ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 8 (6): 553-558, 2009
ISSN 1682-8356

Evaluation of Some Phenotypic, Physiological and Egg Quality Traits of African Black Neck Ostrich under Arid Desert Conditions of Libya

S. El-Safty[1] and Kh. M. Mahrose[2]
[1]Department of Poultry Production, Faculty of Agriculture, Ain Shams University, Cairo, Egypt
[2]Department of Poultry, Faculty of Agriculture, Zagazig University, Zagazig, Egypt

Abstract: Twenty birds of African Black Neck Ostrich (10 of both males and females) were used in the present study in a completely randomized design to verify and evaluate the differences between males and females of ostrich in some phenotypic and physiological traits, likewise the egg quality traits were estimated under the poor desert conditions of south Libya. The main results of the present study showed that males of ostrich were taller ($p \leq 0.01$) than females (240.9 vs. 218.0 cm) and had significantly ($p \leq 0.05$) lower feather length than those of females either in tail or wing feathers. Serum albumin level was higher ($p \leq 0.05$ and 0.01) in males than females, while the reverse occurred with each of globulin, calcium and magnesium. The poor desert situations of the current study had a pronounced effect on the measurements of both internal and external egg quality. Where, all values of egg quality traits were less than those found by many investigators. Correlation coefficients among the traits that have been studied were significant ($p \leq 0.05$ and 0.01) varied between negative and positive values in some cases. The highly negative correlation was observed between male height trait and serum albumen, while the converse result was realized with serum globulin trait.

Key words: Black Neck Ostrich, egg quality traits, serum albumen

INTRODUCTION

Since the mid-1980s, there has been worldwide farming of ratites, particularly with ostriches for feathers, meat, skin and oil (Glatz and Miao 2008). The farming of ostriches is well established in South Africa and is gaining in popularity in agriculture around the world (Deeming 1997). The South African ostrich industry is built mainly around the South African black ostrich (*Struthio camelus domesticus*), which was developed during the 1800s and 1900s through various crosses between the wild southern African subspecies (*S. c. australis*) and the North African subspecies (*S. c. camelus*). This hybridization was embarked on in a successful attempt to improve feather quality (Engelbrecht *et al*., 2008). The production of ostriches has been widely discussed in countries other than in their preferred and natural environment the desert (Mahrose, 2002 and 2007; Al-Nasser *et al*., 2003; Horbanczuk, 2005 and Cooper *et al*., 2007 and 2008). Ostriches have evolved in desert environments and then have developed adaptations to successfully cope with challenges therein (Cooper *et al*., 2007). Recent interest in ostrich farming has led to an increasing demand for information about this bird and how to manage it in a commercial environment (Deeming, 1999 and Minka, 2003).

It is of interest to note that the ostrich is the largest living bird around the world, measuring up to 2.75 m in height and up to 150 kg in mass. The adult male birds are mainly black with white wing primaries and tail feathers, and a grey colored neck. While, the adult female is a dull brown-grey all over with light grey to white wing primaries and tail feathers (Deeming, 1999). Recently, there are attempts to document normal blood chemistry and haematology in ostriches in relation to age, sex, husbandry conditions and laying period (Levi *et al*., 1999; Nahid *et al*., 2006 and Mahrose, 2007). The successful raising of ostriches from the egg to the breeder bird stage requires high standards of nutrition. The producer should be knowledgeable about how the ingredient will provide the essential nutrients for growth and development, the utilization capacity of each nutrient and expected performance outcomes (Cooper *et al*., 2004).

The present study was conducted to verify and evaluate the differences between males and females of ostrich in some phenotypic and physiological traits and also determine the egg quality measurements under the poor desert conditions of south Libya.

MATERIALS AND METHODS

The present study was carried out on an ostrich farm located at Ariel valley project, which located in the south desert of Libya, during month of May, 2007. Twenty birds of African Black Neck Ostrich (10 of both males and females) at 28 months in age were used in the current study in a completely randomized design. The number of all birds at the farm was 80 birds (53 males and 27 females) reared in 2 hectares on sandy floor surrounded by a wire fence to 3 m in height. Each bird was daily fed on 2.5 kg from a mixture consisted of 150 mash yellow corn and 50 kg of barley, in addition to an added quantity of green *Alfa Alfa*, which was given to the birds daily at the mid-day according to the farm procedures. Clean water was free and available all the time and was provided by a mixture of vitamins and amino acids as one time per two weeks. The average of maximum and minimum temperatures during the studying period was 35.5 and 19.8°C, respectively and the relative humidity was 25.5%.

