Ann. Fac. Medic. Vet. di Parma (Vol. XXII, 2002) - pag. 155 - pag. 162

ITALIAN OSTRICH (*Struthio camelus*) EGGS: PHYSICAL CHARACTERISTICS AND CHEMICAL COMPOSITION

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Introduction

Ostrich breeding started in Italy at the beginning of the ‘90s and it has rapidly evolved; as for every new activity, a lot of problems have to be faced and solved to make it a zootechnic reality.

Productive parameters like fertility and hatching percentage are unsatisfactory, especially when compared with other avicultural species. On average, 20% of eggs are unfertile and hatching ability is about 60% (Salghetti, 2000).

The avian egg is a highly complicated biological system, in which physical and chemical characteristics deeply affect incubation process, embryo’s development and hatching (Narushin and Romanov, 2002). The value of each parameter is closely connected with all the others and the relationship between variables is so complex that it is very difficult to evaluate every single weight by itself; therefore, abnormality in their interactions can affect their physiological function.

Weight, shape index, shell thickness and porosity are the parameters that most affect both gas exchange necessary to embryonic metabolism and protective action against pathogenic and traumatic agents (Hunton, 1995).

In other commonly bred avian species, optimal ranges of these parameters for a good hatching have been determined (Narushin and Romanov, 2002), while for ratites reliable data are still lacking, also because of the poor standardization of ostrich breeding.

Moreover, very little research has been carried out regarding ostrich eggs’ nutritional profile as indicator of nutritional chick status (Angel, 1994); therefore, the hypothesis that an unbalanced nutrition is the cause of bad reproductive efficiency (embryonic mortality, poor vitality of chicks) is the result of researches on other species (Wilson, 1997).

In practice, these problems increase during laying period and it could mean that a progressive consumption of nutritional reserves of laying ostriches occurs.

The aim of the current research, which is part of a wide programme directed to identify egg’s intrinsic and extrinsic elements able to affect reproductive parameters, is a physical and chemical characterization of ostrich eggs produced in Italy, related to laying period cycle.

Material and methods

During laying period (February-September) in 2001, the 1st, 20th, 40th and 60th egg of 32 laying hens Blue Neck x African Black (5 ± 1.45 old) from 2 Tuscan farms have been collected.

Couples or trios, housed in 60x15 m fenced pens, were fed 2.5 cm cutted alfalfa hay *ad libitum* and 1kg/bird/d of a pelleted ratite breeder ration (CP: 18.5% as fed; DE 2431 Kcal/kg feed). Water was supplied for *ad libitum* consumption.

Nests were routinely checked twice a day and collected eggs were kept at +4°C till they arrived at the laboratory.

Ponderal and morphological surveys - weight, length, breadth, short and long circumference have been recorded. On the basis of these measurements shape index (length/maximum breadth ratio), surface area (using the formulae of solids of revolution) and egg weight/surface area ratio have been calculated (Narushin, 1997).

Eggs have been opened at large end and yolk, albumen and shell have been collected and weighted. A homogeneous sample of each component has been sampled and frozen until chemical analysis (A.O.A.C., 1984).

On the shell portion corresponding to large end shell thickness has been measured by callipers.

Data have been processed by analysis of variance (SPSS 11.0, 1999) using the following statistical model:

$Y_{ijkl} = m + U_i + A_j + F_{jk} + b_1H_{1ijkl} + e_{ijkl}$

when:

Y_{ijkl}: single observation

m: average

U_i: fix effect of laying order (1,...,4)

A_j: fix effect of farm (1, 2)

F_{jk}: casual effect of female within farm

b_1H_{1ijkl}: regression coefficient with egg weight (H_1, g)

e_{ijkl}: residual error

Results and discussion

Physical characteristics of eggs have been reported in table 1. Average weight is 1444 g like value reported in literature (Sales *et al.*,1996) and it varies during laying period. Particularly, the first egg is lighter than the 20th ($P<0.05$) and the 40th ($P<0.01$), while the difference with the 60th is not significant ($P>0.05$).

