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RESEARCH ARTICLE

Egg physical quality and hatchability in captive African Ostrich (Struthio camelus camelus, Linnaeus 1758) reared in Benin: effect of season and relationships

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Abstract

The current study carried out on 33 ostriches of 7 years old aimed to determine egg quality and hatchability in relation with season. It appears that egg weight was of 1370 g in rainy season to 1200 g in dry season ($p<0.05$). The eggs collected during rainy season were longer (150 mm vs 148 mm) and wider (125.12 vs 123.93 mm) than those of dry season ($p<0.05$). The long circumference (42.05 vs 41.38 cm) was more important in rainy season than the value recorded in dry season. Nevertheless, the short circumference (39.4 to 38.9 cm), egg specific gravity (1.03 to 1.13 g/cm^3), egg shape index (83.5 to 83.86%) and egg yolk weights (411 to 445 g) weren't affected by season ($p>0.05$). However, the higher egg volume (1197.42 vs 1157.84 cm^3) and albumen weight (668 vs 539 g) were obtained in rainy season ($p<0.05$), while the shell thickness (2 vs 2.2 mm), the shell weight (248 vs 250 g) and shell percentage (18.4 vs 21.4%) were greater in dry season than in rainy season ($p<0.05$). The fertility rate (51 vs 57%), hatchability, ratio chick weight/egg weight (73 vs 68%) and incubation time (41 vs 42 days) were higher in dry season than in rainy season ($p<0.05$). The hatching rate was negatively and weakly associated to egg weight, egg breadth and short perimeter ($-0.5 \leq r \leq -0.42$; $p<0.05$) but positively and weakly correlated with egg length ($r=0.44$; $p<0.05$).

Egg selection based on physical quality traits can improve hatching rate in ostriches.

INTRODUCTION

Food security is today the greatest challenge of the United State Organization for Food and Agriculture (FAO) and consists in obtaining, guaranteeing and increasing the quality and the quantity of food production for the population which increase year by year. In the field of animal production, poultry breeding represents one of the ways on which the countries of sub-Saharan Africa in general and the Benin in particular, were committed to increase their production of animal proteins. In Benin, in spite of the efforts provided by the government, the meat production in general and poultry meat in particular is under the needs expressed by the consumers and this deficit is compensated by imports which increase year by year (DE, 2010; CountrySTAT, 2012). For more durability and food security in animal protein, the meat production must be directed towards non-conventional species such as grasscutter, snail and in the circumstance ostrich (Struthio camelus). Struthio camelus was registered by Linnaeus in the tenth edition of his Systema Naturæ in 1758. Belonging to Animalia Kingdom, Eumetazoa Subkingdom, Bilateria Branch, Chordata

Phylum, Vertebrata Subphylum, Gnathostomata Superclass; Aves Class; Paleognathae Superorder; Struthioniformes Order, Struthionidae Family, Struthio Genus, Struthio camelus Species, Ostrich is the biggest avian species but unapt to flight (Sahan et al., 2003).

In Benin, ostrich farming is recent. Reproductive performance parameters like fertility and hatching rate in ostrish are unsatisfactory, especially when compared with other avian species. On average, 20% of eggs are unfertile and hatching ability is about 60% (Salghetti, 2000). 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; Deeming, 1995; Elobied et al., 2010).

Several authors showed that physical egg quality traits in ostrich such as egg size length and width vary considerably, and the average values are about 18 and 15 respectively (Dimeo et al., 2003; Elobied et al., 2010). Last authors also indicated that the average perimeter length and width of the ostrich eggs were around 44.6 and 40.4 cm respectively with a shape index of 82.8. Elobied et al. (2010) found that mean of external physical egg measurements were 44.53 ± 1.13 and 40.35 ± 0.90 for mean circumference length and width, 15.43 ± 0.55 and 12.56 ± 0.38 cm for axial length and width of 139 fresh eggs of the first year lay measured while the shape index value was 81.79 ± 0.76. Deeming (1993) and Cogburn (2006) showed that the ostrich eggs are the largest of all eggs averaging 1545g -1640g with range mass of 1-2 kg. Ostrich meat is richer in protein and iron than beef (Cornette and Lebailly, 1998), but it is much less fatty (2% vs 3-15% for beef)

If ostrich reproduction aspects and egg quality traits were investigated worldwide, no study was carried out on the ostrich population reared in Benin.

