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RED-NECKED OSTRICH (STRUTHIO CAMELUS CAMELUS) EGG PRODUCTION, EXTERNAL CHARACTERISTICS AND HATCHABILITY

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Abstract: The objective of this study is to evaluate the average production performance of captive red-necked ostrich raised in the Sudan, pertaining to egg production, egg external characteristics and hatchability over three consecutive production seasons. The parent stock consisted of 9 males and 19 females, 2-3 years old and was in the second season of production, fed on 14% CP and 9.23MJ/Kg. The overall mean seasonal values showed 20.35 ±10.82 eggs produced per hen at a weight of 1650.73 ±215.89 gm with fertility 54.59±20.09 % and hatchability of incubated eggs 32.65± 16.22 %, with fertile ones 57.41± 17.53 %. Mean 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. Shape index value was 81.79 ± 0.76. The overall means of hatching egg weight, water loss % of hatched eggs, one day chick's weight and the percentage of chicks to the egg weight were 1687.80 ±201.47 gm, 10.99±2.07 %, 1094.11± 185.20 gm and 64.58± 05.09 % respectively. Results were compared to similar ones in open literature.

Keywords: *ostrich, egg production, hatchability, external characteristics*

INTRODUCTION

Ostrich farming was started in South Africa during the eighteenth century, mainly for the feathers. Before 1986, commercial ostrich production was virtually unknown to the rest of the world (Hallam, 1992). Ostrich products (feather and egg) trade was old in history and dates back to old civilizations (Van Schalkwyk, 1997). Ostrich farming activities in Europe are centered mainly in the United Kingdom, Belgium, Holland and France (Deeming and Angel, 1996). Target production is breeding.

The wild ostrich type prevalent in the Sudan is the red-necked type, Struthio camelus camelus. In the early eighties, ostriches

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were observed in Northern Sudan in Bayyuda Desert (Obeid, 1981). Nowadays the bulk of ostrich population drew back to Lat. 13oN, namely the Dindir National Park which is remarkable for being the only location of high ostrich abundance in the semi-arid savanna. Also the Blue Nile (southwards), southern Kordofan and Darfur (southwestern) ecozones are suitable ostrich habitats (Nikolaus, 1987), but no census of ostrich population estimations were given. In the Sudan, ostrich farming was only recent. Some ostrich collection farms were established for export purposes before the first intensive ostrich farm was granted a permit in 1992 (WCA, 1996). Ostrich egg production was shown by Degen et al. (1994) and Van Schalkwyk et al. (1996) to be exceedingly variable. They found large differences between the seasons, with relatively short periods of peak production in commercial conditions. The fact that ostrich egg production increases, peaks and subsequently declines as the breeding season progresses, is a well established fact in both wild ratite populations (Jarvis et al., 1985a) and domesticated birds (Deeming, 1996d and More, 1996b),however allowing for the age factor when young ostriches experience lower production rates than elder ones. Average egg production per hen per season around the world was variable but most authors record a minimum of 30 eggs and a range of maximum production of 60–80 eggs which can sometimes reach 100 eggs (More,1996b;1997).The hen naturally produces an egg every other day under good conditions amounting to a normal clutch of 12 – 18 eggs per season for natural hatching (Kreibich and Sommer, 1995).The number of chicks that hatch from a given number of eggs depends largely on the fertility of the breeding flocks. Cogburn (2006) reported that fertility is not a highly heritable trait i.e. only 8%, therefore other factors play the larger part in whether or not the male is producing fertile eggs.Many authors mentioned that ostrich egg size length and width vary considerably, and the average values are about 18 and 15 respectively (Dimeo et al. 2003; Shanawany and Dingle,1999). Last authors also reported that the average circumference length and width of the ostrich eggs were around 44.6 and 40.4 cm respectively with a shape index of 82.8. Deeming (1993) reported that the ostrich eggs are the largest of all eggs averaging 1545g -1640g with range mass of 1-2 kg, while Ar et. al.,(1996) found in a sample of 17000 eggs, an average mass of 1461g, valuing the contents of one ostrich egg to two dozen of chicken eggs. The red-necked type is a vicious ostrich to raise compared to the African black type originating from South Africa, which is easily managed and defined by Cogburn (2006) as the right commercial bird to stock. Worldwide studies on different ostrich production aspects were done on the African blacks. Hence very few studies were done on the red-necked ostrich which is untill now is the only species available in the wild and farmed in the Sudan.

