects of egg shape index on egg quality traits are given in Table 3, whereas the phenotypic correlations between egg shape index and egg quality traits are given in Table 4.

Table 3. Effects of Egg Shape Index on Internal and External Quality Traits of Eggs

Traits	≥ 78	< 76 -77 >	≤ 75	P value
Egg weight (g)	20.09±0.14	20.09±0.16	19.99±0.12	0.841
Egg volume (cm^3)	18.34±13	18.34±0.15	18.25±0.11	0.842
Eggshell surface area (cm^2)	37.32±0.20	37.32±0.23	37.18±0.17	0.838
Eggshell thickness (mm)	0.242±0.00	0.242±0.00	0.242±0.00	0.682
Unit surface eggshell weight (g)	0.54±0.00	0.54±0.00	0.54±0.00	0.831
Eggshell ratio (%)	11.22±0.11	11.27±0.14	11.13±0.12	0.722
Albumen index	10.48±0.16	10.86±0.18	10.98±0.15	0.069
Yolk index	55.10±0.43	56.56±0.58	55.52±0.51	0.214
Yolk ratio (%)	39.80±0.47	41.45±0.57	40.89±0.45	0.097
Eggshell weight (g)	2.24 ±0.014	2.52±0.017	2.21±0.016	0.140
Albumen ratio (%)	51.50±0.87^a	48.75±0.75^b	49.44±0.43^b	0.015
Albumen weight (g)	10.32±0.18^a	9.76±0.13^b	9.86±0.08^b	0.005
Yolk weight (g)	7.96±0.06^b	8.29±0.09^a	8.13±0.06^{ab}	0.012
Yolk / albumen ratio (%)	78.27±1.23^b	85.94±1.55^a	83.22±1.04^a	0.000
Haugh unit	85.98±0.46^b	86.86±0.52^{ab}	87.44±0.33^a	0.034

^{a,b} Different letters in the same row indicate significant differences between groups (P < 0.05)

As seen in Table 3, the albumen ratio was significantly affected by the egg shape index, and this ratio increased due to the increase in the shape index. The highest albumen ratio (51.50%) was found in the group with the high shape index group (≥78). The albumen ratio values obtained in this study were like the ones reported by Aysöndü et al. (2005), Çetin et al. (2008), Tekinşen et al. (2008) lower than the value reported by Günhan (2014) and higher than the value reported by Özkan (2020). Egg shape index also significantly affected the albumen weight. As with the egg shape index, the albumen weight increased due to the increase in egg shape index, and the highest albumen weight (10.32 g) was determined in the group with the high egg shape index (≥78). The obtained albumen weight values were found lower than the ones reported by Aysöndü (2005), Günhan (2014), Günlü et al. (2003), and Özbey and Esen (2007), higher than the values reported by Özkan (2020), and like the ones reported by Çağlayan et al. (2009) and Çetin et al. (2008). The yolk weight was also significantly affected by the egg shape index. However, depending on the increase in the shape index, the yolk weight decreased, and the highest yolk weight was obtained in the group with the low shape index (≤ 75). It was determined that the yolk weight values obtained were similar to the values stated in the literature (Aysöndü et al 2005; Çetin et al 2008; Günhan 2014; Günlü et al 2003; Kırıkçı et al 2007). Again, yolk/albumen ratio and Haugh unit were also significantly affected by egg shape index. As the egg shape index increased, both the yolk/albumen ratio and the Haugh unit decreased, and the lowest yolk/albumen ratio and Haugh unit values were found in the group with the high egg shape index (≥ 78). One of the most commonly used methods for determining quality traits in eggs is the Haugh unit. Eggs with a Haugh unit value greater than 78 are included in the class of perfect eggs according to the Turkish Standards Institute Haugh unit values. Therefore, it is undesirable for the eggs to have a Haugh unit value of less than 78. The Haugh unit value is higher in fresh eggs and lower in stale eggs (Türkoğlu et al 1997). The Haugh unit values obtained in this study are in the class of perfect eggs according to the Turkish Standards Institute Haugh unit values. Obtained Haugh unit values are lower than those reported by Aysöndü (2005), however, higher values were obtained when compared to those reported by Demirel and Kırıkçı (2009), Garip et al (2010), Günhan (2014), and Özbey and Esen (2007). On the other hand, egg weight, egg volume, shell surface area, shell thickness, unit surface shell weight, shell ratio, albumen index, yolk index, yolk ratio and shell weight were not significantly affected by the change in egg shape index value in our study.