The aim of the current research, which is part of a project directed to identify egg's intrinsic and extrinsic elements able to affect reproductive parameters in ostrich farmed in Benin, is to evaluate the reproductive performances and physical eggs quality traits and hatchability.

Specifically, it is to:

- Assess the egg components and external egg quality traits according to the season;
- Evaluate the fertility rate, the fecundity rate and young ostrich weight at hatching.

Materials and methods

Study area

The current study was carried out at the ostrich farm of Tatagtou at Dassari in the district of Materi in the North of Benin from the 1st of December 2012 to 31st of December 2013. Situated between North latitude of 10 ° 43' and 11 ° 20' and between East longitudes of 1 ° 03' and 1 ° 16', the district of Dassari covers an area of 589 km2 with a population of 24891 inhabitants (INSAE, 2003). This area exhibits climatic conditions of Sudanese type, characterized by unique rainy season and unique dry season. The rainy season cover the months from May to October with an average rainfall close to 1000 mm per year. The dry season generally runs from November to April. This season is characterized by continental trade winds (dry and fresh) from the Sahara from November to February on the one hand and by a period of high heat from March to April on the other. The monthly average temperatures vary between 17 and 35°C. During the rainy season, the vegetation is lush with various vegetal species and a great availability in fodders for animal feeding.

The animals and management

The study on reproduction performances, egg production, quality and hatchability in Red-necked ostrich (Struthio camelus camelus) was performed on 33 ostriches (8 males vs 25 females) of 7 years old reared in private ostrich farm in North Benin. These birds were divided into 8 fenced pens with natural pasture access at the sex ratio 3:1. All the animals were fed ad-libitum throughout the study with the same laying pelleted ratite breeder diet (Crude protein: 18.5%; Digestible Energy: 2431 Kcal/kg and 2.4% calcium) with fodder and vitamins complements. Water was also supplied for ad-libitum consumption. Shade was provided by trees and shelters.

Data collection

Internal and physical egg quality traits

Twenty fresh laid eggs (10 eggs from dry season and 10 eggs from rainy season) were randomly selected and used for evaluation of internal and physical egg characteristics. Egg weight was measured using a dial balance of 2500 g as maximum weight and 20g as accuracy.

Axial length and width were measured using digital Vernier Calipers. Long and short circumferences of the eggs were measured using a tape.

Egg components (albumen, yolk and shell) of each egg were separated and collected in a polythene sack and weighed fresh. Egg shell was cleaned and dried at 65°C during 2 hours before weighing. Shell thickness was measured in the three different regions of the egg: top (air chamber), mid (equatorial) and end (opposite) region, using digital vernier calipers to the nearest 0.01 cm.

Percentages of egg components (shell, yolk and albumen materials) as a ratio to total egg weight were determined according to the method used by Al-Obaidi et al. (2012) using the equation:

Egg components percentages (%) = (component weight (g) × 100)/ egg weight (g)

Egg volume (EV) was determined according to Hoyt, (1979) using the equation:

Egg volume (cm^3) = $0.51xLxB^2$, L: egg length, B: egg width.

Egg specific gravity (ESG) determined according to Stadelman and Cotterill (1995) and Al-Obaidi et al. (2012), using the equation:

Egg specific gravity (g/cm^3) = egg weight (g)/egg volume (cm^3).

Egg shape index was determined using a vernier caliper device according to the equation (Panda, 1995; Al-Obaidi et al., 2012; Elobeid and Mohamed, 2013):

Egg shape index = Egg breadth (short circumference) x 100 /Egg length (long circumference).

