Productivity of commercially farmed ostriches (*Struthio camelus*) in Saudi Arabia

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Abstract

A study was conducted to record preliminary data on the productivity of ostriches (*Struthio camelus*) in two ratite farms (A and B) in Central Saudi Arabia. Breeders in Farm A started egg laying at 19 months of age with an average production of 12 eggs per female in their first season. Older (imported) breeders had averages of 1.2, 7 and 23 eggs per female in the first three production seasons in Saudi Arabia. Farm B breeders had average production of 13.5 and 35.2 eggs per female in their first two production seasons. The crude rate of egg defection in the two farms was 9.6%. The main causes of egg defection were egg undersize, presence of holes, cracks and rough shells. Mean fertility rates of ostrich eggs in Farm A was 52.5% and in Farm B it was 68.6%. The mean hatchability rates were 75% and 67.3% in Farm A and B, respectively. Farm A had an overall embryonic mortality of 25% of the fertile eggs whereas Farm B had 32.7% overall embryonic mortality. Most of Farm A embryonic mortality (61.9%) was late while 38.1% occurred during early embryonic development.

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Introduction

Ratites, particularly ostriches, have recently received increasing attention as meat producing animals (Cilliers, 1998; Verwoerd, 2000). Meat from ostriches is becoming increasingly popular throughout the world. Other important ostrich products include leather, oil and feather. Therefore, ostrich farming is emerging as a promising profitable investment (Perelman, 1998). Many countries, including Saudi Arabia, are witnessing significant growth in the number of investors allocating money and efforts towards the establishment of ratite enterprises.

This paper presents information on the productivity of ostriches (*Struthio camelus*) raised commercially in two farms in Saudi Arabia.

Materials and methods

The study was conducted in two ratite farms (A and B) in Al-Qassim in the Central region of Saudi Arabia.

Farm A: This Farm was established in 1997. The breeding stock, *Struthio camelus* var *domesticus,* was imported from France as ready-to-lay breeders and was composed of 400 birds with male to female ratio at 1:2 (i.e. 133 males and 267 females). The birds were housed in communal pens with dimensions of 100 X 200 meters each. Each pen was supplied with two shaded areas of 10 X 20 meters, eight water troughs and four concrete feeders. The stocking density ranged between 60 to 70 birds per pen. The farm had a hatchery section with incubating and hatching equipments (Mayenne Eclosion, St. Jean Sur Mayenne, France). The chick rearing section was composed of 24 rooms of varying sizes ranging between 9 to 32 m^2 each. The grower birds (above 3 months old) were housed in several pens of varying sizes, ranging between 20 X 30 m^2 to 100 X 200 m^2. All grower pens were supplied with shade, feeders and drinkers.

Farm B: This farm was established in the year 1999. The parent stock, also *Struthio camelus* var *domesticus*, was purchased locally as young chicks from a pioneer ostrich project which had imported its original stock from South Africa. The breeders in this Farm were housed as pairs or couples with a male to female ratio of 1:1 in pens with dimensions of 15 X 50 m. Each pen was supplied with shade, a feeder and a water trough. The farm also had incubating and hatching equipment (Natureform Inc., Jacksonville, Florida, USA). The chick rearing section was composed of five rooms and outside exercise areas ranging from 90 to 120 m^2. The growers section was composed of 12 pens of varying sizes, ranging from 320 to 6000 m^2 and was supplied with shaded areas, feeders and drinkers.

Farm A manufactured its own feed while the source of feed for Farm B was a commercial feed supplier (Arasco, Saudi Arabia). Feed was provided *ad libitum*.

