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The Effect of Eggshell Thickness on Hatching Traits of Partridges

■Author(s)

Yamak US[I]
Sarica M[I]
Boz MA[II]
Ucar A[III]

[I] Deparment of Animal Science, Agricultural Faculty, Ondokuz Mayis University, Samsun, Turkey, usyamak@omu.edu.tr, 00903623121919/1389
[II] Deparment of Animal Science, Agricultural and Natural Science Faculty, Bozok University, Yozgat, Turkey, m.akif.boz@bozok.edu.tr, 00903542161094/4483
[III] Deparment of Animal Science, Agricultural Faculty, Ankara University, Ankara, Turkey, ucara@ankara.edu.tr, 00903125961370

■Mail Address

Corresponding author e-mail address
Umut Sami Yamak
Deparment of Animal Science, Agricultural Faculty, Ondokuz Mayis University, Samsun, Turkey
Phone: 00903623121919/1389
Email: usyamak@omu.edu.tr

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ABSTRACT

Incubation is an important factor in poultry production, particularly in species with relatively low fertility and hatchability rates. This study examined the effect of eggshell thickness on hatching traits of partridges (*A. chukar*). A total of 462 eggs from intensively reared partridges were separated into three groups according to eggshell thickness, which was measured ultrasonically before incubation. Hatchability, chick weight, and chick length were assessed at the end of the incubation period. Hatching times were recorded during hatching. Embryonic mortalities in unhatched eggs were classified according to mortality stage at the end of incubation. The effect of eggshell thickness on hatchability was found to be insignificant for all groups. Moreover, eggshell thickness had no significant effect on chick weight or length.

INTRODUCTION

Partridges are most commonly maintained for hobby purposes (Juzl *et al.*, 2012). In addition, intensive breeding is performed to help maintain the natural population (Yamak, 2015). Many countries have a long history of intensive partridge rearing (Yilmaz & Tepeli, 2009). In Spain, for example, over 3 million partridges are raised and released each year (Gonzalez-Redondo, 2004). Turkey has 5 partridge breeding stations that breed and release partridges into nature. Artificial hatching is the only way to produce partridges in intensive conditions. The incubation yields in partridges have been reported to range between 40% and 85%, with most studies reporting yields of around 50% (Cetin 2002; Yilmaz & Tepeli 2009; Karabag *et al.* 2010; Yamak, 2015). Given the low incubation rates, the hatching process gains in importance.

Hatchability is affected by numerous factors. The avian eggshell must withstand the breaking forces imposed upon it during incubation, but be fragile enough to allow for successful hatching (Birchard & Deeming, 2009). Eggshell thickness is usually measured using a thickness measurer as described by Peebles & Daniel (2004), either with or without the membrane; however, this method does not sufficiently reflect the effect of shell thickness on hatchability. Hence, some researchers have assessed eggshell thickness according to egg specific gravity (Bennet, 1992; Mcdaniel *et al.,* 1981), which is closely related to shell thickness (Voisey & Hamilton, 1976).

Most of the studies examining the relationship between eggshell thickness and hatchability were focused on chicken eggs (Sergeyeva, 1986; Tsarenko, 1988; Bennet, 1992; Yamak *et al.*, 2015), and only limited studies were performed with different poultry species, including turkeys, geese, and ostriches (Koneva, 1968; Tsarenko *et al.*, 1978; Gonzalez *et al.,* 1999). Moreover, all the above-mentioned studies determined eggshell thickness indirectly.

Despite the importance attached to identifying all factors affecting hatchability in poultry species with low incubation yields, very few studies have examined the relationship between eggshell thickness and hatchability of partridge eggs. Therefore, using an ultrasound gauge to directly measure eggshell thickness, this study evaluated the relationship between partridge eggshell thickness and hatchability, hatching time, embryonic mortality, chick weight and chick length.

MATERIAL AND METHODS

This study was conducted at the Experimental Farm of the School of Agriculture of Ondokuz Mayis University. A total of 462 eggs from partridges (*A.Chukar*) was obtained from the Yozgat Partridge Breeding Station of the Turkish Ministry of Forests and Water Affairs.

