

Determination of Some Characteristics of Incubated Unfertilized Emu (*Dromaius novaehollandiae*) Eggs

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ABSTRACT

The study was conducted to determine the weight, shell characteristics, internal characteristics, and weight loss of unfertilized emu eggs before and after incubation. Eggs used in the study were collected from 2 female Emu raised in a private facility in Antakya district of Hatay in 2022. Egg weight was determined before incubation, and using this weight value, egg height, and egg width were determined with the formula. After incubation, the whole egg weight, content weight, and weight of the shell with uncleaned inner surface of the unfertilized eggs were determined. Pre-hatching egg weight, shell weight, shape index, and pore number were determined as 556.38 g, 59.57 g, 70.36%, and 25174.91-38767.41 number, respectively. After incubation, egg weight decreased and relative egg weight loss was 14.90%. As a result, the pre- and post-hatching characteristics of infertile Emu eggs were determined, and a contribution was made to a small number of scientific studies.

Kuluçkaya Yatırılan Döllenenmiş Emu (*Dromaius novaehollandiae*) Yumurtalarının Bazı Özelliklerinin Belirlenmesi

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ÖZ

Çalışma Emuların dölsüz yumurtalarında kuluçka öncesi ve sonrasında ağırlık, kabuk özellikleri, iç ortam özellikleri ve ağırlık kaybının belirlenmesi amacıyla yapılmıştır. Çalışmada 2022 yılında Hatay ili Antakya ilçesinde özel bir tesiste yetiştirilen 2 adet dişi Emudan toplanan yumurtalar kullanılmıştır. Kuluçka öncesi yumurta ağırlığı tartılarak belirlenmiş, bu ağırlık değeri kullanılarak yumurta boyu ve yumurta eni formül yardımıyla tespit edilmiştir. Kuluçka sonrasında civciv çıkışı olmayan dölsüz yumurtaların bütün yumurta ağırlığı, içerik ağırlığı ve iç yüzeyi temizlenmemiş kabuk ağırlığı tartılarak saptanmıştır. Kuluçka öncesi yumurta ağırlığı, kabuk ağırlığı, şekil indeksi ve por sayısı verilen sırayla 556,38 g, 59,57 g, %70,36 ve 25174,91-38767,41 adet olarak belirlenmiştir. Kuluçka sonrası yumurta ağırlığı azalmış ve bağıl yumurta ağırlık kaybı %14,90 olarak gerçekleşmiştir. Sonuç olarak, dölsüz Emu yumurtalarının kuluçka öncesi ve sonrası özellikleri belirlenmiş, az sayıdaki bilimsel çalışmaya katkı verilmiştir.

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1. Introduction

Reproduction starts at the age of 20-24 months in emu birds. Senthilkumar et al. (2014) reported that emus produced their first egg at the age of 764.1 days and that 84.87% of the eggs were laid in January-October. Regarding egg production, it was reported that emus can lay eggs from late fall/early winter to spring (Nußstein, 2009). The shell surface of emu eggs is uneven and has a dark green (emerald green) color and the shells are strong. The mean egg weight is 560 g and the shape index is 68% (Rao et al., 2008). It was stated that egg weight and morphological characteristics of emus were stabilized after the first two years of production and that the egg weight of emus did not change significantly after this age, although there was a numerical difference (Majewska et al., 2008). Usually, there are a few days between eggs and after 6-10 eggs are laid, male emus incubate. The incubation of emus lasts about 8 weeks, during which time the male emu birds are responsible for natural incubation (Davies, 1976).