Deeming (1995) and Gonzales *et al.* (1999) pointed out that also for ostrich there is a relationship between egg weight and hatchability: intermediate-sized eggs hatch better than small or large ones.

Several mathematical functions have been elaborated to better explain that and the most reliable among all formulae suggested in years seems to be the egg weight/surface area ratio (W/S) (Romanoff and Romanoff, 1949; Tsarenko, 1988).

According to that, with no relation with laying period, heavier the eggs are, higher is the W/S (b=0.001; $P<0.01$) and this means a less than proportional variation of surface compared with weight. These results are in good agreement with Narushin and Romanov (2002).

Eggs with W/S ratio diverging from average show high embryonic mortality because of abnormal development of the embryo in the initial phase or because of asphyxia in the final days of incubation and this seems to be due to an inadequate eggshell conductance (gas quantity that it diffuses per time unit) as reported from Gonzales *et al.* (1999).

The same authors pointed out that a high shape index characterize ostrich eggs, which tend to differ from typical ovoid shape of the most of other avian species. The average is 82.86 like shape index of Keffen and Jarvis (1984) and 4% higher than the value reported by Sales *et al.* (1996).

During laying period shape index has varied in a not linear way, increasing from the 1st to the 40th egg ($P<0.05$) and than decreasing at the 60th ($P>0.05$).

Shell thickness of large end showed a progressive reduction during laying period ($P<0.001$), from 2.02 to 1.82 mm and only the value of the 60th egg lays within the range given by Sales *et al.* (1996). Gonzales *et al.* (1999) pointed out the reverse relation between shell thickness and egg hatching and they observed that an increasing of 0,2 mm of thickness at equator can reduce hatchability by over 30%.

Proportional composition of eggs is presented in table 2; both yolk and albumen percentage are significantly related with egg weight, but with a negative relationship for yolk ($b=-0.008$; $P<0.01$) and positive for albumen ($b=0.012$; $P<0.01$).

Eggs produced in Italy show a higher proportion of shell and lower of yolk compared with Sales *et al.* (1996).

The 1st egg has more yolk and less albumen than the 20th and 40th ($P<0.05$); middle values have been reported for the 60th egg ($P>0.05$).

Results of chemical analyses on shell, albumen and yolk are reported in table 3.

Shell moisture is deeply affected by season at laying moment. The first egg, laid in late winter, is characterized by a higher value compared with eggs laid in spring or summer ($P<0.05$), which have incurred dehydration and ash concentration even if they were left in the nests for only a few hours.

Crude protein content of albumen varies during laying period, rising the highest value at the 60th egg ($P<0.05$).

That is quite interesting because one of the biological functions of albumen, and particularly of protein fraction (ovoalbumin, ovotransferrin, ovomucoid, lysozime, etc.), is embryo's protection against bacterial attack. This effect is due both to a higher albumen viscosity, which restricts bacterial movements, and to the direct action of lysozime, an enzyme that catalyzes hydrolysis of β-glycosidic bonds of polysaccharides in the cell wall (MacDonnel *et al.*, 1954).

Moreover, the yolk fat concentration has an interesting variation: lipid content shows a progressive increase from the 1st to the 60th egg ($P<0.05$).

It is common knowledge that lipids are 30% of yolk and that they are the primary nutrient source to assure embryo's vitality (Speake *et al.*, 1998). Lipids provide a range of essential components for tissue development and functionality (Noble *et al.*, 1996a) and also supply over 90% of energetic needs. The ß-oxidation of fatty acids is the predominant pathway of energy provision in this system (Freeman and Vince, 1974) and approximately 50% of the initial fatty acid content of the yolk is recovered in the tissue lipids of the chick (Noble and Cocchi, 1990; Lin *et al.*, 1991), while the remaining part is used for energy production. On the contrary, the carbohydrate content of the egg is very low and its contribution to energy production is limited to the first few days of embryo's development.