Eggs were collected from the flock at 52 weeks of age. All eggs were collected on the same day and transferred to the university farm's hatchery. Eggs were numbered and weighed, and shell thicknesses were measured with an Eggshell Thickness Gauge (ORKA Tech. Ltd., Israel) that uses precision ultrasound to gauge thickness without breaking the egg and is accurate to within 0.01 mm. Three measurements were performed for each egg, and the mean of these measurements was recorded as eggshell thickness. The thinnest and thickest eggshell thickness values were also recorded. The difference between the thickest and thinnest eggshell values were determined using the formula X_{max}-X_{min}/3, and this value was added to the mean eggshell thickness value and recorded as the range of eggshell thickness for the thick-shell group and deducted from the mean eggshell thickness value and recorded as the range of eggshell thickness for the thin-shell group (Figure 1). Based on these figures, eggs were distributed into one of three groups (Thin, Medium and Thick) according to eggshell thickness (Figure 2).

Eggs were placed in an incubator (Cimuka Incubator Company, Turkey) and transferred to individual pedigree hatch baskets at 20 d of incubation to allow for chick measurement according to egg number. Hatching was controlled for periodically from Day 22, as follows:

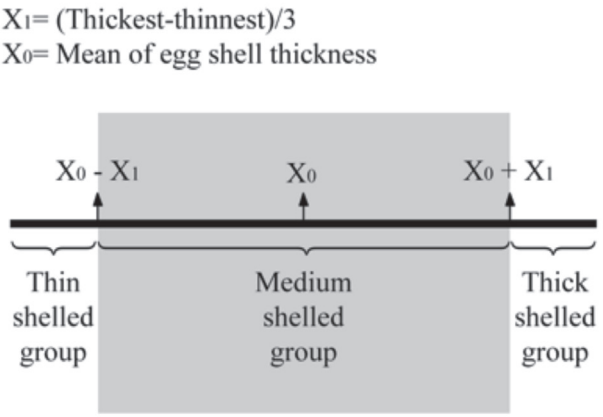

Figure 1 – Method used to determine eggshell thickness groups.

T1: End of incubation, Day 22 (17:00)
T2: Start of incubation, Day 23 (9:00)
T3: Early stage of incubation, Day 23 (11:00)
T4: Middle stage of incubation, Day 23 (13:00)
T5: Late stage of incubation, Day 23 (15:00)
T6: End of incubation, Day 23 (17:00)
T7: Start of incubation, Day 24 (9:00)
T8: End of incubation, Day 24 (17:00)
T9: Start of incubation, Day 25 (9:00)
T10: End of incubation, Day 25 (17:00)

The number of chicks hatched at each time was recorded and classified according to eggshell thickness. Hatching was completed at the end of Day 25. All unhatched eggs were broken open to determine fertility. Chick weight at hatch was measured using a

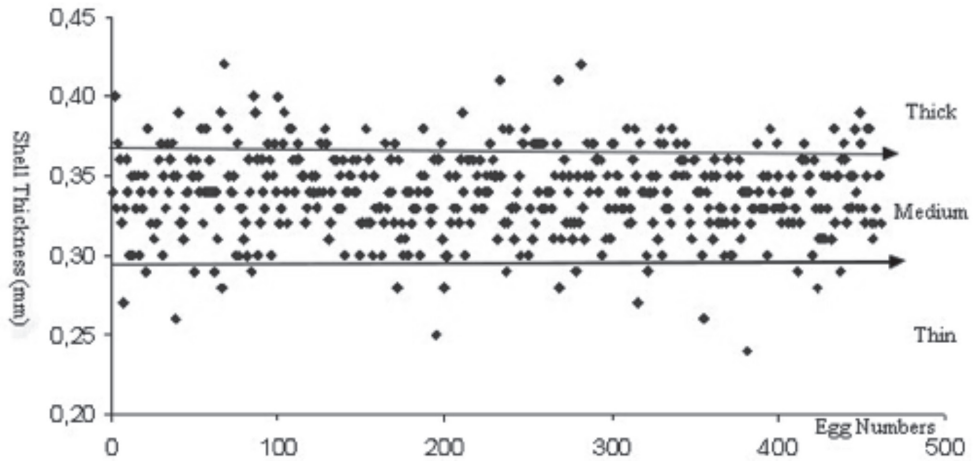

Figure 2 – Distribution of eggs according to eggshell thickness.

bascule with a sensitivity of up to 0.01 g. Chick length at hatch was determined by measuring each chick from the tip of the beak to the end of the middle toe, with the chick's dorsal surface extended over a ruler, as described by Wolanksi *et al.* (2006).