Experimental protocol

Measurements and observations:

Phenotypic traits: Bird height, body girth, tail feathers length, wing feathers length, shank length and neck length were measured using metric tape in cm.

Physiological traits: Rectum temperature was measured using a digital thermometer. 20 blood samples (10 from each sex) were withdrawn from the brachial vein of each bird (3.0 mL of blood from each bird) using sterile disposable syringes and needles. Haematocrit and Red blood cells count (by photo-meter 4010, made in Germany) were measured from a part of the blood sample and the another part of the blood was centrifuged after coagulation at 5000 rpm for 10 min to separate serum from blood cells and frozen stored at-20°C for later examinations. Total protein, albumin, cholesterol, calcium, phosphorus and magnesium levels in serum were estimated using available commercial kits (Bio Merieux, France for total protein; Kit Chuimica Clinica, Spain for albumin; Kit Biocon, Germany for cholesterol and calcium; Kit Centeronic, Germany for phosphorus and Kit Dialab, Auetralia for magnesium) according to the procedure outlined by the manufacturer. Globulin values were obtained by subtracting the values of albumin from the corresponding values of total proteins.

Egg quality traits: A sample of 10 eggs was used to assist some of external and internal egg quality traits of the present flock under the study. All eggs used were weighed individually to the nearest gram using sensitive electronic scale. Length and width of each egg was measured with venire. The eggs were broken out to determine the height and weight of albumen and yolk. The liquid contents of the egg were put a side and shell plus membranes washed to remove adhering albumen. After drying, shells were weighed upon cooling to the nearest 0.01 g. The shell thickness with membranes was measured with a dial gauge micrometer to the nearest 0.01 mm, using the average of 3 points at the equatorial region after the shell membranes had been removed. The membranes thickness of the shell was also measured by digital micrometer. Eggs were separated carefully into yolk, albumen and shell and then the internal traits were measured. Thick albumen height (cm) was determined using three legs micrometer. Albumen weight was estimated by subtracting the egg weight from both yolk weight plus shell weight. Yolk diameter (cm) was determined using calibrator (0.1 mm accuracy). Yolk height was measured by using tripod micrometer and reading to the nearest cm. Yolk weight was weighed separately to the nearest 0.1 g for each egg. Yolk color was also measured using Roche Yolk Color Fan, it is a standardized tool which shows the range of yolk colors from one degree (very light yellow) to fifteen degree (very dark yellow).

Some of external and internal egg quality traits were calculated using formulae on the basis of the aforementioned measures as follows:

$$\text{Egg surface area (cm}^2\text{)} = 4.735W^{0.662}$$

where, W = Egg weight (Paganelli *et al.* 1974)

The following measurements of egg quality traits were calculated according to Romanoff and Romanoff (1949):

$$\text{Shape index(\%)} \frac{\text{Width(cm)}}{\text{Length(cm)}} \text{x100}$$

$$\text{Shell ratio(\%)} \frac{\text{Shell weight}}{\text{Egg weight}} \text{ x 100}$$

$$\text{Albumen ratio (\%)} \frac{\text{Albumen weight}}{\text{Egg weight}} \text{x100}$$

$$\text{Yolk index (\%)} \frac{\text{Yolk weight}}{\text{Yolk diameter}} \text{ x 100}$$

$$\text{Yolk ratio (\%)} \frac{\text{Yolk weight}}{\text{Egg weight}} \text{x100}$$

Statistical analysis: Data of the present study were statistically analyzed by ANOVA, using SAS (1998) computer program by adopting the following model:

$$Y_{ij} = \mu + S_i + e_{ij}$$

where,

Y_{ij} = An observation,

μ = The overall mean, common element to all observations,

S_i = The effect of the I sex (male and female) and

e_{ij} = The random error.

The significant differences among the averages were tested using Duncan`s multiple range test (1955). The correlation coefficients (PROC CORR) among phenotypic and physiological parameters, external and internal egg quality traits, and body measurements and some egg quality traits were estimated to analyze the different relationships among traits.