Reproduction performances parameters

During the experiment, 488 eggs were collected of which 120 were collected in rainy season and 368 in dry season. For the evaluation of reproductive parameters according to the season, 3 incubations of 39 eggs were performed in dry season and 3 other incubations of 23 eggs were carried out in rainy season. These ostrich eggs were manually collected and stored for seven days at room temperature, before transfer to the incubator. Collection date was marked on the egg surface before storage. The eggs were weighed when transferred to the incubator and were set vertically with the air chamber in top. The eggs were candled in a dark room before and at the end of the incubation period using a candling box. The second candling was done at the end of the third week of incubation to determine fertility rate. During incubation, eggs were manually turned over 180° every 6 hours (Van Schalkwyk et al., 1998). Fertile eggs were transferred to the hatchery and infertile eggs were excluded. The incubator room (with dimensions 12×6×3 meters) was made of cemented walls and straw roof. Ventilation of incubator room was by roof fans and windows for adjustment of temperature to 36.1°C. Temperature is measured daily in the morning and mid-day by an incubator built-in thermometer and the humidity is controlled by using water pans resting on the incubator floor. Eggs were incubated at 36.1°C and relative humidity 25% till hatched. The hatching chick was allowed time to dry up, and then disinfected with diluted iodine solution to suppress liable bacterial infection. Chicks were accommodated in a brooder room of dimensions 5 x 3.5 x 3m. Hatched chick weight (g) was recorded immediately after drying up and the duration of incubation was estimated by season.

Axial length and width, long and short circumferences of the eggs were measured on each egg, and egg volume, egg specific gravity and egg shape index were calculated before incubation in order to determine the correlations existing between egg physical quality traits and hatchability

Statistical analysis

Data obtained from the egg quality traits and reproduction performance during dry and rainy season in Red-necked ostrich (Struthio camelus camelus) reared in Benin were analyzed with the software SAS (Statistical Analysis System, 2006). The season effect was the unique factor of variation used in the analysis of variance. The F test was used to determine the significance of the season effect on each parameter. Means were calculated and compared two by two by the Student's t test. The *proc corr* procedure of SAS was used for calculation of correlation coefficients.

Results

Variation of external and internal Physical quality traits of eggs from Red-necked ostrich (Struthio camelus camelus) reared in Benin according to the season

The variation of external and internal physical quality traits of eggs from Red-necked ostrich (Struthio camelus camelus) reared in Benin according to the season are shown in table 1.

The average egg weight was of 1370 g in rainy season to 1200 g in dry season ($p<0.05$). The eggs collected during the rainy season were longer than those of the dry season (150 mm vs 148 mm; $p<0.05$). Similarly, the highest egg breadth was found in the rainy season (125.12 mm vs 123.93 mm; $p<0.05$). The long circumference (42.05 cm vs 41.38 cm) was more important in rainy season than the value recorded in dry season. Nevertheless, the short circumference was not affected by the season and was respectively of 39.4 cm, and 38.9 cm ($p>0.05$). Similarly, the

egg shape index didn't vary significantly according to the season with the respective values of 83.5 and 83.86 for rainy season and dry season (p>0.05). However, a higher egg volume was found in rainy season compared to the score of the dry season (1197.42 cm^3 vs 1157.84 cm^3; p<0.05). The egg specific gravity (ESG) was not affected by the season and was of 1.13 g/cm^3 in rainy season and 1.03 g/cm^3 in dry season (p>0.05).
The egg shell thickness (2 mm vs 2.2 mm), the shell weight (248 g vs 250 g) and shell percentage (18.4% vs 21.4%) were greater in dry season than in rainy season (p<0.05).
The egg yolk weights recorded in dry and rainy seasons were similar and varied from 411 g and 445 g (p>0.05); while the yolk percentage varied significantly according to the season with the highest rate found in rainy season (p<0.01). Similarly, the highest albumen weight (668 g vs 539 g) and albumen percentage (48.8% vs 44.2%) were obtained during the rainy season (p<0.05).