MATERIALS AND METHODS

Stock and housing

A commercial red-necked ostrich S. *camelus* breeding flock was maintained in EL-Rajaa Agricultural Scheme, El Gitaina Province, 70 Km. South to Khartoum on the White Nile, White Nile State. The parent flock consisted of 9 males and 19 females, 2-3 years old and in the second season of production. The birds were housed in four pens A, B, C, and D each of dimensions 40 X 30 m. Longitudinally half-cut oil barrels were used as feeders and drinkers. The flock male/female ratios in pens A, B, C and D were 1:2.7, 1:1.5, 1:1.7 and 1:2.0 respectively with an overall male/female ratio of 1:1.9.

Table 1 Percent composition (as fed basis) and analyzed chemical composition (dry matter basis) of parent flock rations.

Ingredient	*Percentage*	*Component*	*Percentage*
Sorghum	30.00	Dry matter	94.00
Groundnut meal	08.50	Crude protein	13.62
Molasses	05.00	Crude fiber	16.99
Wheat bran	10.00	Ether extract	02.78
Groundnut hay	28.00	Nitrogen-free extract	47.61
Groundnut hulls	07.00	Ash	13.00
Concentrate	04.00	Ca	3.06
Oyster shell	07.00	P	00.46
Common salt	00.50	Energy (MJ ME/Kg)*	09.23
Total	**100.00**		

* Calculated according to Lodhi et al. (1976).

Feeding

The breeding flock was maintained on a laying ration for two weeks before the beginning of lay for adaptation. The ration was formulated to meet breeding ostrich nutritional requirements (Kreibich and Sommer, 1995) as shown in Table 1. Feeding was offered *ad lib.* 8.00 a.m. daily with water always availed.

Eggs parameters

Eggs were collected manually. Collection date was marked on the egg surface before storage. Eggs were stored for a maximum of 7 days at room temperature before being transferred to incubation and hatching. Before incubation and at the end of the storage period, eggs were measured for external physical characteristics. All eggs were weighed (g) using a dial balance of maximum weight two kilograms (egg setting weight). Axial length and width were measured (cm) using a digital Vernier Calipers. Long and short circumferences of the eggs were measured (cm) using a tape. Egg shape index (%) was calculated as the percent value of the breadth to length ratio (Panda, 1995). Egg density was performed randomly on five eggs by water displacement method.

Incubation and hatching

Upon arrival at the incubation room, eggs were given a serial incubation number . Incubation time was recorded. An ostrich incubator (Nageib, Nageib Co. Eygypt) was used. Hatcher of the same company was used as separate. Eggs were manually turned over 180^{o} every 6 hours (Van Schalkwyk *et al.*, 1998).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^{0}C and relative humidity 25% till hatched. Eggs were candled prior to incubation using a candling box of dimensions 30x22x24cm with a 200-watt lamp. The second candling was done at the end of the third week of incubation to determine fertility. Final candling was done at the end of the fifth week before hatching.

Hatched chicks

The hatching chick was allowed time to dry up, then the navel area was gently swabbed

Table 2 Percent composition (as fed basis) and calculated chemical composition (dry matter basis) of starter chick rations.

Ingredient	*Percentage*	*Component*	*Percentage*
Sorghum	65.00	Dry matter	95.00
Groundnut meal	13.00	Crude protein	22.85
Sesame meal	15.00	Crude fiber	04.33
Super concentrate	05.00	Ether extract	04.87
Bone meal	01.34	Nitrogen-free extract	56.93
Oyster shell	00.38	Ash	06.02
Common salt	00.25	Ca	01.34
Methionine 97%	00.03	P	00.79
Total	**100.00**	Energy (MJ ME/Kg)*	14.75

* Calculated according to Lodhi et al. (1976).

two or three times in the first 24 hours of life with diluted iodine solution to suppress liable bacterial infection. Chicks were accommodated in a brooder room of dimensions 4x3x2.5m. Hatched chick weight (g) was recorded immediately after drying up. The number of surviving hatching chicks per batch was recorded. Starter ostrich chick ration (Table 2) was fed *ad libitum* for one week to the brooding chicks. Clean water was provided *ad lib.*

RESULTS

The laying period of the breeding flock extended for 150, 220 and 152 days for the first, second and third season of production respectively. Table 3 shows the effect of time of lay (between seasons or within) on mean egg weight. Mean egg weight during late first season was heavier ($p<0.05$) than early season. Egg weight increases across seasons at all times (early, mid or late) with heavier average egg weight (1641.38 ± 72.99 g) in late season.