STATISTICAL ANALYSIS

An analysis of variance was carried out in order to compare means of the studied traits (eggshell thickness, egg weight, chick weight, chick length) for thin, medium, thick eggshell thickness treatment groups. The Duncan's multiple range test was applied to compare the means among treatment groups. The Chi-Square test was performed for hatching rate at various hatching times. Differences were considered significant at $p<0.05$. Kendal's tau correlation analysis was used to assess relationships between eggshell thickness and hatching traits. Pearson correlation analysis was performed to identify correlations between eggshell thickness, egg weight, chick weight and chick length. All statistical analyses were carried out using SPSS Software Version 20.0 with license of Ondokuz Mayis University.

RESULTS

The mean values of egg weight, shell thickness, chick weight, and chick length at hatch are given in Table 1. Eggshell thicknesses ranged between 0.24-0.42 mm and included thin (≤0.30 mm), medium (0.30-0.36 mm) and thick (≥0.36) -shelled eggs. Out of a total of 462 eggs, 20 eggs were classified as thin-shelled, 318 as medium-shelled and 124 as thick-shelled. Fertility rates for thin-, medium- and thick-shelled eggs were 70%, 83% and 81.45%, respectively. Hatching rates were 92.86%, 91.67% and 89.11%, respectively. Hatching times of eggs by eggshell thickness group are presented in Table 2. Hatching rates differed significantly between groups for T1-T6, but no significant differences were observed between groups for T7-T10 ($p>0.05$).

Results of Pearson's correlation analysis are given in Table 3. No significant correlation was found between eggshell thickness, egg weight, chick weight, or chick length.

DISCUSSION

The overall mean eggshell thickness in the current study was found to be 0.34 mm. This is consistent with Castilla *et al.* (2009), who reported eggshell thicknesses ranging between 0.25 mm and 0.338 mm, but higher than Garip *et al.* (2010), who found a mean eggshell thickness of 0.219 mm. Reported variations in eggshell thickness could be related either to the fact that partridges are wild rather than domesticated, or to measurement methodology. In particular, whereas most studies measured eggshell thickness at the blunted edge, the present study measured eggshell thickness midway between the blunted edge and the point on the equator at which the eggshell was pipped.

The mean egg weight in the present study was found to be 20.76 g. Partridge egg weight has been reported to range between 16 g and 25 g, with a mean weight of 21 g (Yannakopoulos 1992; Sarica *et al.* 2003). The mean egg weight in the present study falls within this range and is in agreement with Hashemipour *et al.* (2011), who found a mean egg weight of 20.99 g, but lower than Garip *et al.* (2010) and higher than Mourao

Table 1 – The mean values of hatching traits in partridges, by eggshell thickness (Mean ± SEM)

Eggshell thickness group	n	Eggshell thickness (mm)	Egg weight (g)	Chick weight (g)	Chick length (cm)	Hatching rate %
Thin	20	0.28 ± 0.003c	20.3 ± 0.34b	13.57 ± 0.37	11.22 ± 0.18	92.86
Medium	318	0.33 ± 0.001b	20.81 ± 0.09ab	14.01 ± 0.08	11.54 ± 0.03	92.27
Thick	124	0.37 ± 0.001a	21.17 ± 0.15a	13.92 ± 0.13	11.47 ± 0.06	90.84
Sig.		<0.001	0.026	0.451	0.083	

a, b, c: Differences in superscript letters within columns represent significant differences between groups ($p<0.05$). SEM: Standard Error of Means

Table 2 – Hatching rates (%) of egg shell thickness groups at various hatching times

Eggshell thickness group	Hatching rate (%)									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Thin	07.69b	38.46b	38.46b	38.46b	38.46b	38.46b	84.62	84.62	92.31	100.00
Medium	44.36a	63.89a	66.85a	77.08a	82.72a	87.70a	93.15	96.46	98.71	99.14
Thick	36.95a	71.95a	84.15a	84.15a	84.15a	85.72a	93.47	94.84	99.12	99.12
Sig.	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.790	0.669	0.845	0.997

a, b: Differences in superscript letters within columns represent significant differences between groups ($p<0.05$).

Table 3 – Coefficient of correlations between eggshell thickness, egg weight, chick weight and chick length

Egg and Chick Traits	Egg weight	Chick weight	Chick length
Shell thickness	0.258	0.078	0.012
Egg weight		0.816**	0.347
Chick weight			0.355

**p<0.05

et al. (2010). The present study also found that egg weight significantly varies with eggshell thickness (P=0.026), with the highest egg weight found in the thick-shelled group.