Effect of season on reproduction parameters in ostrich reared on natural pasture in Benin
The reproduction parameters measured herein depend on season (table 2) except chick weight at hatching. The fertility rate was higher in dry season than in rainy season (51% vs 57%; p<0.001). Similarly, the hatchability of incubated eggs was higher in egg collected and incubated in dry season than the one of rainy season (p<0.05). The chicks hatched during the rainy season were slightly heavier than those hatched in dry season (p<0.05). The ratio chick weight/egg weight was greater in dry season than in the rainy season (73% vs 68%; p<0.01). The incubation length was slightly longer in egg collected and incubated during dry season than the duration recorded in rainy season (41 days vs 42 days; p<0.05).

Relationships between egg physical characteristics and reproduction parameters in ostrich populations reared on natural pasture in Benin

The relationships between egg physical characteristics and reproduction parameters in ostrich populations reared on natural pasture in Benin are given in table 3. The egg weight was highly and positively correlated with egg length, egg width, egg volume, chick weight, long circumference, and short circumference (p<0.001; 0.85 ≤ r ≤ 0.95), but highly and negatively associated with the shell percentage and the ratio chick weight/egg weight (p<0.01; -0.98≤ r ≤ -0.68), and weakly and negatively associated with the hatching rate (r=-0.48; p<0.05).
The egg length was highly and positively correlated with egg width, egg volume, chick weight, long circumference, and short circumference (P<0.001; 0.78 ≤ r ≤ 0.93), but highly and negatively associated with the shell percentage and the ratio chick weight/egg weight (p<0.01; -0.83≤ r ≤ -0.69), and weakly and negatively associated with the hatching rate (r=044; p<0.05).
The egg width was highly and positively correlated with egg volume, chick weight, long circumference, and short circumference (P<0.001; 0.78 ≤ r ≤ 0.96), but highly and negatively associated with the shell percentage (P<0.001; r = -0.9), moderately and negatively associated to the ratio chick weight/egg weight (P<0.01; r ≤ -0.6), and weakly and negatively associated to the shell weight and the hatching rate (P<0.05; r ≤ -0.5).

The shape index was highly and negatively associated with the egg length (P<0.001; r = -0.75). The chick weight was highly and positively correlated with egg weight, egg length and breadth, the long circumference, and the short circumference (P<0.001; 0.78 ≤ r ≤ 0.95), but weakly and negatively associated to the ratio chick weight/egg weight and the hatching rate (P<0.01; -0.5≤ r ≤ -0.4). The hatching rate was negatively and weakly associated to the egg weight, the egg breadth and the short perimeter (-0.5 ≤ r ≤ -0.42; p<0.05) but positively and weakly correlated with egg length (r=0.44; p<0.05).

Table 1: Variation of external and internal Physical quality traits of eggs from Red-necked ostrich (Struthio camelus) reared in Benin according to the season

Variables	Rainy season (N=10)		Dry season (N=10)		ANOVA
	Mean	SE	Mean	SE	
Egg weight (g)	1370	55	1200	52	*
Egg length (mm)	149.94	0.66	147.78	0.62	*
Egg width (mm)	125.12	0.39	123.93	0.4	*

Shape index (%)	83.5	0.25	83.86	0.24	NS
Egg volume (cm^3)	1197.42	11.65	1157.84	11.11	*
Egg specific gravity (g/cm^3)	1.13	0.04	1.03	0.038	NS
Shell thickness (mm)	2.02	0.04	2.2	0.04	*
Shell weight (g)	248	0.43	249	0.41	*
Shell percentage (%)	18.44	1.01	21.4	0.97	*
Yolk weight (g)	445	17.5	411	16.7	NS
Yolk percentage (%)	32.8	0.38	34.33	0.37	**
Long circumference (cm)	42.05	0.12	41.38	0.24	*
Albumen weight (g)	667	40.5	539	38.6	*
Albumen percentage	48.79	1.21	44.27	1.15	*
Short circumference (cm)	39.4	0.16	38.9	0.14	NS

NS : Non significant; * **:** P<0.05 ; ** : P<0.01, **SE :** Standard Error; **ANOVA** : Analysis of variance.

