THE INFLUENCE OF EXTERNAL MORPHOLOGICAL TRAITS ON OSTRICH (*STRUTIO CAMELUS*) INCUBATION RESULTS DURING FIRST LAYING PERIOD

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Abstract. Reproduction results of African ostriches (*Strutio camelus*) under breeding conditions are worse than of other fowl species. Therefore, it is important to search for possibilities of their improvement, among others by evaluation of ostrich eggs incubation results' dependence on physical characteristics of the hatching eggs. The aim of the study was to determine the impact of eggs' quality traits (weight, specific gravity, shape index, and shell colour) on incubation results during the first laying period of African ostriches (*Struthio camelus*). 100 ostrich eggs were incubated in four sets. Hatching eggs weight had a significant influence on incubation results. Eggs weighing about 1500g should be assigned for incubation. There is a clear trend towards hatchability increasing with egg weight growth. Better results of incubation were registered for more spherical than for elongated eggs i.e. characterised by higher values of shape index. The embryo development in fertilized eggs resulted in considerably higher weight loss than in unfertilized eggs. The obtained results point to the necessity to pay attention to external traits of ostrich eggs intended for incubation as well as their more intensive selection on the basis of such traits as weight or shape index. Perhaps this procedure would allow improving significantly the results of hatching. Furthermore, it appears that research continuation, including larger amount of material, would allow generalizing the conclusions.
Keywords: ostrich (*Struthio camelus*), egg weight, egg fertility, hatchability, embryo mortality

Introduction. Reproduction of African ostriches (*Struthio camelus*) under breeding conditions generates a lot of problems and its results are usually worse than in other fowl species. An important element of these birds' breeding is the correct course of egg incubation and searching for possibilities of its improvement (Ley et al, 1986). For incubation monitoring the biological analysis of eggs sets is conducted. It allows to control systematically the embryo development and to determine the most important factors that affect the course and results of incubation, such as temperature (Ipek et al. 2003), eggs array (Sahan et al., 2003) and time of storage before placing the eggs into the incubator (Brand et al ., 2011).

However, not only incubation conditions affect the number of obtained full-fledged ostrich chicks. Such factors as females age, season (Brand et al., 2008), microbial contamination (Jahantigh, 2010), the ratio of males to females on the farm (Dzom and Motshegwa, 2009), birds density (Lambrechts et al., 2004) and nutrient content in diet have been pointed out (Brand et al., 2003). Also the dependence of incubation results on eggs physical traits, such as hatching eggs weight (Majewska et al., 2010), porosity and thickness of shell, shape index and eggs densities (Abbaspour-Fard, 2010) has been indicated. These indicators become important in the majority of the collected eggs are intended to hatching. In addition, their evaluation is possible without using any special instruments and deterioration of eggs' hatching quality. The knowledge of eggs hatchability dependence from their external morphological features allows highly predictive hatching results and helps to avoid losses during incubation.

The aim of the study was to determine the impact of eggs' quality traits (weight, specific gravity, shape index, shell colour) on incubation results during the first laying period of African ostriches (*Struthio camelus*).

Materials and methods. The research material consisted of hatching eggs of African ostrich *(Struthio camelus)*. The birds stock counted four females and two males. The eggs were collected during the first laying period of birds.

100 ostrich eggs were exposed to incubation in four sets, by 24, 27, 24 and 25 eggs respectively using hatching apparatus by "QUATRO". On the 39th day of incubation, the eggs were relocated to a hatchery. The eggs were individually numbered, the shape indexes (minor and major diameter ratio) were calculated and shell colour was measured using EQM apparatus (Egg Quality Measurement by TSS). Prior to incubation, the eggs were weighed to assess the initial weight as well as egg specific gravity.