Although it was stated in the study by Bernacki and Heller (2003) that the egg weight increased due to the increase in the egg shape index, in our study, it was determined that the egg weight did not increase significantly despite the increase in the shape index, and the egg weight varied between 19.99-20.09 g. Obtained egg weights were found as similar to the ones reported by Kırıkçı et al (1999), Çetin et al (1997) and Redondo (2010), less than the values reported by Alkan et al (2007), Aysöndü (2005), Çetin et al (2001), Çetin et al (2008), Günhan (2014) and greater than the value reported by Özkan (2020). It is thought that the differences between the egg weights determined in this study and the egg weights specified in the literature are due to the differences in the genotype used in the research, density, climatic conditions, nutrition system and age.

Table 4. Phenotypic Correlations Between Internal and External Quality Traits of Partridge Eggs

Traits	SI	EW	ESW	YW	AW	ET	YI	AI	HU	ESA	USEA	ER	AR	YR	Y/AR
EW	0.044														
ESW	0.048	-0.202*													
YW	-0.141	-0.161**	0.338*												
AW	0.182*	0.186*	0.158**	-0.167*											
ET	-0.062	0.060	-0.073	-0.228*	0.260*										
YI	-0.012	-0.173*	0.251*	0.867*	-0.304*	-0.240*									
AI	-0.164*	0.178*	0.051	-0.043	0.314*	0.042	-0.220*								
HU	-0.199*	-0.034	0.160**	-0.008	0.346*	-0.008	-0.210*	0.890*							
ESA	0.045	1.00*	-0.203*	-0.162**	0.187*	0.060	-0,174*	0.178*	-0.034						
USEA	0.045	1.00*	-0.203*	-0.163**	0.188*	0.059	-0.177*	0.179*	-0.033	1.00*					
ER	-0.007	-0.780*	0.768*	0.330	-0.026	-0.081	0.284*	-0.081	0.127**	-0.781*	-0.781*				
AR	0.149**	-0.366*	0.257*	-0.061	0.844*	-0.281*	-0.182	0.203*	0.348*	-0.366*	-0.366*	0.399*			
YR	-0.126**	-0.713*	0.368*	0.804*	-0.225*	-0.193*	0.720*	-0.135**	0.017	-0.714*	-0.715*	0.708*	0.182*		
Y/AR	-0.204*	-0.218*	0.075	0.701*	-0.776*	0.084	0.726*	-0.260	-0.268	-0.218*	-0.220*	0.199*	-0.612*	0.622*	
EV	0.044	1.00*	-0.242*	-0.161**	0.186	0.060	-0.173*	0.178	-0.034	1.00*	1.00*	-0.780*	-0.366*	-0.713*	-0.218*

*SI: Shape index; EW: Egg weight (g); ESW: Eggshell weight (g); YW: Yolk weight (g); AW: Albumen weight (g); ET: Eggshell thickness (mm); YI: Yolk index; AI: Albumen index; HU: Haugh unit; ESA: Eggshell surface area (cm^2); USEA: Unit surface eggshell area (cm^2); ER: Eggshell ratio (%); AR: Albumen ratio (%); YR: Yolk ratio (%); Y/AR: Yolk/albumen ratio (%); EV: Egg volume (cm^3); *:Significantly at $P < 0.01$; **:Significantly at $P < 0.05$*

Sorumlu Yazar / Corresponding Author: Sezai Alkan sezaialkan61@gmail.com

2021; 11(2): xx-xx

In this study, it was determined that the relationship between egg shape index and egg weight (r=0.044) was positive and insignificant (Table 4). The relationship between egg shape index and egg weight in many poultry species was examined and the results were found to be different from each other. Many studies have shown that there is a positive and significant relationship between egg shape index and egg weight (Alkan et al., 2013; Duman et al 2016; 2016; Fajemilehin et al., 2009; Kuzniacka et al., 2004; Kırıkçı et al., 2003; Olawumi & Ogunlade 2008; Yılmaz et al., 2011). On the other hand, in some studies, this relationship was found to be negative and insignificant (Kul & Şeker 2004; Nowaczewski et al., 2008; Tebesi et al., 2012). In addition, in a study by Bernacki and Heller (2003), it was stated that as egg shape index increases as the egg weight increases. Again, in many studies, it has been determined that there is a significant relationship between egg shape index and egg length and width (Abanikannda et al., 2007; Alkan et al., 2015; Olawumi & Ogundale 2008).