RESULTS AND DISCUSSION

Phenotypic traits: An overview of the ostrich morphology, it could be seen from the results presented in Table 1 the males of ostrich were taller ($p \leq 0.01$) than females (240.9 vs. 218.0 cm) and had significantly ($p \leq 0.05$) lower feathers length than those of females either in tail or wing feathers. On the other hand, there are no significant differences between males and females in each of body girth, shank and neck lengths. The present values are similar to those obtained by Kreibich and Sommer (1995), who reported that body height was ranged from 210-250 cm and neck length also was ranged from 90-95 cm for both sexes of black necks Ostrich. Furthermore, Deeming *et al.* (1996) pointed out that the acceptable normal range for abdominal girth in adult female ostriches would be 123.5-141.5 cm and the abdominal girth should be compared with the mean value for adult female ostriches of 132.5 cm. On the other hand, Mahmoud (1994) pointed out that the average length of the wing feathers of both male and female were 84.5 and 81 cm, respectively, while the average length of the tail feathers for both male and female was 38.6 and 44 cm, respectively.

Physiological traits: The present study provides more comprehensive picture of haematological and various analysts' data of adult males and females of ostriches held under poor husbandry conditions of the desert of Libya. Presented in Table 2 are the mean values obtained for physiological traits of males and females. It is appearing that each of albumin, globulin, calcium and magnesium significantly ($p \leq 0.05$ and 0.01) affected by sex. Where, albumin level was higher in males than females, while the reverse occurred with each of globulin, calcium and magnesium. Most likely, the increase in blood serum calcium in females may be due the production of egg and shell formation which needs more of calcium to meet the requirements of shell formation during the production season. Levels of serum total protein and albumin presented in own results were more than those (4.0 and 1.7 mg/100 mL, respectively) found by Mohri *et al.* (2008). As well as, levels of calcium in the present study were higher than those (9.15 and 8.97 gm/100 ml for males and females, respectively) reported by Aúaoúlu *et al.* (2003) and similar to those (7.7-10.1 and 5.2-15.3 gm/100 mL for males and females, respectively) documented by Okotie-Eboh *et al.* (1992). The level of phosphorus in the present study were in agreement with that (5.5 - 6.2 mg/dl) obtained by Nahid *et al.* (2006), whilst, the values of red blood cells count and magnesium level in their study were $18.16 \pm 9.2 \times 10^6$ and 2.0-2.6 mg/dL, respectively. The lower estimate of magnesium which associated with serum of males may be attributed to the relationship between magnesium levels and muscles activity, where the ostrich males were more active and movement give rise to compete and fight with other males to natural mating of the females. Nonetheless, Levi *et al.* (1989) claimed that the effect of sex on magnesium and phosphorus was only secondary and had insignificant differences between sexes.

Egg quality traits: At the beginning of the productive life of the ostriches, all values of egg quality traits (internal and external) reported in the present work and showed in Table 3 and 4 were slightly less than those found by

Table 1: Means ± SE of some phenotypic traits for African black neck breed ostrich (males and females).

Trait	Males	Females	Prob.
Bird height (cm)	$240.9^a \pm 4.7$	$218.0^b \pm 4.1$	0.01
Body girth (cm)	130.2±8.9	129.0±6.1	NS
Tail feather length (cm)	$44.2^b \pm 2.4$	$51.1^a \pm 1.8$	0.05
Wing feather length (cm)	$85.2^b \pm 2.7$	$98.9^a \pm 7.8$	0.05
Shank length (cm)	46.5±0.84	45.3±0.53	NS
Neck length (cm)	83.5±2.0	82.8±1.9	NS

$^{a\ and\ b}$ Means with different superscripts are statistically different ($p \leq 0.05$) within the same row; NS: not significant, * $p \leq 0.05$ and ** $p \leq 0.01$

Table 2: Means±SE of some physiological traits for African black neck breed ostrich (males and females)

Trait	Males	Females	Prob.
Rectal temperature, °C	38.74±0.19	38.79±0.21	NS
Hematocrit	33.68±0.66	32.76±1.0	NS
RBCs count ($X10^6$)	11.2±0.221	10.8±0.338	NS
Total protein (g/100 mL)	5.18±0.17	5.14±0.24	NS
Albumen (g/100 mL)	$3.66^a \pm 0.05$	$2.74^b \pm 0.21$	0.01
Globulin (g/100 mL)	$1.52^b \pm 0.21$	$2.40^a \pm 0.07$	0.01
Cholesterol (mg/100 mL)	43.2±9.2	45.4±4.6	NS
Calcium (mg/100 mL)	$10.8^b \pm 1.4$	$15.3^a \pm 1.1$	0.05
Phosphorus (mg/100 mL)	5.3±0.65	7.16±0.57	NS
Magnesium (mg/100 mL)	$5.74^b \pm 0.24$	$8.0^a \pm 0.63$	0.01