There are different applications regarding the incubation period and incubation conditions of emu eggs. The incubation period of emu birds is influenced by both environmental and genetic factors. Genetic factors include hereditary embryo developmental rate, egg size, shell thickness, genetic diversity, and population differences. Embryo developmental rate is determined by the genetic material inherited from the parents. This genetic makeup affects the metabolic rate and cell division processes of the embryo, directly altering the incubation period (Dzialowski and Sotherland, 2004; Al-Obaidi and Al-Shadeedi, 2015; Koshiishi and Wada, 2024). Egg size and shell thickness are important genetic traits for oxygen uptake of the embryo and removal of waste materials. Larger eggs or thicker shells can limit gas exchange, slowing embryo development and prolonging incubation. In the study of Adewumi et al. (2008), it was reported that the chicks broke into the air cell on the 47th day of incubation, cracked the eggshell on the 49th day, and completed hatching on the 50th day. Senthilkumar et al. (2012) tested 36.39 °C, 36.67 °C, and 36.94 °C incubation temperatures for emu eggs, and the best hatching result was achieved at 36.39 °C. It was also stated that the increase in temperature increased the embryo mortality rate. The incubation temperature for the best hatching efficiency in emu eggs was reported as 36.39 °C and 24%-35% relative humidity (Minnar and Minnar, 1998), 36.39-36.67 °C and %40 (Stewart, 1992), 36.67 °C (Kinder, 1993) and 35.83-36.11 °C and 25.55-26.67 °C (Rao et al., 2005). Szczerbińska et al. (1999) applied a temperature of 36.4 °C and a humidity of 35% to emu eggs until transfer (day 48), and did not change the temperature in the last stage of incubation but increased the humidity by 10%. They also manually rotated the eggs 180 degrees every 6 hours until transfer. Different incubation conditions for fertilized emu eggs, hatching efficiency was reported to be between 36% and 77% (Dańczak and Majewska, 1999; Wiercińska and Szczerbińska, 2005).

The study aimed to determine the weight, shell characteristics, internal characteristics, and weight loss of unfertilized emu eggs before and after incubation.

2. Materials and Methods

The eggs of the emu bird were obtained from a private facility in Antakya district in 2022. Each egg in the nest was collected on the day of laying and assigned an egg number on the shell. Individually labeled eggs were transferred to the Alternative Poultry Unit of Hatay Mustafa Kemal University for incubation on the day they were laid. The study was conducted on 10 infertile eggs. Egg shell surface was examined visually. Clean-shelled eggs were loaded into the incubator. The eggs were not disinfected.

2.1. Before Putting into The Incubator

Eggs delivered to the unit were visually examined. In this process, the cleanliness of the egg shell surface and cracks and fractures on the shell were detected (Figure 1). Eggs with shell defects were not incubated. Since the number of emu birds in the facility was small, each egg was placed in the incubator at different times. During incubation, the temperature and humidity of the incubator was 37.5 °C and 60%, respectively, and all emu eggs were placed horizontally on the trays (Jagatheesan et al., 2014). Eggs were rotated once a day for 52 days and transferred to an incubator without rotation for 4 days after transfer. The same procedures were applied for each egg.



Figure 1. Image of the shell surface of an Emu egg examined before incubation

2.2. Identified Characteristics

Egg weight (g): Each individually numbered egg was weighed separately on the day of laying to determine the weight of the eggs when they were put into the incubator (Figure 2). A scale sensitive to 0.01 grams was used for weighing.



Figure 2. Image of egg weight determination before incubation

Based on the egg weight detected, the following characteristics of the egg were identified using some formulas;

Table 1. Formulas used for properties

<i>Egg length</i> = $14.7 \times (\text{Egg weight})^{0.341}$	Rahn and Paganelli, 1988
<i>Egg width</i> = $11.3 \times (\text{Egg weight})^{0.327}$	Rahn and Paganelli, 1988
<i>Egg surface area</i> = $4.835 \times (\text{Egg weight})^{0.662}$	Paganelli et al., 1974
<i>Pore count_1</i> = $304 \times (\text{Egg weight})^{0.767}$	Rahn and Paganelli, 1990
<i>Pore count_2</i> = $1041 \times (\text{Egg weight})^{0.504}$	Hoyt, 1979
<i>Pore count_3</i> = $3520 \times (\text{Egg weight} \div \text{Incubation time})$	Rahn and Ar, 1980
<i>Pore density_1</i> = $(\text{Pore count}_1 \div \text{Egg surface area})$	Paganelli et al., 1974
<i>Pore density_2</i> = $(\text{Pore count}_2 \div \text{Egg surface area})$	Paganelli et al., 1974
<i>Pore density_3</i> = $(\text{Pore count}_3 \div \text{Egg surface area})$	Paganelli et al., 1974
<i>Shell weight</i> = $0.0524 \times (\text{Egg weight})^{1.113}$	Rahn and Paganelli, 1989
<i>Egg shell index</i> = $(\text{Eggshell weight} \div \text{Egg surface area}) \times 100$	Ahmed et al., 2005

After putting into the incubator: After incubation, unhatched eggs were cracked and visually examined (Figure 3).