The incubation was conducted according to the available literature (Deeming, 1995; Horbańczuk, 2000). In the setting compartment, the eggs were incubated at 36.0–36.5 °C and relative humidity of 25%, laying flat (horizontal position) with 90 degrees rotation every 3 hrs. In the hatchery the eggs were not rotated, the temperature amounted to 36°C and the relative humidity was 40%. The eggs were candled on the 14^{th}, 28^{th} and 39^{th} day of incubation in order to eliminate unfertilized eggs as well as the eggs with dead embryos. The eggs were weighed on the 1^{st} incubation day and then consequently every seven days (on the 7^{th}, 14^{th}, 28^{th}, and 35^{th} days) and on the 39^{th} day for weight loss estimation.

The obtained data were statistically analyzed using χ^2 test and one-factor analysis of variance with Duncan's test. Pearson's correlation coefficients were estimated between the analysed external egg's traits. Statistical package SPSS 12.0PL (2003) was used.

Results. The tables and figures present the number of eggs, depending on particular examined eggs' traits, which, with the total number of eggs n=100, is the same as percentage share. On the basis of numerical data, particular external morphological traits of ostrich eggs, distributive ranks were formed with 3 intervals in each and further analysis was carried out within them.

Table 1 contains the characteristics of eggs morphological traits in particular laying sets. The average egg weight was 1530 g with specific gravity about 1.138 g/cm^3. The shell color ranged from 46.1 to 57.2%, but it was not influenced by birds' age. However, significant change was noted in eggs shape index. This indicator for eggs in the first laying set had considerably lower values than in subsequent sets. It allows concluding that egg shape changes with the age of birds from elongated (younger birds) to more spherical (older birds).

Table 1. **Characteristics of ostrich eggs in the consecutive laying sets**

Laying set	n	Egg weight (g)		Egg density (g/cm^3)		Shell colour (%)		Shape index (%)	
		Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
1	24	1526.4	69.6	1.139	0.004	51.19	2.19	82.28^A	4.15
2	27	1549.9	100.2	1.138	0.007	52.16	1.65	84.79^B	1.63
3	24	1506.1	140.4	1.139	0.006	52.90	1.98	85.76^B	1.67
4	25	1540.0	153.3	1.137	0.009	51.15	1.95	85.08^B	2.09
Combined	100	1531.2	119.6	1.138	0.007	51.85	2.04	84.49	2.85

$^{A, B}$ - differences are significant at $p \leq 0.01$

Statistically significant dependence of incubation results on birds' age was determined ($p \leq 0.001$). The number of hatched chicks increased remarkably in consecutive sets from 7 to 19% (Fig. 1). Also, the number of unfertilized eggs and dead embryos considerably differentiated in the subsequent laying sets ($p \leq 0.001$). In the two first sets, a significant number of unfertilized eggs was noticed; 17 and 19% respectively. However the total number of unfertilized eggs of both, the 3rd and the 4th sets, only amounted to 8%. In the 3rd and 4th sets, the eggs, in which embryos died during the incubation or during piping were recorded; their number did not deteriorate hatching results significantly.