It was determined that there was a positive and insignificant (r=0.044) relationship between egg shape index and egg volume. Recently, Alkan et al. (2013, 2016) reported that there is a significant relationship between egg shape index and egg volume. However, in the study conducted by Aktan (2004), it was revealed that the relationship between egg shape and egg volume was negative and insignificant.

Again, the relationship between yolk index and egg shape index was low and insignificant (r=-0.012). This result was consistent with the results reported by Duman et al. (2016) and Alkan et al. (2013). In contrast, Sarica et al (2012) reported positive and significant relationship between shape index and yolk index, whereas this relationship was positive and insignificant in the study done by Emamgholi et al (2010).

Again, the relationship between egg shape index and Haugh unit was found to be positive and insignificant (r=-0.199). Duman et al. (2016) and Sarica et al. (2012) reported that there was a significant and positive relationship between the shape index and the Haugh unit. In contrast, like our study Alipanah et al. (2013), Alkan et al. (2013), Alkan et al. (2016), Olawumi and Ogunlade (2008), Onunkwo and Okara (2015), and Zhang et al. (2005) found that the relationship between shape index and Haugh unit was positive and insignificant.

It was determined that the relationship between egg shape index and eggshell thickness was negative and insignificant (r=-0.062). However, different results have been obtained in many studies on the subject. In some studies, the relationship between egg shape index and eggshell thickness was positive and insignificant (Alkan et al., 2016; Özçelik 2002; Zhang et al 2005) while in some studies it was negative and insignificant (Alkan et al., 2013; Tebesi et al., 2012). However, Şekeroğlu et al. (2000) stated that the relationship between egg shape index and eggshell thickness was important.

The relationship between egg shape index and eggshell surface area was also found to be insignificant (r=0.045) in our study. Recently, Alkan et al. (2013) and Duman et al (2016) found the relationship between egg shape index and eggshell surface to be significant. Altuntaş and Şekeroğlu (2008) stated in their study that the surface area of the shell decreased due to the increase in the egg shape index. It is thought that the differences between the findings in the literature may be due to the different poultry species used, rearing systems, care-feeding and environmental conditions. Again, the relationship between egg shape index and unit surface shell weight was found to be positive and insignificant (r=0.045). In a similar study, Alkan et al. (2016) stated that the relationship between egg shape index and unit surface shell weight is positive and insignificant. The relationship between shape index and crust ratio was negative and insignificant (r=-0.07). Alkan et al. (2016) stated that the relationship between egg shape index and shell ratio is positive and insignificant.

The relationship between egg shape index and albumen index was found to be negative and significant (r=-0.164). This result is different than that of Emamgholi et al. (2010), Günlü et al. (2003) and

Sorumlu Yazar / Corresponding Author: Sezai Alkan sezaialkan61@gmail.com

Onunkwo, and Okara (2015) but like the results reported by Alkan et al. (2013) Duman et al. (2016), and Sarica et al. (2012).

Finally, the relationship between egg shape index and albumen ratio was positive and significant (r=0.164), between egg shape index and yolk ratio was negative and significant (r=-0.126), and between egg shape index and yolk/albumen ratio was negative and significant (r=-0.204) in our work. As a comparison, in the study conducted by Alkan et al. (2016), the relationship between egg shape index and albumen ratio was found to be positive and insignificant, the relationship between egg shape index and yolk ratio was negative and insignificant, and the relationship between egg shape index and yolk/albumen ratio was negative and insignificant.