Figure 1 shows the egg weight changes for three consecutive seasons of production. Egg weights of the first season increases progressively till the end of season though less in weight than the second or third season. Peak weights were recorded during the third season which started late (January). Monthly mean egg weights were increasing successively from first to third seasons, with values becoming closer to each other in late season.

Table 3 Effect of time of lay on mean (± s.d.) breeding ostrich egg weight (g).

Production season	*Laying season (mean ± s. d.)*		
	Early	*Mid*	*Late*
First	1358.21 ± 166.38 b	1506.14 ± 77.26 ab	1619.64 ± 73.03 a
Second	1474.40 ± 88.60	1622.40 ± 54.15	1635.90 ± 81.84
Third	1736.40 ± 13.23	1685.20 ± 52.77	1677.30 ± 44.34
Average	**1463.48 ± 185.29**	**1597.00 ± 95.93**	**1641.38 ± 72.99**

Means in a row bearing the same or no letter subscript are similar ($p>0.05$).

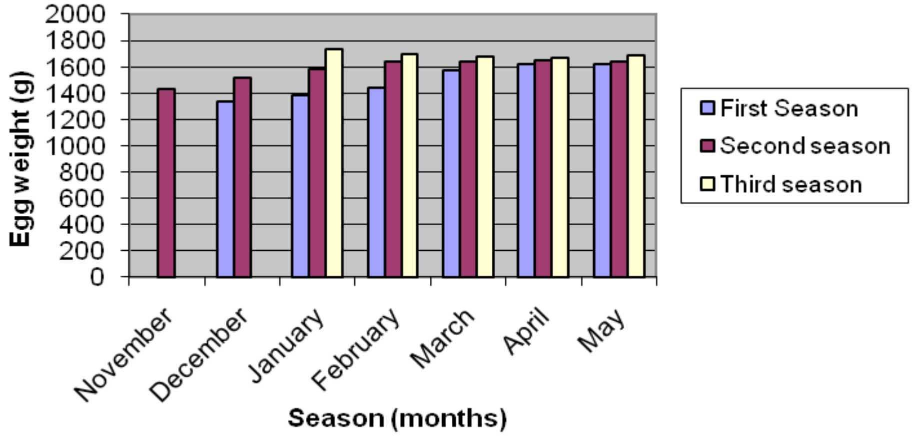

Figure 1 Egg weight changes for three consuctive seasons.

Figure 2 shows monthly changes in egg weight pooled for the three seasons. The rate of increase in egg weight starts slow in the first month highly accelerates in the second month and the rate continues to accelerate; but at a slower rate for the remaining period of the season. External egg measurements are shown in Table 4. Mean circumference length and width and axial length and width of 139 fresh eggs of the first year lay were measured. Shape index value was 81.79 ± 0.76.

Table 5 shows the average incubation/hatching values based on egg weight categories (150 g increment) during of the first year of production. Average chick weight increases up to the fifth group (1058.00 g). Hatchability and fertility are negatively related up to the fifth group also when hatchability declines.

Table 6 shows average ostrich egg hatchability performance for each of the three years of production with overall values. The

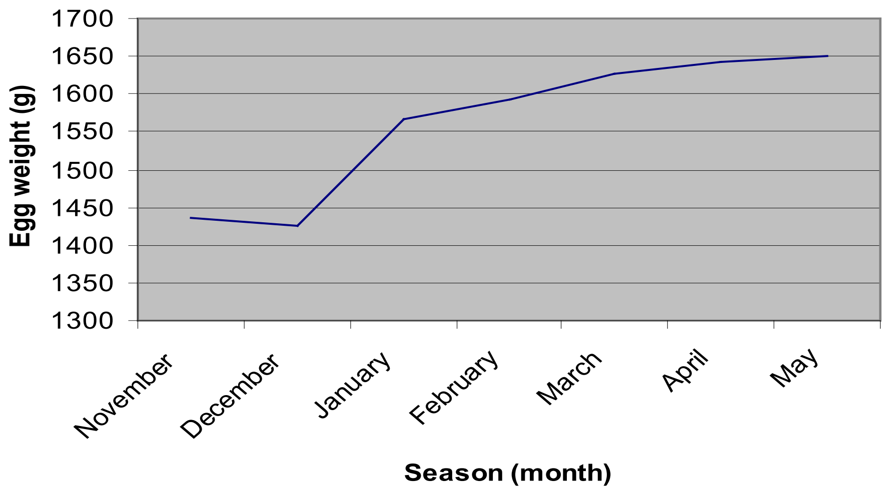

Figure 2 Monthly average egg weight changes for three seasons.