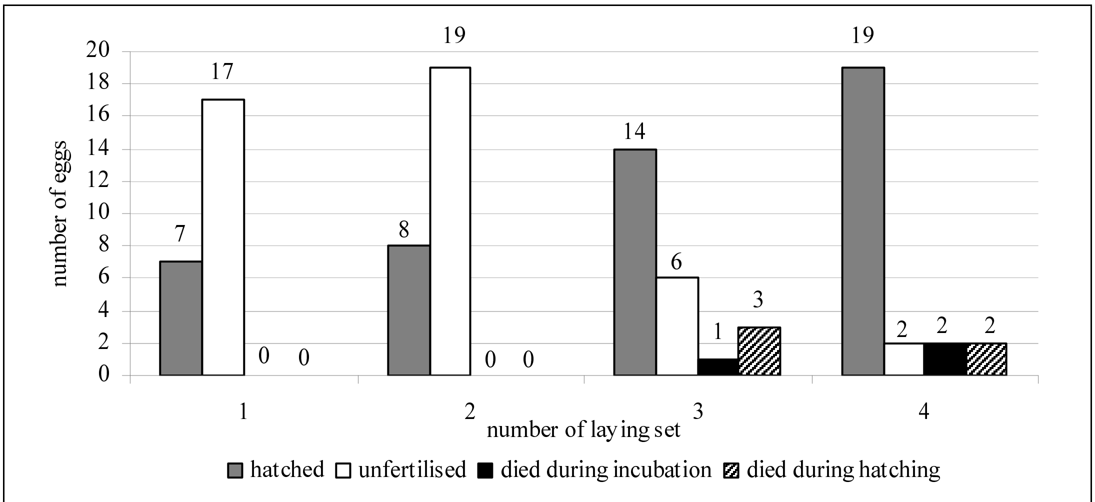

Fig. 1. **The incubation results in particular laying sets**

In Table 2, Pearson's correlation coefficients between the analyzed external ostrich egg traits are presented. A statistically significant relation between the weight of eggs and their specific gravity as well as weight loss during the incubation was established. An important connection between the shape index of eggs and their specific gravity also was proved. The correlation coefficient amounting to 0.350 between weight loss and shell colour seems to be interesting, because it suggests that eggs with lighter shell lose more water during incubation than the eggs which reflect less light.

On the basis of initial egg weight, the experimental material was divided into 3 groups i.e. eggs weighing up to 1400 g, then from 1401 to 1600 g and above 1601 g (Fig. 2). A statistically significant dependence of incubation results on the weight of initial eggs was stated ($p \leq 0.001$). The lowest fertile eggs frequency was characteristic of the biggest eggs (over 1600 g), the largest number of dead embryos was also observed in this group. The biggest number of healthy chicks hatched from the smallest eggs and from those, which were placed in the middle range of weight. However, it should be noted that 21 eggs from 1400 to 1600 g range were unfertilized.

Table 2. **Pearson's correlation coefficient between African ostrich eggs' traits**

	Initial weight	Specific gravity	Colour	Shape index
Specific gravity	-0.433**			
Colour	0.006	-0.036		
Shape index	-0.112	0.239*	-0.133	
Weight loss after 39 days of incubation	-0.279*	0.232	0.350*	0.017
*Correlation is significant at p≤0.05 (two-sided); **Correlation is significant at p≤0.01 (two-sided)				

On the basis of the same initial weight ranges, water loss during the incubation was analysed. The registered changes are presented in Fig. 3. Regardless of the initial weight, its loss in eggs at subsequent weighing was similar in all groups. The total weight loss after 39 days of incubation accounted for 10.5 to 11.5 %; the differences were not statistically confirmed.

Table 3, contains the average egg weight loss depending on the results of incubation analysis. Although not all relations were statistically confirmed, it should be noted that embryo development, also in eggs, in which embryos died during incubation or piping, caused a considerably higher water loss than in unfertilized eggs. This might be due to more intensive gas exchange between the environment and the interior of eggs, resulting from the increasing demand for oxygen in developing birds.

Another analysed feature of eggs which may affects hatching results is egg specific gravity. Its ranges, according to which eggs were divided and hatching results are shown in figure 4. It was statistically confirmed (p≤0.001) that the number of healthy chicks increases with egg density. The highest number of ostrich chicks hatched from egg with the highest value of this parameter. Since the specific gravity is an indicator of eggs freshness that shows the relation between hatching results and the time of egg storage time before sets them to the incubator.

Fig. 5 illustrates how the hatching results changed depending on the shape index of eggs. It is shown that with the rise of this parameter, the number of hatched chicks also increases and the number of eggs classified as hatching waste decreases (p≤0.001). The dependence of the number of clean (unfertilised) and dead embryos on eggs' shape index was not proved. This confirmed the earlier observations that eggs from older birds have a more spherical shape and better hatching results.