Table 2: Variability of reproduction parameters in ostrich

Variables	**Rainy season**		**Dry season**		**ANOVA**
	Mean	**SE**	**Mean**	**SE**	
Fertility rate (%)	50.61	0.51	56	0.48	***
Chick weight (g)	929.63	36.8	874.93	35.09	NS
Ratio chick weight/egg weight (%)	68.47	0.98	73.13	0.94	**
Incubation duration (days)	40.98	0.4	41.88	0.38	*
Hatching rate (%)	17.44	1.48	37.8	8.63	*

NS : Non Significant; * : P<0.05 ;** : P<0.01 ; *** : P<0.001, **SE :** Standard Error; **ANOVA** : Analysis of variance
Hatching rate (%): Number of chicks x 100 / Number of egg set.

Table 3: Correlations between egg physical characteristics and reproduction parameters in ostrich populations bred in North Benin

Variables	Egg weight	Egg length	Egg width	Shape index	Shell thickness	Shell weight	Shell percent	Egg volume	Chick weight	Ratio CW/EW	Long circumference	Short circumference	Incubation duration	Hatching rate
Egg weight (EW)	1													
Egg length	0.85^{***}	1												
Egg width	0.89^{***}	0.8^{***}	1											
Shape index	-0.4^{NS}	-0.75^{***}	-0.2^{NS}	1										
Shell thickness	-0.35^{NS}	-0.37^{NS}	-0.4^{NS}	0.15^{NS}	1									
Shell weight	-0.39^{NS}	-0.43^{NS}	-0.5^{*}	0.15^{NS}	0.9^{***}	1								
Shell percentage	-0.98^{***}	-0.83^{***}	-0.9^{***}	0.4^{NS}	0.4^{NS}	0.4^{NS}	1							
Egg volume	0.91^{***}	0.93^{***}	0.96^{***}	-0.4^{NS}	-0.55**	-0.63*	-0.9^{***}	1						
Chick weight (CW)	0.95^{***}	0.78^{***}	0.8^{***}	-0.3^{NS}	-0.2^{NS}	-0.32^{NS}	-0.96^{***}	0.83^{***}	1					
Ratio CW/EW	-0.69^{***}	-0.69^{**}	-0.6^{**}	0.4^{NS}	0.5^{*}	0.4^{*}	0.65^{**}	-0.6^{**}	-0.4^{*}	1				
Long circumference	0.95^{***}	0.84^{***}	0.8^{***}	-0.5^{*}	-0.4^{NS}	-0.4^{NS}	-0.94^{***}	0.95^{***}	0.9^{***}	-0.69^{**}	1			
Short circumference	0.92^{***}	0.81^{***}	0.9^{***}	-0.3^{NS}	-0.42^{NS}	-0.5^{*}	-0.9^{***}	0.9^{***}	0.86^{***}	-0.68^{**}	0.83^{***}	1		
Incubation duration	-0.11^{NS}	0.2^{NS}	-0.1^{NS}	0.2^{NS}	0.1^{NS}	0.1^{NS}	0.1^{NS}	-0.12^{NS}	-0.1^{NS}	-0.04^{NS}	-0.2^{NS}	0.1^{NS}	1	
Hatching rate	-0.48^{*}	0.44^{*}	-0.5^{*}	0.1^{NS}	0.1^{NS}	0.2^{NS}	0.4^{NS}	-0.44^{NS}	-0.5^{*}	0.3^{NS}	-0.42^{NS}	-0.5^{*}	-0.004^{NS}	1

NS : Non significant; * : P<0.05 ; ** : P<0.01 ; *** : P<0.001.

Discussion

External and internal Physical quality traits of eggs from Red-necked ostrich (Struthio camelus) reared in Benin according to the season

With exception of shape index, egg specific gravity, yolk weight and short circumference, the others external and internal physical quality traits measured here in from Red-necked ostrich (Struthio camelus) eggs reared in Benin varied according to the season. These observations confirm those reported by Superchi et al. (2002) on ostrich Italy, Sahan et al. (2003) and Elobied et al., (2010) in eggs from red neck ostriches.