Table 4 Mean (± s.d.)* external measurements of breeding ostrich eggs.

Item	*Mean ± s. d.*
Circumference – length (cm)	44.53 ± 1.13
Circumference – width (cm)	40.35 ± 0.90
Axial length (cm)	15.43 ± 0.55
Axial width (cm)	12.56 ± 0.38
Shape index	81.79 ± 0.76

* Done on the 139 fresh eggs of the first year's lay

Table 5 Average incubation/hatching values based on egg weight (g) categories* of the first year of production.

Item	*Egg weight range*					
	<1150	*1150-1300*	*1301-1450*	*1451-1600*	*1601-1750*	*1751-1900*
Number of eggs/category	3	14	32	55	26	9
Aver. egg weight/category	1008.30	1245.36	1384.84	1519.82	1675.50	1848.89
No. of fertile eggs	2	5	14	40	18	6
Fertility %	66.66	35.71	43.75	72.73	69.23	66.66
Hatchability % of fertile eggs	33.33	64.29	56.25	27.27	30.77	00.00
Number of live chicks	2	4	7	20	5	0
Aver. chick weight (g)	775.00	800.00	914.29	1008.75	1058.00	00.00
Aver. chick weight% of the egg weight	69.51	64.57	66.44	66.36	62.13	00.00

* Done on the 139 fresh eggs of the first year's lay.

mean egg production/hen was 17.42 in the third season of production which is below ($p>0.05$) the overall average 20.35±10.82. Mean overall egg weight 1650.73 ± 215.89 g, fertility 54.59±20.09%, hatchability % of incubated eggs 32.65± 16.22 , water loss% of hatched eggs 10.99±2.07, mean chick weight % of the egg weight 64.58 ± 05.70 and water loss % of late embryonic death eggs 8.79±1.72 are similar ($p>0.05$) to either seasonal average.

DISCUSSION

Ostrich egg production during the three seasons showed variation on the number of eggs produced per hen and the length of the breeding seasons 7, 6 and 5 months for the first, second and third season respectively. The peak egg production in the study is March which differs from peak egg production reported by Deeming (1994) in the Northern hemisphere as May and June a time which is near the end of the laying season in central Sudan. Van Niekerk (1996) reported that peak egg production takes place when the natural day length is on the increase. The trend of egg production is characterized by low egg production at the beginning and at the end of the season, while peak production is in the middle of the season.

Weekly egg production per hen was variable in the three seasons1.08, 1.63 and 1.46 eggs respectively for first, second and third season and the overall mean was 1.39 a value which was less than the average

Table 6 Ostrich egg hatchability performance values for three years of production.

Item	*Year of production (mean± s.d.)*			
	First	*Second*	*Third*	*Overall*
Mean egg production/hen	23.00 ±00.00	23.34 ±13.71	17.42 ±08.14	20.35 ±10.82
Mean egg weight (g)	1508.23 ±96.23	1643.52 ±232.94	1681.96 ±206.10	1650.73 ±215.89
Fertility %	61.15 ±00.00	35.06 ±09.49	68.91 ±14.71	54.59 ±20.09
Hatchability % of incubated eggs	27.34 ±00.00	16.77 ± 08.45	46.41 ± 08.52	32.65 ± 16.22
Hatchability % of fertile eggs	44.71 ±00.00	45.95 ± 12.46	68.11 ± 05.82	57.41 ± 17.53
Mean weight of hatched eggs (g)	1468.55 ±150.21	1723.19 ±181.09	1710.54 ±194.02	1687.80 ±201.47
Water loss% of hatched eggs	9.94 ±0.50	11.31 ±2.29	10.76 ±2.82	10.99 ±2.07
Mean chick weight (g)	968.82 ±00.00	1105.45 ±136.61	1117.40 ±165.08	1094.11 ±185.20
Mean chick weight% of the egg weight	65.41 ± 01.23	64.25 ± 03.27	64.71 ± 06.68	64.58 ± 05.70
Total embryonic deaths % of incubated fertile eggs	55.29 ±00.00	54.05 ± 12.40	31.89 ± 05.82	49.09 ±11.44
Mean egg weight (g) of late embryonic deaths	1549.77 ±83.03	1671.93 ±151.77	1709.17 ±235.09	1680.04 ±207.89
Water loss% of late embryonic death eggs	10.48 ±01.90	8.01 ±1.37	9.06 ±2.43	8.79 ±1.72

weekly egg production per hen reported by Jost (1993).