$^{a,and,\ b}$Means with different superscripts are statistically different within the same row, NS: Not significant, * $p \leq 0.05$ and ** $p \leq 0.01$

Table 3: Means±SE of some external egg quality traits for African black neck breed ostrich

Trait	Measure
Egg weight (g)	1105.7±9.4
Egg surface area (cm^2)	294.8±1.65
Egg length (cm)	14.4±0.22
Egg width (cm)	10.9±0.16
Shape index (%)	76.4±2.2
Shell weight (g)	222.3±4.9
Shell (%)	20.1±0.45
Shell thickness (mm)	1.8±0.06
Shell membranes thickness (mm)	0.138±0.02

Table 4: Means±SE of some internal egg quality traits for African black neck breed ostrich

Trait	Measure
Egg weight, (g)	1105.7±9.4
Yolk weight, (g)	370.7±20.5
Yolk (%)	33.5±1.9
Yolk height, (cm)	3.2±0.10
Yolk diameter, (cm)	10.9±0.78
Yolk color	10.0±0.57
Yolk index (%)	30.4±2.2
Albumen weight, (g)	514.8±19.3
Albumen (%)	46.5±1.5
Albumen height, (cm)	2.6±0.55

Table 5: Phenotypic correlation coefficients among some phenotypic and physiological parameters in African black neck breed ostrich

Trait	Sex	SL	NL	BG	TFL	WFL	BH
TP	M	-0.39	0.20	0.35	0.57	0.002	0.84
	F	0.10	-0.22	0.05	-0.72	-0.85	0.10
RT	M	-0.08	0.66	0.02	0.70	-0.31	0.78
	F	-0.78	-0.25	-0.27	0.42	0.21	0.19
Aib	M	-0.10	-0.27	-0.56	-0.77	-0.10	-0.96
	F	0.09	-0.52	0.15	-0.63	-0.64	-0.15
Glob	M	-0.29	0.22	0.41	0.63	0.02	0.89
	F	0.07	0.72	-0.26	-0.45	-0.79	0.69
Ht	M	-0.01	-0.35	0.31	0.19	0.10	0.14
	F	-0.64	0.65	-0.82	0.07	-0.47	0.92
Ca	M	-0.39	0.49	-0.26	0.22	-0.28	0.36
	F	0.18	0.23	-0.05	-0.75	-0.98**	0.39
P	M	-0.50	0.00	-0.30	-0.49	0.10	-0.26
	F	-0.07	0.71	-0.23	0.49	0.42	0.35
Chol	M	-0.10	-0.64	-0.04	-0.89	0.44	-0.81
	F	0.13	-0.03	0.23	0.55	0.83	-0.39
Mg	M	0.05	0.04	0.77	0.61	0.32	0.91
	F	0.52	0.20	0.44	0.11	0.37	-0.28
RBCs	M	-0.01	-0.35	0.31	0.19	0.10	0.14
	F	-0.82	0.65	-0.86	0.22	-0.33	0.93

*P=0.05 **P=0.01 M: Male F: Female SL: Shank length NL: Neck length BC: Body girth TFL: Tail feather length WFL: Wing feather length BH: Bird height TP: Total protein RT: Rectal temperature Alb: Albumen Glob: Globulin Ht: Hematocrit Ca: Calcium P: Phosphorus Chol: Cholesterol Mg: Magnesium RBCs: Red blood cells.

Table 6: Phenotypic correlation coefficients among some egg quality parameters in African black neck breed ostrich

Trait	EW	YW	AW	SW	Y	A	S	STH	YD	LO	SH	MTH
EW	-	0.08	0.59	0.22	-0.17	0.24	-0.26	-0.13	0.25	0.06	-0.07	0.30
YW		-	-0.76	-0.80	0.97	-0.95	-0..99*	-0.95	-0.94	-0.94	0.77	0.67
AW			-	0.99*	-0.89	0.93	-0.77	-0.92	-0.93	0.94	-0.99**	-0.02
SW				-	-0.93	0.95	0.88	0.88	0.96	0.95	-0.99*	-0.44
Y					-	-0.99*	-0.97	-0.99*	-0.99	-0.99	0.91	0.46
A						-	0.96	0.99**	0.99*	0.99*	-0.93	-0.40
S							-	0.95*	0.95	0.94	-0.79	-0.81
STH								-	0.95*	-0.52	0.64	-0.62
YD									-	-0.22	0.36	-0.57
LO										-	-0.98	0.85
SH											-	-0.91
MTH												-