Table 1 - Physical characteristics of eggs (estimated average ± s. e.) related with laying order

		average	LAYING ORDER 1st	20th	40th	60th	b weight	SEM
Egg weight	g	1443.86	1383.01*a* ± 22.43	1460.16*b* ± 28.02	1516.80*b* ± 47.07	1415.48*ab* ± 85.89	-	126.89
W/S		2.65	2.66 ± 0.02	2.61 ± 0.02	2.65 ± 0.04	2.66 ± 0.09	0.001**	0.11
Shape index		82.86	80.51*a* ± 0.72	82.92*b* ± 0.85	85.45*b* ± 1.47	82.55*ab* ± 3.17	- 0.003	3.79
Shell thickness	mm	1.93	2.02*A* ± 0.01	1.98*B* ± 0.01	1.91*C* ± 0.02	1.82*D* ± 0.03	0.000**	0.10

a, b ≠ per P≤0.05
A, B ≠ per P≤0.001
** P≤0.01

Table 2 - Proportional composition of eggs (estimated average ± s. e.) related with laying order

		average	LAYING ORDER 1st	20th	40th	60th	b weight	SEM
Shell	%	19.86	19.81 ± 0.25	20.12 ± 0.30	19.76 ± 0.51	19.77 ± 1.09	- 0.005*	1.31
Albumen	%	55.25	53.29*A* ± 0.42	56.18*B* ± 0.49	56.08*B* ± 0.85	55.44*AB* ± 1.84	0.012**	2.20
Yolk	%	24.28	25.56*b* ± 0.40	23.19*a* ± 0.47	23.88*a* ± 0.81	24.49*ab* ± 1.75	- 0.008**	2.10

a, b ≠ per P≤0.05
A, B ≠ per P≤0.01
* P≤0.05
** P≤0.01

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Table 3 - Chemical composition of shell, albumen, yolk (estimated average ± s. e.) related with laying order

				LAYING ORDER				
			average	1st	20th	40th	60th	SEM
Shell								
	% as fed	moisture	1.06	2.47*b* ± 0.23	1.02*a* ± 0.27	0.58*a* ± 0.48	0.18*a* ± 0.02	0.22
		ash	98.07	96.75*a* ± 0.85	98.02*ab* ± 1.02	98.52*b* ± 1.76	98.97*b* ± 3.79	4.53
Albumen								
	% as fed	moisture	89.51	90.09*b* ± 0.19	90.14*b* ± 0.22	89.81*ab* ± 0.38	88.00*a* ± 0.83	0.99
		protein	9.56	8.63*a* ± 0.23	8.81*a* ± 0.27	9.21*a* ± 0.47	11.57*b* ± 1.01	0.60
		ash	0.88	1.26 ± 0.11	1.03 ± 0.14	0.80 ± 0.23	0.42 ± 0.50	0.21
Yolk								
	% as fed	moisture	51.21	51.55 ± 1.18	50.81 ± 1.40	51.04 ± 2.43	51.44 ± 5.23	6.26
		protein	15.19	16.14 ± 0.43	16.17 ± 0.50	15.27 ± 0.87	13.16 ± 1.88	0.66
		fat	31.37	29.70*a* ± 0.38	30.74*b* ± 0.45	31.06*b* ± 0.78	33.96*b* ± 1.68	2.25
		ash	2.10	2.60*b* ± 0.13	2.28*ab* ± 0.15	2.07*ab* ± 0.26	1.44*a* ± 0.55	2.01

a, b ≠ per P≤0.05

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The results do not justify a depletion of maternal organic reserves during laying as the cause of bad reproductive efficiency; however, an adequate supply of essential fatty acids is more important than the total amount of lipid supplied by the parent bird.

Noble *et al.* (1996b) carried out a comparative study on lipid composition of egg yolks from ostriches reared wholly under natural conditions and from farmed birds, which have a worse hatching percentage. There were considerable differences throughout the fatty acid concentration; particularly, linolenic acid accounts were 80% less in eggs of farmed ostriches than in eggs of wild birds. As opposed to the domesticated chicken in which much weight is placed on the role of linoleic acid in embryo's development, the authors suggest for ostrich a considerably greater emphasis on linolenic acid.