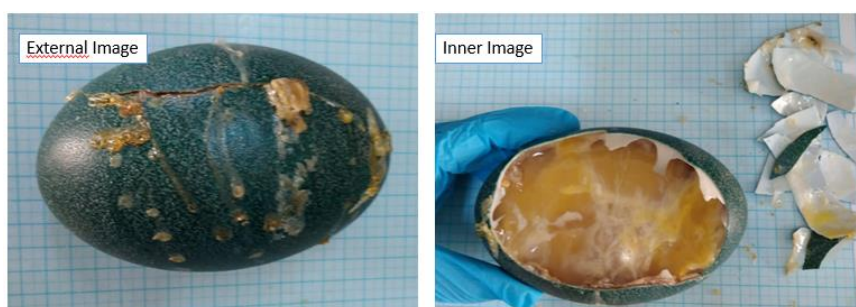


Figure 3. External and internal image of the unhatched egg after incubation

2.3. Characteristics Determined After Examination

Egg content weight and weight of the shell with uncleaned inner surface (g): The shell of the unhatched egg was removed piece by piece until the inner environment could be seen. Embryo development was checked visually (Figure 4). The cheesy content was transferred into a tared container and weighed. The shell pieces were then weighed to determine the weight of the shell with the uncleaned membranous inner surface.

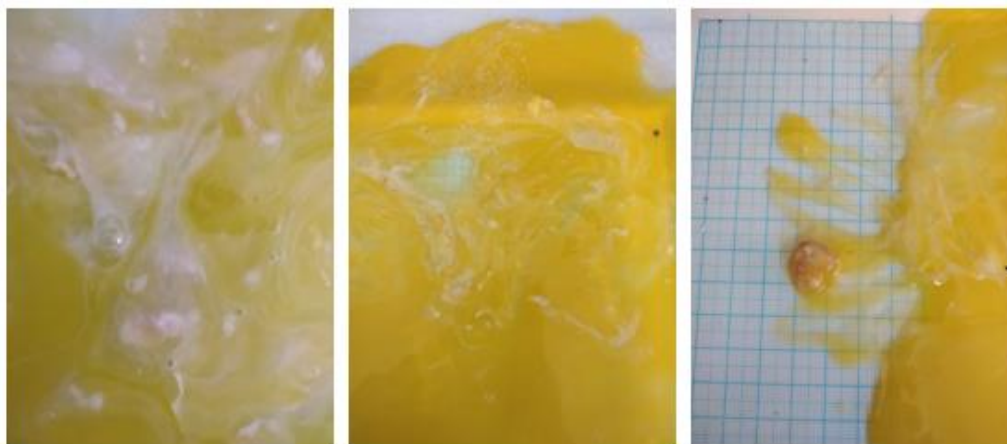


Figure 4. Internal image of the unhatched egg after incubation

Egg weight at the end of incubation (IEEW);

$IEEW (g) = (\text{Egg content weight} + \text{Weight of membranous shell with uncleaned inner surface})$

$\text{Content Ratio (\%)} = (\text{Egg content weight} + \text{Egg weight at the end of incubation}) \times 100$

Ratio of the membranous shell with uncleaned inner surface (MSW);

$MSW (\%) = (\text{Weight of membranous shell with uncleaned inner surface} / \text{Egg weight at the end of incubation}) \times 100$

The absolute and relative weight loss of the egg during incubation was determined;

$\text{Absolute weight loss (g)} = (\text{Egg weight} - \text{Egg Weight at the end of incubation})$

$\text{Relative weight loss (\%)} = \frac{(\text{Egg weight} - \text{Egg weight at the end of incubation})}{\text{Egg weight}} \times 100$

Mean shell thickness (mm): The whole egg was divided into three areas, as shown in Figure 6, and the shell thickness of 3 different areas from each of these areas was measured using calipers. The mean shell thickness was determined by taking the arithmetic mean of these measurements (Alaşahan and Günlü, 2012).