*P=0.05 **P=0.01 EW: Egg weight YW: Yolk weight AW: Albumen weight SW: Shell weight Y: Yolk % A: Albumen % S: Shell % STH: Shell thickness YD: Yolk diameter Lo: Long axis of egg SH: Short axis of egg MTH: Membranes thickness.

Table 7: Phenotypic correlation coefficients between body measurements and some egg quality traits in African black neck breed ostrich.

Trait	SL	NL	BG	TFL	WFL	BH
EW	0.30	0.47	0.12	0.58	0.61	0.14
YW	-0.99*	0.96	0.99*	0.72	0.24	0.98
AW	0.74	-0.54	0.78	-0.15	0.45	-0.87
SW	0.48	-0.76	0.72	0.05	0.56	-0.94*
Y	-0.96	0.86	-0.97	0.51	-0.02	0.99*
A	0.94	-0.82	0.96	-0.45	0.14	-0.98
S	0.49	-0.97*	0.76	-0.24	0.24	-0.96
STH	0.31	-0.82	0.12	0.05	0.39	-0.81
AH	-0.98	-0.99	0.98	-0.99	-0.98	0.99
YH	0.99	-0.99	0.99	0.99	0.98	-0.98
YD	0.92	-0.72	0.23	-0.32	0.14	-0.89
Lo	-0.05	-0.17	0.88	-0.21	0.11	-0.23
SH	0.21	0.03	-0.79	0.11	-0.10	0.07
MTH	-0.47	0.31	0.45	0.24	0.25	0.26

*P=0.05 SL: Shank length NL: Neck length BC: Body girth TFL: Tail feather length WFL: Wing feather length BH: Bird height EW: Egg weight YW: Yolk weight AW: Albumen weight SW: Shell weight Y: Yolk % A: Albumen % S: Sell % STH: Shell thickness AH: Albumen height YH: Yolk height YD: Yolk diameter Lo: Long axis of egg SH: Short axis of egg MTH: Membranes thickness.

some investigators (Mahrose, 2007 and Mushi *et al.* 2007). It can worthy be noted that the ostrich egg is not in oval shaped, it is also very difficult to define visually the round end from the sharp one (Zaharchenko, 2005).

However, the values of the length and width are affected by egg weight (Di Meo *et al*., 2003). The same author added that shell weight percentage averaged 19% and the higher shell percentage caused a decrease in the percentage of albumin and yolk. They also stated that these components did not affect by laying period, unlike the chicken hen, where as laying progresses, there is a lower percentage of albumen and higher percentage of yolk. Amer (2005) reported the following values of ostrich egg characteristics for hatched and unhatched eggs, respectively; egg length was 15.12 and 15.31 cm; egg width was 12.23 and 12.25 cm, egg shell weight was 237 and 249 g and egg shell thickness was 1.835 and 1.8 mm. With respect to yolk color trait of the eggs studied, it could be seen that the yolk color was acceptable color for consumers, if ostrich's eggs were used as table eggs. According to RYC fan, the yolk color ranged from 6-12 degree is usually considered as acceptable for consumer's satisfaction (Chowdhury *et al*., 2008). Generally, it is therefore stated that both age and prevailing environmental conditions may be affected the internal and external egg quality traits.