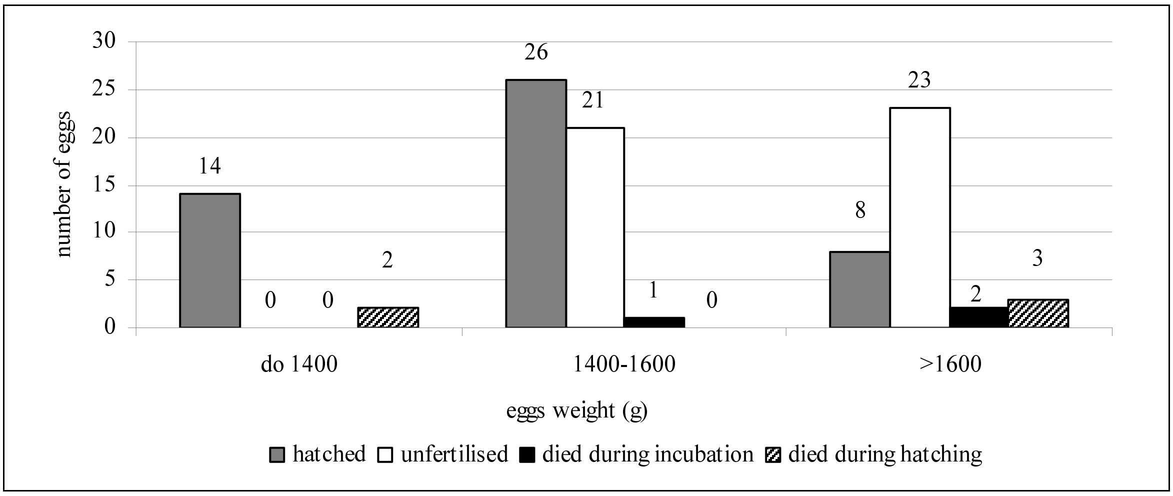

Fig. 2. **The incubation results in particular egg weight ranges**

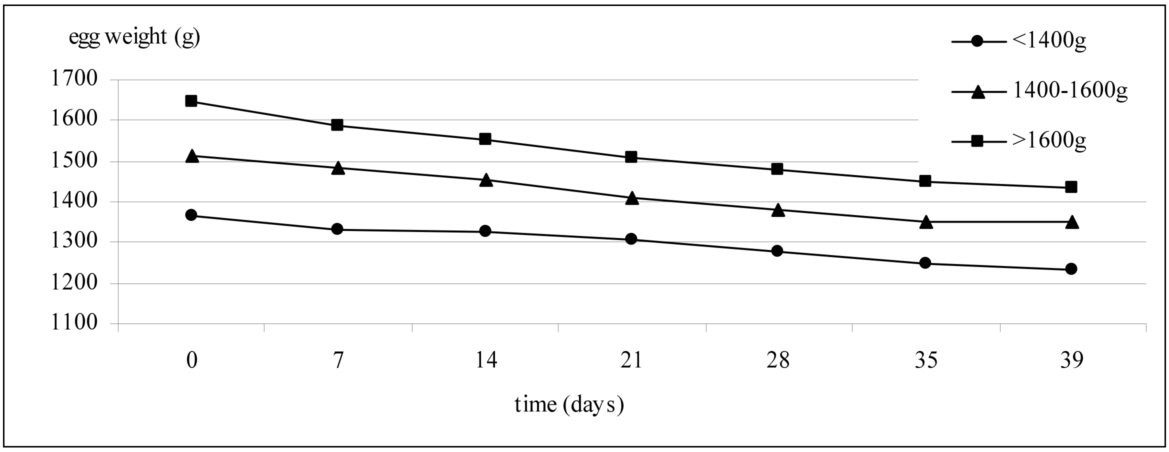

Fig. 3. **The changes in eggs' weight during the incubation**

Table 3. **Weight losses in ostrich eggs up to consecutive days of incubation**

Time (days)	Hatched		Unfertilised		Died during incubation		Died during hatching		Combined	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
7	2.07^{B}	0.48	1.78^{A}	0.13	1.86^{B}	0.04	2.24	0.52	1.94	0.39
14	4.16^{B}	0.52	3.73^{A}	0.33	3.72^{Ba}	0.10	4.48^{b}	1.00	3.97	0.52
21	6.10	0.73	5.68	0.45	5.39	0.20	6.56	1.42	6.07	0.79
28	8.04	0.98	7.65	0.82	7.11	0.37	8.65	1.82	8.02	1.06
35	10.08	1.22	9.34	0.76	8.84	0.39	10.75	2.30	10.02	1.31
39	11.09	1.38	9.85^{a}	0.69	9.80	0.19	11.88^{b}	2.68	11.02	1.52