Conclusion

Physical and morphological characteristics of eggs produced in Italy do not differ substantially from other countries. Nevertheless, the variability of parameters like weight, shape index, W/S ratio and shell thickness related to laying order must be taken into due consideration in incubation programme management to improve hatching percentage.

It is hoped that non-destructive techniques for the estimation of egg quality characteristics will be identified in the near future also for ostrich. This instrument will help to solve many biological and technological problems connected to incubation and hatching.

It will also be important to go into the variations of albumen and yolk composition during laying period and it will therefore be interesting to study whether peculiar feed integrations to reproductive animals can affect egg's nutritive value in relation with embryonic development.

Key words: ostrich, eggs, physical characteristics, chemical composition
Stichworte: Strauss, Ei, Physischmerkmale, chemischer Zusammensetzung
Parole chiave: struzzo, uova, caratteristiche fisiche, composizione chimica

SUMMARY - During the laying period (February-September), the 1st, 20th, 40th and 60th egg of 32 Blue Neck x African Black ostrich females (5±1.45 years old) have been collected. Weight, shell thickness, length, breadth, short and long circumferences have been measured. Shape index and weight/surface area ratio have been calculated. Chemical analysis has been carried out on egg's constituents. These parameters are deeply affected by laying order: weight (1444±27.6 g) and shape index show little values at the beginning and at the end of laying period. High shape index (82.86±0.94) means that ostrich eggs are more spherical than eggs of other avian species. Shell thickness (1.93±0.01 mm) has a linear decrease following laying order. Albumen protein content and yolk fat content increase from the 1st to the 60th egg (respectively from 9.63 to 11.57%; $P<0.05$ and from 29.70 to 33.96%; $P<0.05$).

RIASSUNTO - Caratteristiche fisiche e composizione chimica centesimale delle uova di struzzo (*Struthio camelus*) prodotte in Italia.

Il 1°, 20°, 40° e 60° uovo di 32 femmine di struzzo Blue Neck x African Black (5±1,45 anni di età) sono stati raccolti nel corso del periodo di ovodeposizione (febbraio-settembre).

Su ciascun uovo è stato valutato lo spessore del guscio e sono stati effettuati rilievi di ordine ponderale (peso) e morfologico (lunghezza, larghezza, circonferenza all'asse maggiore e minore). Si sono ricavati l'indice di forma ed il rapporto peso/superficie. Sui costituenti dell'uovo si è proceduto ad effettuare l'analisi chimica centesimale.

Tali parametri vengono notevolmente influenzati dall'ordine di deposizione: il peso (1444±27,6 g) presenta i valori inferiori nelle fasi iniziali e finali, analogamente all'indice di forma, il cui valore elevato (82,86±0,94) indica uova tendenzialmente meno ellittiche delle altre specie avicole. Lo spessore del guscio (1,93±0,01 mm) cala linearmente al progredire dell'ordine di deposizione. La composizione chimica presenta un progressivo aumento dal 1° al 60° uovo del contenuto proteico dell'albume (da 9,63 a 11,57%; P<0,05) e del contenuto lipidico del tuorlo (da 29,70 a 33,96%; P<0,05).

ZUSAMMENFASSUNG - Italienische Eier von Straussen (*Struthio camelus*): physische Merkmale und chemische Zusammensetzung