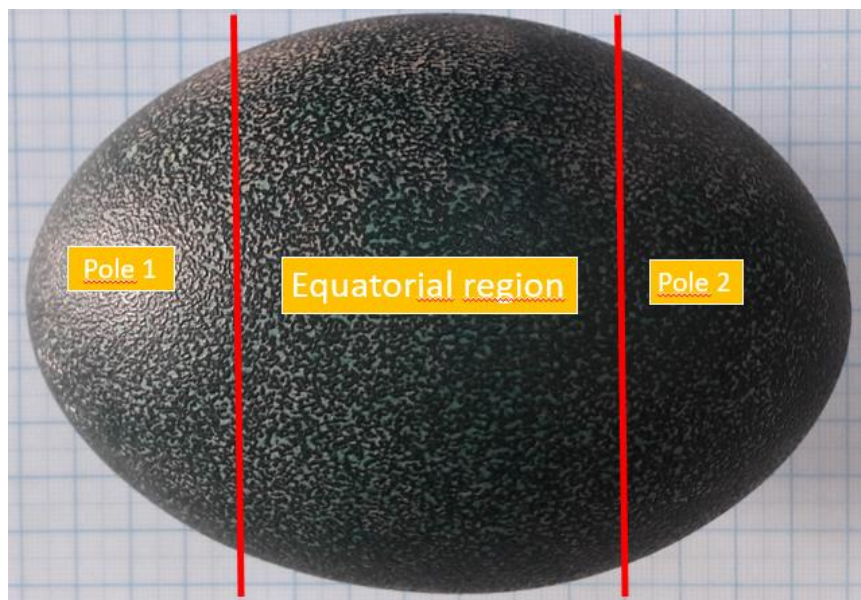


Figure 5. Areas used in the determination of egg shell thickness

2.4. Statistical Analysis

The raw data regarding the characteristics in the study were analyzed using Descriptive Statistical Analysis in the IBM SPSS Statistics 22 package program. Mean $\pm$ standard error values were presented.

3. Results and Discussion

The characteristics of the eggs determined before incubation were presented in Table 2. Egg weight, shape index, pore number, and pore density values were 556.38 g, 70.36%, 25174.91-38767.41 units, and 79.32-122.09 pores/cm², respectively. In addition, the egg surface area was 317.47 cm² and the shell weight was 59.57 g. In the study, the mean weight of emu eggs was determined as 556.38 g (Table 1). External characteristics such as egg weight, shell characteristics, and shape index are parameters that contribute significantly to the hatching of healthy chicks (Alabi et al., 2018). This egg weight value was similar to the values reported as 560 g by Rao et al. (2008) and 562.23 g by Senthilkumar et al. (2014). However, the mean egg weight obtained in current study was lower than the results obtained in other studies on emus. In some studies conducted on emus, egg weight was found to be 608.2 g by Szczerbińska et al. (1999), 663 g by Majewska et al. (2008), 637 g by Jales (2007), 590.85-633.46 g by Senthilkumar et al. (2014), and 587.93 g by Quintero et al. (2022). However, current study finding was higher than the emu egg weight value of 517.28 g (Quintero et al., 2022).

Table 2. Some characteristics of Emu eggs before incubation

Characteristics	Mean
Egg weight (g)	556.38±11.77
Egg surface area (cm ²)	317.47±4.49
Egg length (mm)	126.87±0.93
Egg width (mm)	89.26±0.63
Shape index (%)	70.36±0.02
Elongation	1.421±0.00
Shell weight (g)	59.57±1.40
Shell Ratio (%)	10.70±0.03
Egg shell index (%)	18.75±0.18
Pore number 1 (units)	38767.41
Pore number 2 (units)	25174.91
Pore number 3 (units)	34972.46
Pore Density 1 (Pore number/cm ²)	122.09
Pore Density 2 (Pore number/cm ²)	79.32
Pore Density 3 (Pore number/cm ²)	110.09