$^{A, B}$ - differences are significant at $p \leq 0.01$; $^{a, b}$ - differences are significant at $p \leq 0.05$

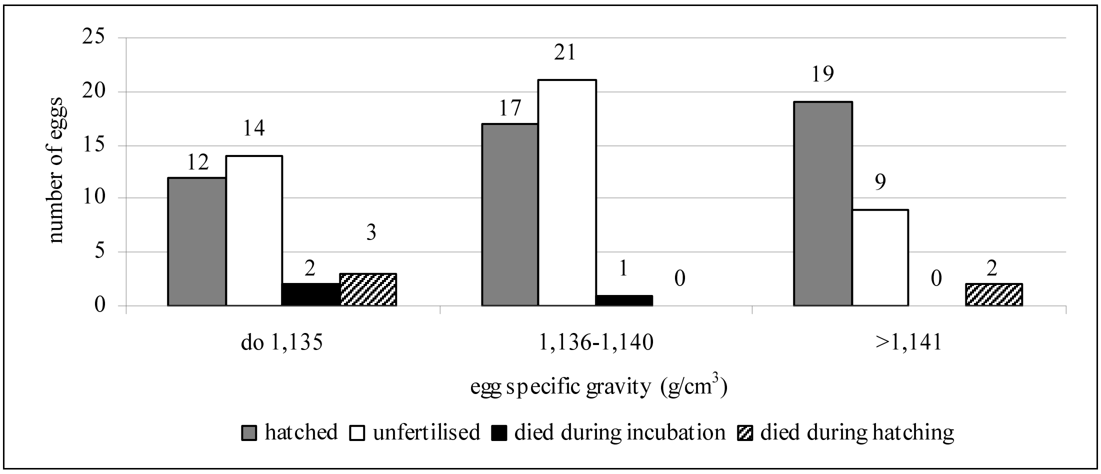

Fig. 4. **The incubation results in particular egg specific gravity ranges**

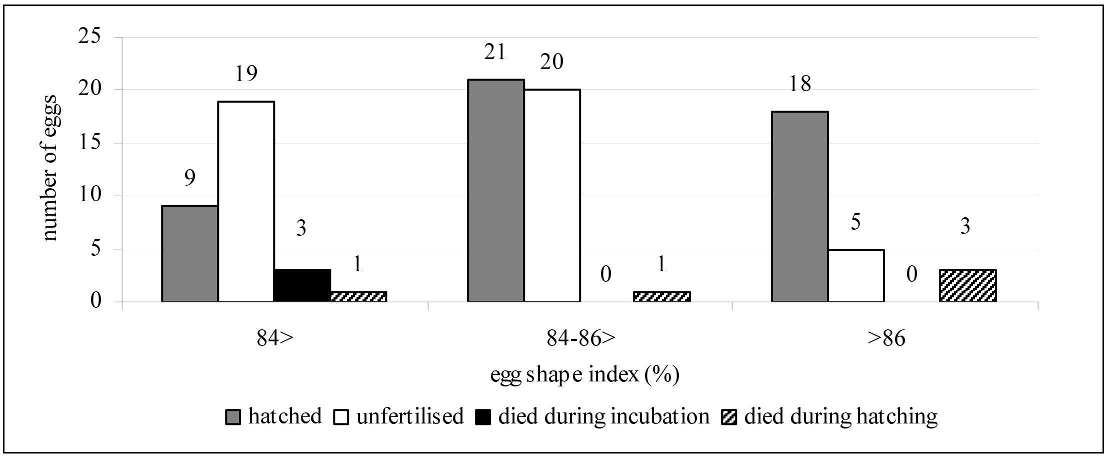

Fig. 5. **The incubation results in particular egg shape index ranges**

There was no effect of egg shell colour on hatching results. Dividing eggs by this indicator value in groups up to 50, from 51 to 53 and over 54% of the reflected light it was found that the hatching results were very similar in all evaluated ranges.