The mean chick weight at hatch in the current study was 13.83 g. Caglayan *et al.* (2009) and Cetin *et al.* (1997) reported similar chick weights (13.81 g and 13.74 g, respectively). Chick weight did not vary significantly among eggshell thickness groups. In other words, although thick-shelled eggs were heavier than thin- and medium-shelled eggs, the chicks hatched from thick-shelled eggs were not significantly heavier than those hatched from thin- and medium-shelled eggs. The differences in eggshell weights could account for these findings. Kirikci *et al.* (2007) showed that eggs weighing above or below the mean weight had significantly higher eggshell weights.

The mean length of partridge chicks at hatch in the current study was 11.41 cm. Chick length did not vary significantly among eggshell groups. Chick length is a common parameter used in broiler chicks because it is highly correlated with live weight at older ages (Msoffe *et al.* 2001).

Hatching rates in the present study were found to vary among eggshell thickness groups from T1-T6 ($p<0.05$; $p<0.01$), with hatching rates in this period significantly higher for the medium- and thick-shelled groups in comparison with the thin-shelled group (Table 2). This could be due to the limited number of thin-shelled eggs overall. The vast majority of the eggs in the medium- and thick-shelled groups hatched at T8, or 24.5 days (96.46% and 94.84%, respectively). Gonzalez-Redondo *et al.* (2012) also found 24.5 days to be the average incubation period for partridge eggs. Although the incubation period in our study did not vary significantly by eggshell thickness, thin-shelled eggs had a relatively longer hatching period than medium- and thick-shelled eggs, with only 84% of thin-shelled eggs hatched at 24.5 days and 92% at 25 days. New studies with more thin-shelled eggs would be needed to clarify these results.

Of the different parameters examined in the present study, the only significant correlation was found between egg weight and chick weight (Table 3, $p<0.01$). This is an expected finding for most poultry species and is in line with Caglayan *et al.* (2009), who found a correlation of 0.82 between partridge egg weight and chick weight. Msoffe *et al.* (2001) also found a correlation of 0.96 between broiler chick length at hatch and adult body weight. Many studies have investigated the correlation between chick weight and chick length; however, most of these have been conducted with broiler chickens. Wolanski *et al.* (2006), found a correlation of 0.303 between chick weight and length of broiler chickens. In this study, a correlation of 0.355 was found between chick weight and length; however, this correlation was not significant (Table 3). Correlations between eggshell thickness and chick weight and between chick length and egg weight were also not significant.

There are limited studies in the literature investigating the relationship between eggshell thickness and egg hatchability of different poultry species. Bennet (1992) found hatchability rates of thin-shelled eggs to be between 3%-9% lower than those of thick-shelled eggs in chickens, whereas Tsarenko (1988) reported a 30% difference in hatchability rates between thin- and thick-shelled eggs. Both Koneva (1968) and Tsarenko *et al.* (1978) found hatchability rates of thin-shelled eggs to be 20%-40% lower than those of thick-shelled eggs in turkey and geese, whereas Andrews (1972) found the hatchability rates of thin-shelled turkey eggs to be higher than those of thick-shelled eggs. Gonzalez *et al.* (1999) also found thin-shelled ostrich eggs to have higher hatchability rates than thick-shelled eggs. Despite the differences in the findings among studies, in all cases, a relationship was found between eggshell thickness and egg hatchability. In contrast, this study found no relationship between eggshell thickness and hatchability. Similarly, a previous study by the same authors (Yamak *et al.* 2015) found eggshell thickness to have no significant effect on hatchability. The difference in study findings can be attributed to differences in the methods used to measure eggshell thickness; namely, our studies measured eggshell thickness directly using ultrasound, whereas all of the other studies determined eggshell thickness using indirect methods.

CONCLUSION

This study measured eggshell thickness directly with an ultrasound gauge and found no significant differences in egg weights, hatching rates, hatching time, chick weights, or chick lengths as a function of eggshell thickness. The non-significant correlation

between eggshell thickness and chick weight suggests that pipping is not prevented by eggshell thickness, and that once the chick embryo has completed its development, even thick-shelled eggs may hatch successfully. It should be noted that despite the important role of the eggshell in incubation, eggshell thickness has not been sufficiently investigated. Moreover, the few studies that have addressed this topic have measured eggshell thickness indirectly using specific gravity, which, as Sarica *et al.* (2010) have demonstrated, may not yield accurate results, since the correlation between specific gravity and eggshell thickness varies with age. Thus, future studies comparing measurement methods may be warranted.

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