Während der Legezeit (Februar-September) wurden das 1., 20., 40. und 60. Ei von 32 Strausshennen Blue Neck x African Black (5±1.45 Jahren alt) gesammelt. Eigewicht, Länge, Breite, Längeumfang, Breiteumfang, Schalendicke wurden gemessen. Der Formindex und das Verhältnis Gewicht/Schalenfläche wurden errechnet. Chemischer Zusammensetzung von Eiweiß, Dotter und Schalen wurden analysiert. Die Legereihenfolge beeinflusst das Eigewicht (1444±27.6 g) und das Formindex (82.86±0.94) in ähnlicher Weise: es gibt Mindestwerte am Anfang und am Ende der Legezeit. Ein hoher Formindex bedeutet, dass Strausseier weniger elliptisch als die Eier von den anderen Vogelsorten sind. Schalendicke (1.93±0.01 mm) nimmt in linearer Weise mit der Legereihenfolge ab. Mit der Progression von der Legereihenfolge nehmen die Protein- (von 9.63 bis 11.57%; P<0.05) und Fettgehalt (von 29.70 bis 33.96%; P<0.05) zu.

Bibliografia

A.O.A.C. (1984) - Official Methods of Analysis. Washington DC, Association of Official Analytical Chemists,14th Ed.

Angel R. (1994) - Diet effect on egg nutrients in a high producing ostrich. Proc. Assoc. Avian Vet., Reno, NV, 121-126.

Deeming D.C. (1995) - Factors affecting hatchability during commercial incubation of ostrich (*Struthio camelus*) eggs. Br. Poultry. Sci., 36,51-56

Freeman B.M. and Vince M.A. (1974) - The development of the avian embryo. Chapman and Hall, London,119-159.

Gonzales A., Satterlee D.G., Moharer F., Cadd G.G. (1999) - Factors affecting ostrich egg hatchability. Poultry Science, 78, 1257-1262.

Hunton P. (1995) - Understanding the architecture of the egg shell. World's Poultry Science J., 51,141-147.

Lin D.S., Connor W.E., Anderson G.J. (1991) - The incorporation of n-3 and n-6 essential fatty acids into the chick embryo from egg yolks having vastly different fatty acids compositions. Pediatric research, 29, 601-605.

Keffen R.H. and Jarvis M.J.F. (1984) - Some measurements relating to ostrich eggs. Ostrich., 55,182-187.

MacDonnell LR., Feeney B.E., Hanson H.L., Campbell A., Sugihara T.F. (1954) The functional properties of egg white proteins. Food Technology, 9, 49-53.

Narushin, V.G. (1997) - Non-destructive measurements of egg parameters and quality characteristics. World's Poultry Science Journal, 53, 141-152.

Narushin V.G. and Romanov M.N. (2002) - Egg physical characteristics and hatchability. World's Poultry Science J., 58, 297-303.

Noble R.C. and Cocchi M. (1990) - Lipid metabolism and neonatal chicken. Progress in lipid research, 29, 107-140.

Noble R.C., Speake B.H., McCartney R., Foggin C.M., Deeming D.C. (1996a) - Yolk lipids and their fatty acids in the wild and captive ostrich (*Struthio camelus*). Comp. Biochem. Physiol.,113B, 4, 753-756.

Noble R.C., Speake B.H., McCartney R., Foggin C.M., Deeming D.C. (1996b) - Lipid composition of egg yolks derived from wild and farmed environments. Proceedings Int. Conf. "Improving our understanding of ratites a farming environment". Manchester (UK), 27-29/3, 128-129.

Romanoff A.L. and Romanoff A.J. (1949) - The avian egg. New York, John Wiley & sons, Inc.

Sales J., Poggenppoel D.G., Cilliers S.C. (1996) - Comparative physical and nutritive characteristics of ostrich eggs. World's Poultry Science J., 52, 45-52.

Salghetti A. (2000) - Alcune caratteristiche strutturali ed economiche di allevamenti di struzzi. Ann.Fac. di Med. Veterinaria di Parma, 20,63-82.

Speake B.J., Noble R.C., Murray A.M.B. (1998) - The utilization of yolk lipids by the chick embryo. World's Poultry Sci. J., 54,319-334.

Tsarenko P.P. (1988) - Increasing the quality of poultry products: tables and hatching eggs. Agropromizdat, Leningrad, Russia.

Wilson H.R. (1997) - Effects of maternal Nutrition on hatchability. Poultry Sci., 76,134-143.