Production operation in the two farms: Laid eggs were removed from pens either late in the afternoon or early in the morning. After labeling with date and pen number, eggs were transported to the hatchery section where they were inspected for incubation suitability. Defective eggs were discarded. Non-defective eggs were cleaned by tissue paper, fumigated by potassium permanganate and formaldehyde mixture (80 gm potassium permanganate in 130 ml 40% formaldehyde per cubic meter) for 20 minutes (Horbanezuk and Sales, 1998). Eggs were then stored in a special storage room in the hatchery section at 18ºC and 60% – 70% relative humidity for 2 – 6 days. During storage, eggs were positioned vertically with the air cell uppermost until transfer to the incubator. Twelve hours prior to this, eggs were fumigated again and preheated to 25ºC (Deeming, 1997). Eggs were then incubated at 36.2ºC and 25% relative humidity. Initial candling for fertility assessment was carried out after 3 weeks of incubation using an illuminator in a dark room. Fertile eggs were returned to the incubator, while non-fertile eggs were discarded. Eggs were candled again at day 39 of incubation to ascertain embryo viability and were then transferred to the hatcher for hatching at a temperature of 35.9ºC and a relative humidity of 40%. All non-hatched eggs were opened at day 42 to investigate the cause of hatching failure.

Production records: Record of daily activity was made on specific data sheets. The recorded data included egg production, incidence and causes of egg defection, fertility, hatchability and embryonic mortality rates. The persistency of egg laying was also compared between the original breeders and their descendants, the new breeders. These data included the records of five production seasons (1998 – 2002) in Farm A and two (2002 and 2003) in Farm B.

Statistical analysis: The differences between group means were evaluated by Student's t-test. Probability values (p) < 0.05 were considered significant.

Results

Egg production: Eggs produced in the first three seasons in Farm A were laid by the original parent stock (N=268) while eggs produced in the following two seasons (2001 and 2002) included eggs laid by new breeders hatched in the Farm (N=168). In the first three seasons (1998, 1999 and 2000), the mean egg production per season was 1.2, 7 and 23 eggs per female, respectively. The new breeders started egg laying at 19 months, with an average egg production of 12 eggs per female in the first season.

In Farm B, total egg production showed an increase from 3122 eggs in 2002 season to 7924 eggs in 2003 season with 153.8 % increase. The mean egg production was 35.2 eggs per female in the last season (2003) compared to 13.5 eggs per female in 2002 season although the number of layers has dropped from 231 to 225 females. In both farms, egg laying started in January and February and then the number of eggs laid increased gradually to reach the peak in April or May then dropped to reach the minimum in November and December.

Ostrich egg defection: There was a total of 2044 defective ostrich eggs out of 21221 eggs examined in the two farms in the five production seasons giving a crude rate of egg defection of 9.6%. The causes of egg defection and the relative incidence of each cause are summarized in Table 1. As the number of laid eggs increases the number and percentages of defective eggs also increases. Most of the defective eggs in Farm A (34.5%) had sizes below the acceptable level for incubation (undersize) whereas for Farm B most of the defective eggs (43.9%) had holes on the shells.

The original breeders showed sustained level of egg production which continued for a longer duration in contrast to the new breeders which showed an unsustained and non-persistent pattern of egg laying. For both original and new breeders, August witnessed the lowest egg production while September and October, showed a slight increase in egg laying before it dropped again towards the end of the season in December (Fig. 1).

Fertility: Fertility rates of breeding ostriches in both Farms are shown in Table 2. As can be seen there was low fertility in the first production season in Farm A (32.4%) compared to the following three seasons (55.6%, 60.7% and 61.2%) (P=0.001). The fertility rate of the incubated eggs was lowest (36.5%) at the beginning of the breeding season, then improved with progress of the season (67.6%) before it dropped again (47.7%) at the end of the season. In Farm B, it can be observed that the mean fertility rate for the 2003 season (66.6%) was generally higher than that for the 2002 season (50.2%). Moreover, the overall mean fertility rate in Farm B ostriches (68.6%) was generally higher than that in Farm A (52.5%) although none of those differences was significant ($P>0.05$).

Hatchability: The hatchability rates of ostrich eggs in Farm A and Farm B are also shown in Table 3. It can be noticed that ostriches in Farm A had lower overall mean fertility rate (52.5%) for the four seasons (1998 – 2001) when compared to the overall mean hatchability rate of the fertile eggs (75%) throughout the four seasons ($p<0.05$). The hatchability pattern of incubated eggs usually declined towards the mid and end of the production season compared to hatchability at the beginning of the season (Fig. 2). The overall mean hatchability rate of ostrich eggs in Farm A (75%) was generally higher than that for Farm B (67.3%) but the difference was not significant ($P>0.05$).