The egg weight was on average of 1370 g in rainy season to 1200 g in dry season. Comparable egg weight of ostrich was reported by Sahan et al. (2003). The eggs collected during the rainy season were longer than those of the dry season. The significant effect of the season on the egg quality traits is also reported by Superchi et al. (2002), Fair et al. (2005) and Elobied et al. (2010). The egg weights found in the current study are consistent with those reported by Mushi et al. (2007) and Superchi et al. (2002) in ostriches in Botswana. These authors (Mushi et al., 2007) found 1321g for average egg weight. The three main components of the egg (albumen, yolk and shell) make up percentages of 57.1%–59.4%, 21%–23.3% and 19.6% respectively, as shown by Dimeo et al. (2003). These proportions differ from the values recorded herein because of the fact that the yolk percentage found in our study was higher than the one reported by Dimeo et al. (2003). This variability of the egg composition in ostrich could be due the age of the birds during the experiment or the laying season. However, our finding on egg composition (albumen, yolk and shell percentages) is comparable to the reports of Al-Obaidi et al. (2012) in domestic subspecies of ostrich Struthio camelus camelus flocks reared in the zoo of Baghdad city.

In the current study, shape index or index format eggs averaged 83.5 %. This value is slightly higher than the index of 81.6 % reported by Mushi et al., (2007) in ostrich eggs from Botswana. According to Horbañczuk (2001), egg shape preconditions appropriate positioning of the embryo. In our investigation, the shape index varied from 83 to 84%. Egg shape is species-specific and in the case of ostriches, according to Horbañczuk (2001) as well as Jar-Vis et al. (1985), it lies within the 76-85.5% interval. The values obtained herein do not exceed this range.

In the current study, the long circumference was higher in rainy season than the value recorded in dry season. Nevertheless, the short circumference was not affected by the season. Furthermore, the egg shell thickness (2 mm vs 2.2 mm), the shell weight (248 g vs 250 g) and shell percentage (18.4% vs 21.4%) were greater in dry season than in rainy season. Similar variation in ostrich egg composition according to the season was also reported by Superchi et al. (2002) who found that the first eggs, laid in late winter, are characterized by a higher moisture content in shell compared with eggs laid in spring or summer. Our findings corroborate those reported by Mushi et al. (2007) who showed that ostrich egg measure on average 15.77 cm and 12.88 cm respectively for the eggs length and width measured at the egg equatorial regions. Moreover, according to Elobied et al. (2010), long circumference, length and width of red neck ostrich eggs are respectively of 44.53 ± 1.13 cm, 15.43 ± 0.55 cm 12.56 ± 0.38 cm. Average eggs shell thickness of ostrich eggs was reported by Dimeo et al. (2003) to range from 2.2 mm to 2.24 mm in equatorial regions. The current results are also in good agreement with the finding of Narushin and Romanov (2002). The significant effect of the season on the overall egg quality traits is also reported by Fair et al. (2005) and Elobied et al. (2010).

Effect of season on reproduction parameters in ostrich reared on natural pasture in Benin

The fertility rate in the current study varies between 51% and 57%. This performance is lower than the one of 79% reported by Kontecka et al. (2011) in 7 years old ostrich. However, Horbañczuk (2001) as well as Majewska et al. (2005) reported fertility rate of 71.2 in seven years old ostrich and 46.6% in five year old ostriches. The variability observed in the fertility rate could be due to the difference in the rearing system and feeding.

After incubation, the chicks hatched during the rainy season were heavier than those hatched in dry season. According to Elobied et al. (2010), the overall mean fertility value in ostrich is 54.59 ±20.09%. The fertility increase in dry season may be due to the relative increase in the day length of the breeding season.