The production per hen increased in ascending order according to their advancing age. The bulk of egg production peaked in March for a short duration and then declined as the breeding season progressed. This picture coincides with the findings of Van Sckalkwyk *et al.*, (1996), Deeming (1996d) and Degen *et al.* (1994) in domesticated stock and Jarivs *et al.* (1985a) in the wild ostrich.

The trend of seasonal egg weight changes obtained show that egg weight increases successively during the season (early, mid and late) with heavier egg weights obtained late in the season. Average egg weight categories of the first season of production were 12.23% for less than1300(g) and 81.3% for weight range1300 to 1750 and 6.47% weight range 1750-1900. The monthly trend of mean egg weights had also increased from first to third season; with mean egg weights becoming closer in value to each other during late season. The pooled changes in the egg weight for the three seasons revealed the rate of monthly increase in eggs weight had accelerated greatly in the second month and the rate then retarded to the remaining period of the season. Peak weight was recorded during the third season which started late January. Our values on average egg weight (1641.38 $\pm$ 72.99) was similar to the findings of Ar *et al.* (1996) and Van Schalkwyk *et al.* (1999) in the African black ostriches.

Female ostriches during the first season started laying eggs late by one month compared to elder breeders, thereby produced less eggs. Fair *et al.* (2005) showed that 2-year old hens (just mature) started slowly, increased egg production steadily up to five months into the breeding season but produced least eggs. This was attributed to the lack of sexual maturity and experience. Similar seasonal trend in egg weight changes was confirmed by Jarvis *et al.* (1985a) in the wild and Degen *et al.* (1994) and Deeming (1996d) in the domesticated birds. Female ostriches in the breeding season produce an egg every other day. Eggs were collected from the breeding pen on daily basis, but the claim of Ar (1996)and Deeming (1996a) that the daily removal of eggs from the nest will increase egg production and the laying season was beyond verification in this study.

Fertility of ostrich eggs showed variation with the breeding groups and the season of production. The overall mean fertility value was 54.59 ±20.09%. Comparable fertility values (27.4-91.2%) were reported by More(1996b, 1997) who observed fertility to have considerably varied between farms.

The decreased fertility (35.06$\pm$09.49%) in the second season may be due to the new grouping of birds or the rearrangement of males and females over pens. Incompatibility arising within the groups was due to the lack of familial homogeneity. Increasing the numbers during this season may have decreased the fertility as suggested by Deeming (1996a) that productivity increases and fertility lowers as the group size increases. Duration of lay for the different groups was short i.e. 215, 93, 76 and 28 days for groups A, B, C and D respectively.

Increasing the fertility in the third season (68.91$\pm$14.71%) may be a result of the increasing time of lay within the groups (153 days). Males and females in different pens were fairly compatible and minor changes were imposed. On the other hand, the third season started late relative to the other seasons by 1- 2 months, the reason why the production started steadily high. The fertility increase may be due to the relative increase in the day length of the breeding season.

Incubated egg water loss throughout the three seasons was higher for the hatched ones (10.99 $\pm$ 2.07%) and lower for the late dead embryos or dead in the shell (8.79 $\pm$ 1.72%). Comparable findings were reported by Sahan *et al.* (2003); Nahm (1999); Bowsher (1992); and Van Schalkwyk *et al.* (1999).

The variation in water loss from the incubated eggs were attributed to the egg mass, shell thickness (act as pore length), pore area or pore density, temperature and humidity within and outside the setter (Satteneri and Satterlee, 1994).

Batch incubation performance for the first season marked the third month (March) as peak production with peak fertility. This was tied to the longer daylight at this month of the year compared to the preceding and succeeding months. Furthermore,In batch incubation percent performance for the first season, fertility increased with the season progress while hatchability and embryonic deaths are to the inverse of each other. Hence, every failure in hatchability counts as an embryonic death rather than infertility.