Conclusion

In this study, it was determined that the egg shape index of partridges (*A. Chukar*) significantly affected some of the egg quality traits (albumen ratio, albumen weight, yolk weight, yolk/albumen ratio and Haugh unit). Also, we determined that the relations between some traits were quite different from the values stated in the literature. It is thought that these differences may be due to the different species of poultry used in the research, age, rearing systems, maintenance and environmental conditions. Partridges have a potential to be easily used for meat and egg production in family businesses in rural areas, especially in alternative poultry production. Particular attention should be paid to the cultivation of partridges, especially in the settlements in and around the forest, and the necessary efforts should be accelerated to increase the economic income of the people living here from partridges. Thus, the economic income of the people living in and near the forests can be increased and the negative pressures of these people on the forests can be reduced. For this reason, due importance should be given to the studies on partridges, and it should be revealed that these animals are important sources of genes through breeding studies

Author Contributions

Sezai Alkan, performed the data collection and statistical analysis. *İsmail Türker*, prepared the experimental environment and followed the experimental process. The authors co-authored, read, and approved the article.

Ethics Statement

There are no ethical issues with the publication of this article.

Conflict of Interest

The authors state that there is no conflict of interest.

ORCID

Sezai Alkan https://orcid.org/0000-0003-0601-0122

İsmail Türker https://orcid.org/0000-0003-3125-6810

References

Abanikannda O. T. F., Olutogun O, Leigh A. O., & Ajayi L. A. (2007). Statistical modeling of egg weight and egg dimensions in commerical layers. *International Journal of Poultry Science, 6*, 59-63. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.623.2958&rep=rep1&type=pdf

Alipanah M., Deljo J., Rokouie M., & Mohammadnia R. (2013). Heritabilities and genetic and phenotypic correlations of egg quality traits in khazak layers. *Trakia Journal of Sciences 2*, 175-180. http://tru.uni-sz.bg/tsj/N2,%20Vol.11,%202013/M.Alipanah.pdf

Aktan S. (2004). Determining some exterior and interior quality traits of quail eggs and phenotypic correlations by digital image analysis. *Hayvansal Üretim, 45*(1): 7-13. https://agris.fao.org/agris-search/search.do?recordID=TR2005000043

Alkan S, Karabağ K, Balcıoğlu M S & Galiç A (2007). Kınalı kekliklerde *(Alectoris chukar)* bazı yumurta özelliklerinin ve canlı ağırlıkların belirlenmesi. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 20*(2): 225-228. http://ziraatdergi.akdeniz.edu.tr/_dinamik/144/229.pdf

Alkan S., Karabağ K., Galiç A., & Balcıoğlu B. S. (2008). Kınalı Kekliklerde (Alectoris Chukar) Disi-Erkek Oranının Kuluçka Üzerine Etkileri. *Lalahan Hayvan Arastırma Enstitüsü Dergisi, 48*(1), 45-50. https://dergipark.org.tr/en/pub/lahaed/issue/39441/465202

Alkan S., Karsli T., Galiç A., & Karabağ K. (2013). Determination of phenotypic correlations between internal and external quality traits of Guinea fowl eggs. *Kafkas Universitesi Veteriner Fakültesi Dergisi, 19*(5), 861-867. http://vetdergikafkas.org/uploads/pdf/pdf_KVFD_1412.pdf

Alkan S., & Durmuş İ. (2015). Alternatif kanatlı yetiştiriciliği: Beç tavuğu yetiştiriciliği. *Türk Tarım - Gıda Bilim ve Teknoloji Dergisi, 3*(10), 806-810. https://app.trdizin.gov.tr/publication/paper/detail/TVRnNE1qWXhNUT09

Alkan S., Karslı T., Durmuş İ., & Karabağ K. (2016). Beç tavuklarında (*Numida meleagris*) yumurta şekil indeksinin yumurta kalitesine etkileri. *Türk Tarım-Gıda Bilim ve Teknoloji Dergisi, 4*(9), 758-762. https://app.trdizin.gov.tr/makale/TWpFeE56TTJOZz09/bec-tavuklarinda-numida-meleagris-yumurta-sekil-indeksinin-yumurta-kalitesine-etkileri

Altuntaş E., & Şekeroğlu A. (2008). Effect of egg shape index on mechanical properties of chicken eggs. *Journal of Food Engineering, 85*, 606-612. https://doi.org/10.1016/j.jfoodeng.2007.08.022

Aysöndü M. H. (2005). Kaya kekliklerinde (A.chukar) farklı barındırma şeklinin yumurta verimi, kuluçka özellikleri ve yumurta kalitesi üzerine etkileri [Yayımlanmamış Doktora Tezi]. Fırat Üniversitesi.