Phenotypic correlation coefficients: Data presented in Table 5, 6 and 7 refer to the phenotypic correlation coefficients among the traits studied to give and provide the best relationships we can depend on and may take into considerations. It could be seen that there are certain significant ($p \leq 0.05$ and 0.01) relationships between some traits studied. Concerning data in Table 5, there was a significant ($p \leq 0.05$) positive correlation between each of globulin and magnesium with body height in males, while there was a significant ($p \leq 0.05$ and 0.01) negative correlation between calcium level and wing feather length. Regarding correlation relationships among external and internal egg quality traits, results cited in Table 6 indicate significant ($p \leq 0.05$ and 0.01) positive and negative correlations among most of the external and internal egg quality traits studied. There was a significant ($p \leq 0.05$) positive correlation between body girth in females and yolk weight as seen in Table 7 and this relationship may consider as an indicator to the activity of the ovary and yolk deposition and the productive efficiency which is very important because obesity is a problem which diminishes their reproductive performance (Badley, 1997 and Cooper *et al*., 2005). However, there was a significant ($p \leq 0.05$) negative correlation between shank length and yolk weight (Table 7). Moreover, there was a negative correlation between egg weight and shell thickness. This finding is consistent with the previous findings of Sahan (2003), who noted a significant ($p \leq 0.01$) negative correlation ($r = -0.401$) between egg weight and shell thickness. Meanwhile, Sahan *et al.* (2003) found insignificant negative correlation between egg weight and shell thickness. With respect to the relationship between the percentages of egg components (shell, albumen and yolk) with egg weight, both shell and yolk percents were negatively correlated with egg weight, while the positive relationship was observed with albumen %. In accordance with these results the findings of Superchi *et al.* (2002), pointed out that each of shell, albumen and yolk percentages are significantly ($p = 0.05$, 0.01 and 0.001) related with egg weight, but with a negative relationship for shell and yolk with egg weight.

Conclusion: It could be seen that the poor desert conditions of south Libya affected the measurements recorded for the ostrich raised there, amongst the management practices were near to the wild life pattern and there is not an adequate concern of ostriches. However, if there is some of improvement in the management area, of course we will get further better results.

ACKNOWLEDGEMENT

The authors wish to express thanks to Ariel Valley project administration, especially Mr. Masood and Mr. Abdalla for their assistance in data collection. We also want to thank both of students Abdelghany and Ahlam for their support on the field trial.

REFERENCES

Al-Nasser, A., H. Al-Khalaifa, K. Holleman and W. Al-Ghalaf, 2003. Ostrich production in the arid environment of Kuwait. J. Arid Environments, 54: 219-224.

Amer, N.S.I. 2005. Studies on some factors affecting ostrich production in Egypt. M. Sc. Thesis, Faculty of Agriculture, Al-Azher University, Egypt.

Aúaoúlu, Z., N. Yksek, N. Altuú and A. Kaya, 2003. Studies on some haematological and biochemical parameters in clinically healthy ostriches. Turkish J. Vet. Anim. Sci., 27: 161-163.

Badley, A.R., 1997. Fertility, hatchability and incubation of ostrich (*Struthio camelus*) Eggs. Poult. and Avian Biology Rev., 8: 53-76.

Chowdhury, S.D., B.M. Hassin, S.C. Das, M.H. Rashid, and A.J.M. Ferdaus, 2008. Evaluation of marigold flower and orange skin as source of xanthophyll pigment for the improvement of egg yolk color. Int. J. Poult. Sci., 45: 265-272.

Cooper, R.G., K. Erl-Wanger and Kh. M.A. Mahrose, 2005. Nutrition of ostrich (*Struthio camelus* var *domesticus*) breeder birds. Anim. Sci. J., 76: 5-10.

Cooper, R.G., J.O. Horbanczuk and N. Fujihara, 2004. Nutrition and feed management in the ostrich (*Struthio camelus var. domesticus*). Anim. Sci. J., 75: 175-181.

Cooper, R.G., C. Madeiros, R. Villegas, I.M. Hegab, M.A. Mohammad, N.S. Ibrahim, Kh. M.A. Mahrose and P.C. Glatz, 2007. Some regional thoughts on ostrich farming in arid zones. In: Proceedings of the XIV World Ostrich Congress, Riga, Latvia, October 19-20: 23-30.

Cooper, R.G., K.M.A. Mahrose, M. El-Shafei and I.F.M. Marai, 2008. Ostrich (*Struthio camelus*) production in Egypt. Trop. Anim. Health and Prod., 40: 349-355.

Deeming, D.C., 1997. Production, fertility and hatchability of ostrich (*Struthio camelus*) eggs on a farm in the United Kingdom. Anim. Sci., 63: 329-336.

Deeming, D.C., 1999. Introduction. In: The Ostrich: Biology, Production and Health. D.C. Deeming (Edn.), CABI publishing, Wallingford, Oxon, pp: 1-9.

Deeming, D.C., R.M. Sibly and I.L. Magole, 1996. Estimation of the weight and body condition of ostriches (*Struthio camelus*) from body measurements. Vet. Rec., 31: 210-213.