The hatchability of incubated fertile eggs stands as key character in the evaluation of an ostrich farm success. The first season hatchability in this study was low. Stock was first coming on lay at low rate of egg production hence low hatchability (Deeming, 1996a and Wilson *et al.,* 1997).

The second season hatchability was also low mainly due to the different grouping adopted. New families spent considerable time for acquaintance. The hatchability in the third season was higher than the first two seasons, tied to a high egg lay and better incubation practices. The comparisons of hatchability in the three seasons for incubated and fertile eggs show variability (32.65± 16.22 to 57.41 ±17.55) within groups and seasons. Deeming (1993); and Van Schalkwyk *et al.* (1996) emphasized that hatchability of artificially incubated ostrich eggs was low and variable (ranging from less than 30% to approximately 60%) compared to other avian species. Hatching performance in artificial incubators was found to be poor relative to that expected from poultry (Deeming *et al*., 1993a). Krawinkel (1994) found that egg size and weight had a significant effect on hatching rate.

Swart (1988) had observed that more eggs were produced from large numbers of breeding stock; but numbers of live chicks produced were still low. He suggested that the low and variable (40-30%) hatchability was due to the high embryonic moralities and infertility. Jensen *et al.,* (1992) summarized that the two main reasons for poor incubator hatching results were due to poor hatchability potential of the egg (genetic, nutritional and physical components) and incubator environment factors (temperature, humidity and the carbon dioxide/oxygen balance).

Observation on chick hatching throughout the three breeding seasons revealed that chicks in low weight eggs pip earlier than high weight ones, but average of chick weight had increased with increasing eggs weight. This finding is similar to Gonzalez *et al.* (1999) who associated chick weight with egg size and stated that large eggs produce large chicks. One- day chick weight increased from the first season toward the third season and the overall mean was1094.11±185.20g.Our finding in the overall mean percentage of chick to egg weight ranged between 64.58± 05.70 to 65.41±01.23%.This was in agreement with the findings of Deeming (1993) that hatching chick mass was 65.60%.

BIOGRAPHY

Dr Ahmed El Amin graduated from the University of Khartoum 1974 as Veterinary Surgeon. He worked as Vet Officer till 1975 when privately joined Pfizer Inc., Middle East, as Vet/Ag representative- Sudan. Meanwhile he attained his M.V.Sc. (1982) and Ph.D. (1988) from the Faculty of Veterinary Science, University of Khartoum. Later he was Consultant and Executive Manager of two Animal Feed Companies. He joined The University of Khartoum as Assistant Professor and Head Department, Animal Nutrition, Faculty of Animal Production, University of Khartoum, 1992-1997. He was briefly appointed General Manager, Khartoum University Press, 1997-1998 and afterwards to his current position, Associate Professor, Department of Medicine Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Khartoum. His research covers domestic and wild animal health and production in aspects of drought feeding, molasses toxicity, phytotoxicity and red-necked ostrich *Struthio camelus camelus* nutrition and diseases.

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Dr. Aisha Elfaki Mohammed received her BSc from Zagazig university, Egypt (1984) as Veterinary medicine. She worked as Vet Officer till 1988 when joined Wad Elmagboul Poultry Project, Ministry of Agric. and Animal Resources, Khartoum as Production Manager. Meanwhile she attained her M.Sc., in Poultry nutrition, Faculty of Anim. Prod., Khartoum University, Sudan and Ph.D. in Ratite Medicine, Faculty of Veterinary Science, University of Khartoum, Sudan. She joined the Wildlife Research Center as Assistant Researcher in 1998 as researcher, assistant professor (2001-2006) and Associate Professor 2006 till now. She was appointed Head Department of Wildlife Diseases, Breeding and Production, Wildlife Research Center, Sudan 2003-2009. Her current position Associate Professor, Director of Wildlife Research Center Animal Resources Research Corporation, Ministry of Animal Resources and Fisheries. Her research cover wild animal health and production and red-necked ostrich Struthio camelus camelus nutrition, diseases, behavior, meat yield and quality. Also ostrich captive diseases and affection. She has authored numerous publications including on promoting poultry nutrition, wildlife diseases and ostrich breading and management. She is a Member of Sudan Vet. Union, 1987, Sudan Vet. Council, 2000, Sudan Wildlife Society 2001, Third World Organization for Women of Science (TWOWS), 2003, World Poultry Science Association (WPSA), 2005, Ratite Working Group, 2005 and Secretariat General of Consultancy Board, Ministry of the Cabinet, Sudan, 2008.

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