Bernacki Z., & Heller K. (2003). Ocena jakosci jaj perlic szarych wroznych okresearch niesnosci. *Prace Komisji Nauk Rolniczych i Biologicznych, 51*, 27-32. https://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-ae3f16da-a0c6-479d-88c6-c1c699ae1280

Çağlayan T., Alaşahan S., Kırıkçı K., & Günlü A. (2009). Effect of different egg storage periods on some egg quality characteristics and hatchability of Partridge *(Alectoris graeca)*. *Poultry Science, 88*, 1330-3. https://doi.org/10.3382/ps.2009-00091

Çetin O., Kırıkçı K., & Gülşen N. (1997). Some productivity characteristics of Chukar partridges (A. chukar) in different management conditions. *Eurasian Journal of Veterinary Sciences, 13*(2), 5-10. https://dergipark.org.tr/en/download/article-file/229471

Çetin O. (2000). Farklı kesim yaşlarında kaya kekliklerinin *(A. greaca*) besi ve karkas özellikleri. *Tavukçuluk Araştırma Dergisi,* 2, 41-44.

Çetin O., Kırıkçı K., Günlü A., Tepeli C., & Yılmaz A. (2001, Mayıs, 21-24). *Kaya kekliklerinde (A. Graeca) zorlamalı tüy dökümünün yumurta ve kuluçka verim özelliklerine etkisi ve elde edilen civcivlerin büyüme, besi performansı ve karkas özellikleri*. I. Doğu Anadolu Kanatlı Yetiştiriciliği Sempozyumu (pp. 153-160), Van, Türkiye.

Çetin O, Kırıkçı K, Günlü A, Garip M & Çağlayan T (2008). Kekliklerde *(A. graeca)* yumurtlama zamanının kuluçka sonuçları ile bazı yumurta özelliklerine etkisi. *Atatürk Üniversitesi Veterinerlik Bilimleri Dergisi, 3*(1). 11–17. https://dergipark.org.tr/en/pub/ataunivbd/issue/2897/40227

Demirel Ş., & Kırıkçı K. (2009). Effect of different egg storage times on some egg quality characteristics and hatchability of pheasants *(Phasianus colchicus)*. *Poultry Science, ,88,* 440–444. https://doi.org/10.3382/ps.2008-00131

Duman M., Şekeroğlu A., Yıldırım A., Eleroğlu H., & Camcı O. (2016). Relation between egg shape index and egg quality characteristics. *European Poultry Science, 80*, 1-9. https://doi.org/10.1399/eps.2016.117

Emamgholi B. H., Zerchdaron S., Hassani S., Abbasi M. A., & Khan Ahmadi A. R. (2010). Heritability, genetic and phenotypic correlations of egg quality traits in Iranian native fowl. *British Poultry Science,* 51, 740-744. https://doi.org/10.1080/00071668.2010.528750

Fajemilehin S. O. K., Odubola O. O., Fagbuaro S. S., & Akinyemi M. O. (2009). Phenotypic correlations between some external and internal egg quality traits in the Nigerian helmeted guinea fowl, Numida meleagris galeata pallas. *Applied Tropical Agriculture, 14*, 102-108.

Garip M., Çağlayan T., Kırıkçı K., & Günlü A. (2010). A comparison of egg quality characteristics of partridge and pheasant eggs. *Journal of Animal and Veterinary Advances, 9*(2), 299-301. https://www.researchgate.net/profile/Tamer_Caglayan/publication/250303566_A_Comparison_of_Egg_Quality_Characteristics_of_Partridge_and_Pheasant_Eggs_P_colchicus_A_graeca/links/0deec5372ef6118f0e000000.pdf

Günhan A. (2014). Kaya kekliği (a. graeca) yumurtalarında farklı depolama süresinin kuluçka sonuçları ve bazı yumurta kalite özelliklerine etkisi [Yayımlanmamış Doktora Tezi]. Selçuk Üniversitesi.