Discussion. Average values of the analysed external morphological eggs characteristics were recorded within the ranges reported by other authors (Jarvis et al., 1985 Rainer, 1995). The mean initial eggs weight was even slightly higher than presented by Brand et al. (2003), who gained the experimental material from a commercial ostrich farm. Brand et al. (2007, 2008) indicated a close relation of egg weight and chicks body mass with females' age. They stated that the number of dead embryos during the second phase of incubation, i.e. after candling on the 21st day, increases considerably with the age of females, from which eggs were obtained. In the present study it was determined that death of embryos during incubation or piping occurred in the 3rd and 4th laying sets.

Abbaspour et al. (2010) pointed to better fertilization in eggs weighing over 1500 g with the density ranging within 1.15–1.20 g/cm^3. The eggs with the average weight 1700 g showed admittedly even greater percentage of fertilization, but the proportion of fertilized to unfertilized eggs in this group was almost 1:1. In this research, as in the cited paper, the highest fertilisation percentage was characteristic of the eggs weighing over 1400 g with egg specific gravity about 1.15 g/cm^3. Hassan et al. (2005) showed that the heaviest eggs, weighing more than 1650 g, required longer incubation time, but their hatchability did not differ from the estimated one for lighter eggs. Also water loss during the incubation was considerably smaller in these eggs. The results obtained by Majewska et al. (2010) indicated that the best hatching results and the smallest number of dead embryos were obtained in the group weighing on average from 1451 to 1600 g. The eggs characterised by weight outside this range should be used for consumption. The results obtained in this research were similar.

The mean egg weight loss after 39 days of incubation was similar to the presented by Wiercińska and Szczerbińska (2005) and by almost one third lower than in the studies of Majewska et al. (2010), despite congruent incubation conditions. Also Brand et al. (2005) demonstrated higher percentage of egg weight loss during hatching; on average it amounted to 7.9 and 12.8 % after 21 and 35 days of incubation respectively. In another research, Brand et al. (2009) pointed at high phonotypical correlation coefficient (-0.48) between the initial hatching egg weight and its loss during incubation. The value of this coefficient obtained in the present study is lower but also statistically confirmed. Hassan et al. (2004) suggested a strong relation of weight loss with the temperature of eggs incubation as well as with increasing embryo mortality with temperature growth, even if the change only amounted to 0.5 °C. In the quoted paper, the incubation temperature from 36.5 to 37.5 °C was administered, what resulted in weight loss after 38 days from 12–12.5 %.

Total hatchability from the incubated eggs in this research was only slightly smaller than the presented by Essa and Cloete (2004), who for 14 ostrich families (3 birds in each) estimated it on 53 %; the egg weight also was similar. These authors suggested doing characteristics of external traits of eggs for every female as selection criteria. This would allow eliminating the females whose eggs offer smaller chances of hatching healthy chicks due to their morphological features.

Conclusions. Hatching eggs weight had a significant influence on incubation results. Eggs weighing about 1500 g should be assigned for incubation.

1. There is a clear trend towards increase of hatchability with eggs' weight growth.
2. Better results of incubation were registered for more spherical than for elongated eggs, i.e. characterised by higher values of shape index.
3. The embryo development in fertilized eggs resulted in considerably higher weight loss than in unfertilized eggs.
4. The obtained results point to the necessity to pay attention on external traits of ostrich eggs intended for incubation as well as their more intensive selection on the basis of such traits as weight or shape index. Perhaps this procedure would allow improving significantly the results of hatching. Furthermore, it appears that research continuation, including a larger amount of material, would allow generalizing the conclusions.

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