Di Meo, C., G. Stanco, M.I. Cutrignelli, S. Castaldo and A. Nizza, 2003. Physical and chemical quality of ostrich eggs during the laying season. Br. Poult. Sci., 44: 386-390.

Duncan, D.B., 1955. Multiple range and multiple F test. Biometrics, 11: 1-42.

Engelbrecht, A., S.W.P. Cloete and J.B. van Wyk, 2008. Direct heterosis for liveweight and chick mortality in ostriches. Aust. J. Exp. Agri., 48: 1320-1325.

Glatz, P.C. and Z.H. Miao, 2008. Husbandry of ratites and potential welfare issues: A Rev. Aust. J. Exp. Agri., 48: 1257-1265.

Horbanczuk, J.O., 2005. Current situation in ostrich farming and industry with special references to Middle and Eastern Europe. In: International Conference on Commercial Ostrich-Breeding Development, 30-July, 3, pp: 1-8.

Kreibich, A. and M. Sommer, 1995. Ostrich farm management. Munster-Hiltrup.

Levi, A., B. Perelman, T. Waner, M. van Grevenbroek, C. van Creveld and R. Yagil, 1989. Reference blood chemical values in ostriches (*Struthio camelus*). Am. J. Vet. Res., 50: 1548-1550.

Levi, A., B. Perelman, T. Waner, M. van Grevenbroek, C. van Creveld and R. Yagil, 1999. Haematological parameters of the ostrich (*Struthio camelus*). Avian Pathol., 18: 321-327.

Mahmoud, Fatma, T., 1994. Ostrich performance in relation to reproduction in Giza Zoo. M.V.Sc. Thesis, Faculty of Veterinary Medicine, Cairo University, Egypt.

Mahrose, K.M.A., 2002. Ostrich farming in Egypt. In: Proceedings of World Ostrich Congress, 26-29 September 2002, Warsaw, Poland, pp: 287- 289.

Mahrose, K.M.A., 2007. Some managerial studies on ostriches under Egyptian conditions. Unpublished Ph.D. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Minka, N.S., 2003. Evaluation of the performance of farmed ostrich chicks to juvenile age in Northern Nigeria. Trop. J. Anim. Sci., 6: 69- 73.

Mohri, M., R.N. Sani and R. Masoodi, 2008. Plasma biochemistry of ostrich (Struthio camelus): effects of anticoagulants and comparison with serum. Tropical Animal Health and Production, DOI 10.1007/s11250-008-9261-z.

Mushi, E. Z., J.W. Isa, M.G. Binta and M.C.G. Kgotlhane, 2007. Physical characteristics of ostrich (*Struthio camelus*) eggs from Botswana. J. Anim. Vet. Adv., 6: 676-677.

Nahid, H., S. Ahmed, M.T. Ibrahim, Z.N. Mahmoud and O.S. Ali, 2006. Normal concentrations of some blood constituents in ostrich. J. Scientific Technol., 7: 1-6.

Okotie-Eboh, G., C.A. Baily, K.D. Hicks and L.F. Kubena, 1992. Reference serum biochemical values for emus and ostriches. Am. J. Vet. Res., 53: 1765-1768.

Paganelli, C.V., R.A. Ackerman and H. Rahn, 1974. The avian egg: *in vivo* conductances to oxygen, carbon dioxide and water vapor in late development, in: Piiper, J. (Edn.), Respiratory Function in Birds, Adult and Embryonic, pp: 212-218 (New York, Springer-Verlag).

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

Sahan, Ü. 2003. Near-term embryonic mortality during artificial incubation of the ostrich eggs. Ind. Vet. J., 80: 1002-1005.

Sahan, Ü., Ö. Altan, A. İpek and B. Yilmaz, 2003. Effects of some egg characteristics on the mass loss and hatchability of ostrich (*Struthio camelus*) egg. Br. Poult. Sci., 44: 380-385.

SAS User's Guide, 1998. Statistical Analysis System. Edition 5. SAS Institute Inc., Box 8000, Cary NC 27 511-800, USA.

Superchi, P., C. Sussi, A. Sabbioni and V. Beretti, 2002. Italian ostrich *(Struthio camelus)* eggs: physical characteristics and chemical composition. Annali Della Facoltà Di Medicina Veterinaria, XXII: 155-162.

Zaharchenko, R., 2005. African ostrich's incubation peculiarities. In: International Conference on Commercial Ostrich-Breeding Development, pp: 96-120.