Günlü A., Kırıkçı K., & Çetin O. (2001, Mayıs, 21-24). *Orman içi ve kenarı köylerin ekonomik refahının arttırılmasında alternatif kanatlı yetiştiriciliği ve bunların önemi*. I. Doğu Anadolu Kanatlı Yetiştiriciliği Sempozyumu (pp. 45-51), Van, Türkiye.

Günlü A., Kırıkçı K., Çetin O., & Garip M. (2003). Some external and internal quality characteristics of partridge (*A. graeca*) eggs. *Food, Agriculture and Environment, 1*(3-4), 197-199. https://www.researchgate.net/profile/Kemal-Kirikci/publication/265886337_Some_external_and_internal_quality_characteristics_of_partridge_A_graeca_eggs/links/542aab210cf277d58e875388/Some-external-and-internal-quality-characteristics-of-partridge-A-graeca-eggs.pdf

Kırıkçı K., Tepeli C., Çetin O., Günlü A., & Yılmaz A. (1999). Farklı barındırma ve aydınlatma sartlarında kaya kekliklerinin (a. Graeca) bazı verim özellikleri. *Veteriner Bilimleri Dergisi, 15*(1), 15-22.

Kırıkçı K., Çetin O., Günlü A., Tepeli C., & Yılmaz A. (2003). Investigating of the possibility of second production in a year from rock Partridges (*a. Graeca*) under intensive breeding. *Journal of Food Agriculture & Environment, 1*(2), 267-269. https://doi.org/10.1234/4.2003.378

Kırıkçı K., Günlü A., Çetin O., & M. Garip (2007). Effect of hen weight on egg production and some egg quality characteristics in the Partridge *(Alectoris graeca)*. *Poultry Science, 86*, 1380-1383. https://doi.org/10.1093/ps/86.7.1380

Kul S., & Şeker I. (2004). Phenotypic correlations between some external and internal egg quality traits in the Japanese Quail (*Coturnix coturnix japonica*). *International Journal of Poultry Science*, *3*(6), 400-405. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.599.5627&rep=rep1&type=pdf

Kuzniacka K. N., Bernecki Z., & Adamski M. (2004). Jakos i wylegowosc jaj perlic szarych (*Numida meleagris*) utrzymywanych eksrensywnie. *Zeszyty Naukowe Akademii Techniczno-Rolniczej w Bydgoszczy. Zootechnika, 34*, 115-123. https://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-article-c5830782-bdef-424c-8742-6e918c365af0

Narushin V. G. (2005). Egg geometry calculation using the measurements of length and breadth. *Poultry Science, 84*(3), 482-484. https://doi.org/10.1093/ps/84.3.482

Nowaczewski S., Witkiewicz K., Fratczak M., Kontecka H., Rutkowski A., Krystianiak S., & Rosinski A. (2008). Egg quality from domestic and French Guinea fowl. *Nauka Przyroda Technologie, 2*(2), 1-9. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.600.4605&rep=rep1&type=pdf

Olawumi S. O., & Ogunlade J. T. (2008). Phenotypic correlation between some external and internal egg quality traits in the exotic ISA Brown layer breeders. *Asian Journal of Poultry Science, 2*(1), 30-35. https://www.researchgate.net/profile/Simeon-Olawumi/publication/250303553_Phenotypic_Correlations_Between_Some_External_and_Internal_Egg_Quality_Traits_in_the_Exotic_Isa_Brown_Layer_Breeders/links/5f6874ba299bf1b53ee770b8/Phenotypic-Correlations-Between-Some-External-and-Internal-Egg-Quality-Traits-in-the-Exotic-Isa-Brown-Layer-Breeders.pdf

Onunkwo D. N., & Okara I. C. (2015). Phenotypic correlation between external and internal egg quality traits in three varieties of helmeted Guinea fowl from 28 to 46 weeks of age. *International Journal of Livestock Research,* 5, 60-70.