This variation could be linked to the variation of egg weight and size according to the season. At hatching, chicks in this study weighed on average 930g. This weight is comparable to the value of 1094.11 ± 185.20 g measured in red neck ostrich chicks in Sudan by Elobied et al. (2010). The ratio chick weight/egg weight was not affected by the season and the ratio obtained herein is similar to the value of 64.58 ± 05.09 % indicated for red neck chicks of Sudan by Elobied et al. (2010). The incubation time was longer in eggs collected and incubated during dry season than the duration recorded in rainy season. This influence of the season on reproductive parameters is consistent with the results of Mushi et al. (2007) in ostriches in Botswana and Elobied et al. (2010).

Overall, the average fertility rate and hatchability rate found herein are lower than the respective values ranging from 35 to 69% and from 16 to 46% reported by Sahan et al. (2003) in ostriches from the first to the third year, and the rate of 78% found by Kontecka et al. (2011) in ostrich of 5 years old. Those fertility and hatchability rates are very low in comparison to the other avian species. This could be primarily due to the high death rate of embryos during the final phase of incubation, i.e. from day 35 of incubation (Horbañczuk 2000; Kontecka et al., 2011). Hatchability results reported by Horbañczuk (2000) and Sahan (2002) depend on many factors, including among others: the quality of hatching eggs, handling of eggs before hatching and the applied incubation technique. In the current study, the low hatchability found could be due the quality of hatching eggs. The value of this parameter reported by Majewska et al. (2005) in 5 year-old ostriches ranged from 55.5 to 84.6%, while Ipek and Sahan (2004) demonstrated increased values of hatchability together with age of ostriches amounting to 63.4%in the first period of reproduction and increasing to 73.1% in the fifth laying season.

Relationships between egg physical characteristics and reproduction parameters in ostrich populations reared on natural pasture in Benin

In the current study, significant positive and negative correlations were found between egg physical quality traits and reproductive parameters. These findings show that egg characteristics could be good indicators of hatchability in ostrich. The egg weight was highly and positively correlated with egg length, egg width, egg volume, chick weight, long circumference, and short circumference, but highly and negatively associated with the shell percentage and the ratio chick weight/egg weight, and weakly and negatively associated with the hatching rate. The hatching rate was negatively and weakly associated to the egg weight, the egg breadth and the short perimeter but positively and weakly correlated with egg length. Similar relationships were also reported in the literature (Kontecka et al., 2011). According to Narushin's and Romanov (2002), both thick shells and firm interiors, which are accepted as being higher than average, lead to an increase in egg weight, which probably results in the more successful hatchability of embryos from heavier eggs. Fertile eggs have the highest probability of hatching successfully when their physical characteristics are medial (the average values). For the egg with non-average parameters, the embryo will hatch more successfully if the shell thickness exceeds the mean value (Narushin's and Romanov, 2002). Furthermore, Harun et al. (2001) showed that eggs from Muscovy ducks reflect the basic tendency for low hatchability to be a feature of eggs with shapes that are not within the normal range. In addition, these authors established that more rounded eggs were less successful in hatching than those which were pointed. Similar conclusions have been reported for quail eggs by Nazligul et al. (2001), Kul and Seker (2004) and Sezer (2007) where a negative correlation was found between the shape index and the hatchability of fertile eggs.

The shape index in the current study was highly and negatively associated with the egg length. This indicates that egg size is limited by the length rather than width and confirms the finding of Sezer (2007).

Overall, egg selection based on physical quality traits can improve hatching rate in ostriches as a correlated response.

Conclusion

The study on reproduction performances, egg production, quality and hatchability in Red-necked ostrich (Struthio camelus) reared with natural pasture access in Benin showed that physical quality traits of eggs produced in North Benin is comparable to those reported from other countries. However, the variability of egg weight, egg length, egg width, egg volume, shell thickness, shell weight, shell percentage, yolk percentage, long circumference, albumen weight and albumen percentage according to the season of laying and the relationships between these parameters and hatching rate may be taken into account in incubation program management to improve hatchability in ostrich.
It will be interesting to investigate into the variations of albumen and yolk physico-chemical quality properties composition in relation with the laying season in order to evaluate the nutritive value of those ostrich egg.

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