Embryonic mortality: Farm A had a crude embryonic mortality of 25% whereas Farm B had 32.7% as crude embryonic mortality. The incidence of early and late embryonic mortality in Farm A ostrich eggs is presented in Table 4. The majority of embryonic mortality (61.9%) was in late developmental stages (last two weeks of incubation) whereas 38.1% mortalities occurred during early embryonic development (first four weeks of incubation) ($p<0.05$).

Discussion

The successive improvement in egg production of Farm A ostriches throughout the first three seasons since the arrival of the parent stock from France reflects the need for the imported breeding stock to adapt to the new environment. This is particularly so, since the birds were imported from a distant area with major climatic and ecological variations between the two habitats (Sauer and Sauer, 1966). In this study we record, for the first time, 19 months as the age at which new ostrich breeders could start egg laying in Saudi Arabia yielding a mean of 12 eggs in their first production season. Shanawany and Dingle (1999) reported a later age (two years) for maturity and start of laying by new ostrich breeders. The sharp increase in egg production in the third season compared to the second season in Farm B shows the gradual progress towards full maturity and productivity by the new breeders during their first few years of production life. Degen *et al.* (1994) reported that in the northern hemisphere egg laying by ostriches occurred between March and September with peak numbers of eggs laid in May and June. The concentrations of plasma luteinzing hormone increased in February in both sexes and plasma testosterone concentrations in males increased in April (Degen *et al*., 1994). Egg production resumed its seasonal trend in the following relatively cooler months (September / October). The higher ostrich egg production in the third season in Farm B (35.2 egg / female) by breeders produced locally in Saudi Arabia, compared to egg production in the third season since the arrival of Farm A breeders (23 egg / female), which were imported as mature birds, indicates that the local breeders performed better than the imported ones. This could be due to better adaptation (Shanawany and Dingle, 1999). The continuation of egg and chick production throughout the season, particularly in the last 2 – 3 seasons in Farm A, might indicate better adaptation of the breeders to the Saudi climate or that breeders had attained more maturity (Deeming and Ar, 1999). In this regard, the merits of importing mature stock at the point of lay should be weighed against the expected better performance of locally grown stock. The more persistency and sustainability in egg laying by the original breeders compared to the new breeders might be attributed to the full maturity of their reproductive systems (Deeming and Angel, 1996). The short breeding cycle of ostrich new breeders has been attributed to the immediate drop in gonadotrophins secretion to levels that were insufficient to support the reproductive hormonal requirements (Blache *et al*., 2001).

The higher percentage of defective ostrich eggs in Farm A compared to Farm B was most probably a result of differences in the husbandry system between the two farms. Breeders in Farm A were kept on communal pens and the laid eggs were more subject to damage by other birds, unlike Farm B, in which breeders were housed as couples in separate pens. The higher incidence of oversized ostrich eggs in Farm A compared to Farm B might be due to genetic background. The higher incidence of holes in Farm B ostrich eggs, on the other hand, could be attributed to the rocky nature of the soil in that Farm. The identification and removal of abnormal or defective eggs is essential due to the reduced hatchability of these malformed eggs (Deeming and Ar, 1999; Gonzalez *et al*., 1999).

The high variability in fertility of ostrich eggs in different ostrich breeding countries is well documented in the literature (More, 1996a; More, 1996b; Cloete *et al*., 1998; Deeming and Ar, 1999). The proportional successive improvement in fertility rates in Farm A ostrich eggs throughout the subsequent seasons could be due to the better adaptation of the birds to the local environmental conditions besides the more maturity attained by the breeders (Deeming and Ar, 1999). Ostriches in this Farm had an average initial fertility rate of 32.4% in the first season, rising to 55.6%, 60.7% and to 61.2% in the following seasons. The improvement in fertility with the progress of the season might be due to the fact that females come into production earlier than the males. Murton and Westwood (1997) recorded a similar trend and attributed it to the slow increase in the production of luteinizing hormone and delayed increase in male plasma testosterone concentration at the beginning of the season. The improvement in fertility rate in Farm B ostrich eggs in the second season in contrast to the first season could be due to more maturity of male breeders (Fasenko *et al.*, 1992). Female breeders in communal pens could be mated by more males than in single pens leading to higher fertility rates (Malecki and Martin, 2003). However, the lower fertility rate in Farm A ostrich eggs compared to Farm B could very well be due to the fact that the dominant sterile or less fertile males would not allow other fertile, but less dominant, males to mate (Gowe *et al.*, 1993; Deeming, 1995).