Özbey O., & Esen F. (2007). The Effects of Different Breeding Systems on Egg Productivity and Egg Quality Characteristics of Rock Partridges. *Poultry Science, 86*, 782-785. https://doi.org/10.1093/ps/86.4.782

Özçelik M. (2002). The phenotypic correlations among some external and internal quality characteristics in Japanese quail eggs. *Ankara Üniversitesi Veteriner Fakültesi Dergisi, 49*, 67-72. http://vetjournal.ankara.edu.tr/tr/pub/issue/48922/623961

Özkan Ç. Ö. (2020). Damızlık Kınalı Kekliklerde (*Alectoris chukar*) Meselen E Liquid Takviyesinin Yumurta Verimi Üzerine Etkisinin Belirlenmesi. *ADYÜTAYAM Dergisi, 8*(1), 31-37. https://dergipark.org.tr/en/pub/adyutayam/issue/61049/906444

Redondo P. G. (2010). Effect of long-term storage on the hatchability of red-legged partridge *(Alectoris rufa)* eggs. *Poultry Science, 89*, 379-383. https://doi.org/10.3382/ps.2009-00408

Sarıca M., Camcı Ö., & Selçuk E. (2003*). Bıldırcın, sülün, keklik, etçi güvercin, beç tavuğu ve devekuşu yetiştiriciliği*. Ondokuz Mayıs Üniversitesi Ziraat Fakültesi Ders Kitabı No: 4, s1-42.

Sarıca M., Önder H., & Yamak U. S. (2012). Determining the most effective variables for egg quality traits of five hen genotypes. *International Journal of Agriculture and Biology,* 14, 235-240. https://www.researchgate.net/profile/Hasan-Oender/publication/236267882_Determining_the_Most_Effective_Variables_for_Egg_Quality_Traits_of_Five_Hen_Genotypes/links/02e7e51778139b25d1000000/Determining-the-Most-Effective-Variables-for-Egg-Quality-Traits-of-Five-Hen-Genotypes.pdf

Sreenivasiah, P. (2006). Poultry production: A unique encyclopedia. 3rd Ed. Bangalore, India.

Şekeroğlu A., Kayaalp G. T., & Sarıca M. (2000). The regression and correlation analysis on egg parameters in Denizli poultry. *Journal of Agricultural Faculty Çukurova University*, *15*, 69-74.

Tebesi T., Madibela O. R., & Moreki J. C. (2012). Effect of storage time on internal and external characteristics of Guinea fowl (*Numida meleagris*) eggs. *Journal of Animal Science Advance, 2*(6), 534-542. http://moodle.buan.ac.bw/handle/123456789/318

Tekinşen K. K., Ardıç M., & Torla E. (2008). Keklik yumurtasının başlıca nitelikleri. *Türk Tarım, 184*, 64-67.

Türkoğlu M., Arda M., Yetişir R., Sarıca M., & Erensayın C. (1997). *Science of poultry*. Otakfon-Ofset.

Türkoğlu M., & Sarıca M. (2014). *Tavukçuluk Bilimi: Yetiştirme, besleme, hastalıklar*. Bey-Ofset Matbaacılık.

Yannakopoulos A. L., & Tserveni-Gousi A. S. (1986). Quality characteristics of quail eggs. *British Poultry Science, 27*, 171-176. https://doi.org/10.1080/00071668608416870

Yılmaz A., Tepeli C., & Çağlayan T. (2011). External and internal egg quality characteristics in Japanese quails of different plumage color lines. *Journal of Food, Agriculture and Environment, 9*(2), 375-379. https://www.researchgate.net/profile/Alper-Yilmaz-7/publication/287844927_External_and_internal_egg_quality_characteristics_in_Japanese_quails_of_different_plumage_color_lines/links/589051434585157323405008/External-and-internal-egg-quality-characteristics-in-Japanese-quails-of-different-plumage-color-lines.pdf

Zhang L. C., Ning Z. H., Xu G. Y., Hou Z. C., & Yang Z. (2005). Heritabilities and genetic and phenotypic correlations of egg quality traits in Brown-Egg Dwarf Layers. *Poultry Science, 84*, 1209-1213. https://doi.org/10.1093/ps/84.8.1209