Egg shape characteristics were determined as egg length (126.87 mm), egg width (89.26 mm), shape index (70.36%), and elongation (1.421) (Table 2). Egg length and width are two important values used in the calculation of the shape index and elongation values which define the egg shape. Therefore, measurements should be performed by experienced people. Egg shape index has been reported to affect unhatched egg weight after hatching and weight loss in unhatched eggs (Alasahan and Copur, 2016). Quintero et al. (2022) reported egg length as 118.14 - 126.25 mm and egg width as 83.1 - 85.9 mm for emu aged 2 and 7 years. In current study, the elongation value, which is determined by dividing egg length by egg width, was lower than the values of 1.50 and 1.55 in fertilized and unfertilized eggs in the study of Szczerbińska et al. (1999) and 1.48 in fertilized eggs in the study of Majewska et al. (2008). The shape index value was 35.2 - 66.07% in the study of Jales (2007), 68.24% (mean) in the study of Senthilkumar et al. (2014), and 68.05 - 70.33% in the study of Quintero et al. (2022).

There are pores on the surface of the egg shell of poultry. The number of the pores determined by three different formulas using the egg weight of emu were 38767.41, 25174.91, and 34972.46 units. In addition, the pore densities were 122.09, 79.32 and 110.09 pores/cm². The egg pore number and pore density of emus were reported as 14936-11607 units and 44.4-34.3 pores/cm² by Szczerbińska et al. (1999). The difference in pore number may be due to the difference in detection method.

Egg characteristics determined after incubation are presented in Table 3. At the end of incubation, egg weight, content weight, and weight of the shell with uncleaned inner surface were determined as 471.86 g, 391.62 g, and 80.24 g, respectively. Moreover, the weight lost in the egg during incubation was

14.90%. The mean shell thickness was 1.219 mm in the whole egg and there were numerical differences among areas. Eggs lose weight during incubation. In current study, unfertilized emu egg weight was 471.86 g, absolute weight loss was 84.52 g, and relative weight loss was 14.90%. In some of emu incubation studies, Buttemer et al. (1988) found that weight loss in natural incubation was 10% in 54.5 days; Szczerbińska et al. (1999) found that weight loss was 13.37% in fertilized eggs and 10.75% in unfertilized eggs; Boopathi et al. (2012) reported as 9.48% in fertilized eggs and 11.53% in unfertilized eggs between 1-49 days; Perkas et al. (2024) found that the weight of unfertilized eggs was 481.0 g and weight loss was 17.6% in 46 days.

Table 3. Some characteristics of Emu eggs after incubation

Characteristics	Mean
Egg weight at the end of incubation (g)	471.86±12.37
Content weight (g)	391.62±9.34
Content ratio (%)	83.02±0.24
Weight of membranous shell with uncleaned inner surface (g)	80.24±3.12
Ratio of membranous shell with uncleaned inner surface (%)	16.97±0.24
Absolute weight loss (g)	84.52±18.58
Relative weight loss (%)	14.90±3.15
Pole1 shell thickness (mm)	1.252±0.01
Equatorial region shell thickness (mm)	1.221±0.01
Pole 2 shell thickness (mm)	1.183±0.00
Mean shell thickness (mm)	1.219±0.01

The shell protects the internal environment from the external environment in eggs. Eggshell characteristics such as color, thickness, and weight are important for hatching results. In this study, the weight of the shell with uncleaned inner surface in unfertilized eggs was 80.24 g, the ratio of the shell with uncleaned inner surface was 16.97%, and the mean shell thickness was 1.219 mm (1.183-1.52 mm). Majewska et al. (2008) reported a shell ratio of 13.96 (13.87-14.10%) and a membrane-free shell thickness of 1.17 mm (1.16-1.19 mm) in emu eggs, while Murugan et al. (2013) reported a shell thickness of 1.47 mm.

4. Conclusion

As a result, in the current study, some weight, thickness, and ratio characteristics of unfertilized emu eggs before and after incubation were determined by measurement or calculation. Shell pore number and pore density which were determined based on egg weight before incubation were higher than those determined in other studies. It has been determined that infertile emu eggs experience significant weight loss during incubation.

Conflict of Interest

The authors declare no conflict of interest.

Author Contribution

All authors contributed equally.

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