The hatchability of ostrich eggs was reported to be around 50% in Britain and 35% to 70% in South Africa (Horbanezuk and Sales, 1998). Hatchability in the two farms followed for five seasons in this study ranged from 64.6% to 87.1%. The improved hatchability rate of Farm A ostrich eggs compared to Farm B might be attributed to the better efficiency of hatching equipments in Farm A. Farm A incubators had an in-built water chilling system, which controls and regulates the internal temperature in contrast to Farm B incubation equipments which lack this facility leading to difficulty in controlling the incubation temperature. Fluctuations in incubation temperature can lead to reduced hatchability rates (Sainsbury, 1992). The amount of egg weight loss during incubation as well as proper egg handling and storage are also important influential factors on hatchability of ostrich eggs (Nahm, 2001).

The negative influence of high ambient temperature on egg laying persistency was prominent, as manifested by the lowest number of ostrich eggs laid during August months in all seasons (Deeming and Angel, 1996). High ambient temperature was also incriminated as a cause in the drop in fertility rates of ostrich eggs laid during July months (Gangwar, 1983). Moreover, the drop in hatchability pattern towards the mid of the season could be attributed to the negative effect of high ambient temperature on the efficiency of the incubating and hatching equipments (Gangwar, 1983; Deeming, 1996).

An average of 61.9% late embryonic mortality was recorded in ostrich eggs compared to 38.1% early embryonic mortality. The high percentage of late embryonic mortality in ostrich eggs could be due to insufficient water loss during incubation. This produces a too small air cell which leads to difficulties in the hatching process, due mainly to suffocation (Ley *et al*., 1986; Horbanezuk and Sales, 1998). Some other workers, on the other hand, incriminated the vertical positioning method of the longitudinal axis of the eggs, which has been used in these two farms, as a cause of embryonic death. It has been claimed that horizontal positioning for the first 2 – 3 weeks followed by vertical positioning for the rest of the incubation period yielded better hatchability results and reduced embryonic mortality (Smith *et al*., 1995). Yolk sac infection also has been blamed as a cause of late embryonic mortality due to contamination of hatching eggs with microbial agents which penetrate the egg shell leading to infection of the yolk sac (Huchzermeyer, 1998). An other main cause of early embryonic mortality is late delay in egg collection, leading to pre-incubation of eggs, particularly by male breeders. The subsequent cooling and storage of the pre-incubated egg leads to death of the developing embryo (Shane and Tully, 1996). Other possible causes of early embryonic mortality include poor quality eggs, microbial contaminated eggs, poor storage conditions and incorrect incubation temperature (Deeming, 1997).

There are no previous studies in Saudi Arabia with which these findings can be compared although the Arabian ostrich (*Struthio camelus syriacus*) was once abundant in the deserts of Saudi Arabia. Heavy hunting of the Arabian subspecies resulted in its fragmentation into remote inhospitable regions within the Arabian peninsula which ultimately resulted into its extinction by 1950s (Seddon and Khoja, 1998). Currently, the National Commision for Wildlife Conservation and Development (NCWCD) in Saudi Arabia is implementing a programme of captive breeding and reintroduction of the closet living relative of the Arabian ostrich, the red neck *Struthio camelus camelus*, from Sudan. This relatively wild subspecies is adapted to hot arid conditions and it is hoped that birds released in Saudi Arabia will survive and breed in the bush although it has low productivity compared to other domesticated subspecies. Therefore, in efforts to utilize the emerging interest in commercial ostrich farming, Saudi investors had to rely either on foreign import of their initial breeding stock or reproduce the locally grown stock generated from adapted subspecies such as *Struthio camelus* var *domesticus* which has proved its good performance during this study (Farm B records).

The results and conclusions derived from this study such as productivity indices, fertility and hatchability rates, could be of high importance to the ratite producers and researchers in Saudi Arabia. However, further research to optimize fertility and hatchability rates of ostrich eggs is recommended in attempts to get the maximum output of this developing industry.

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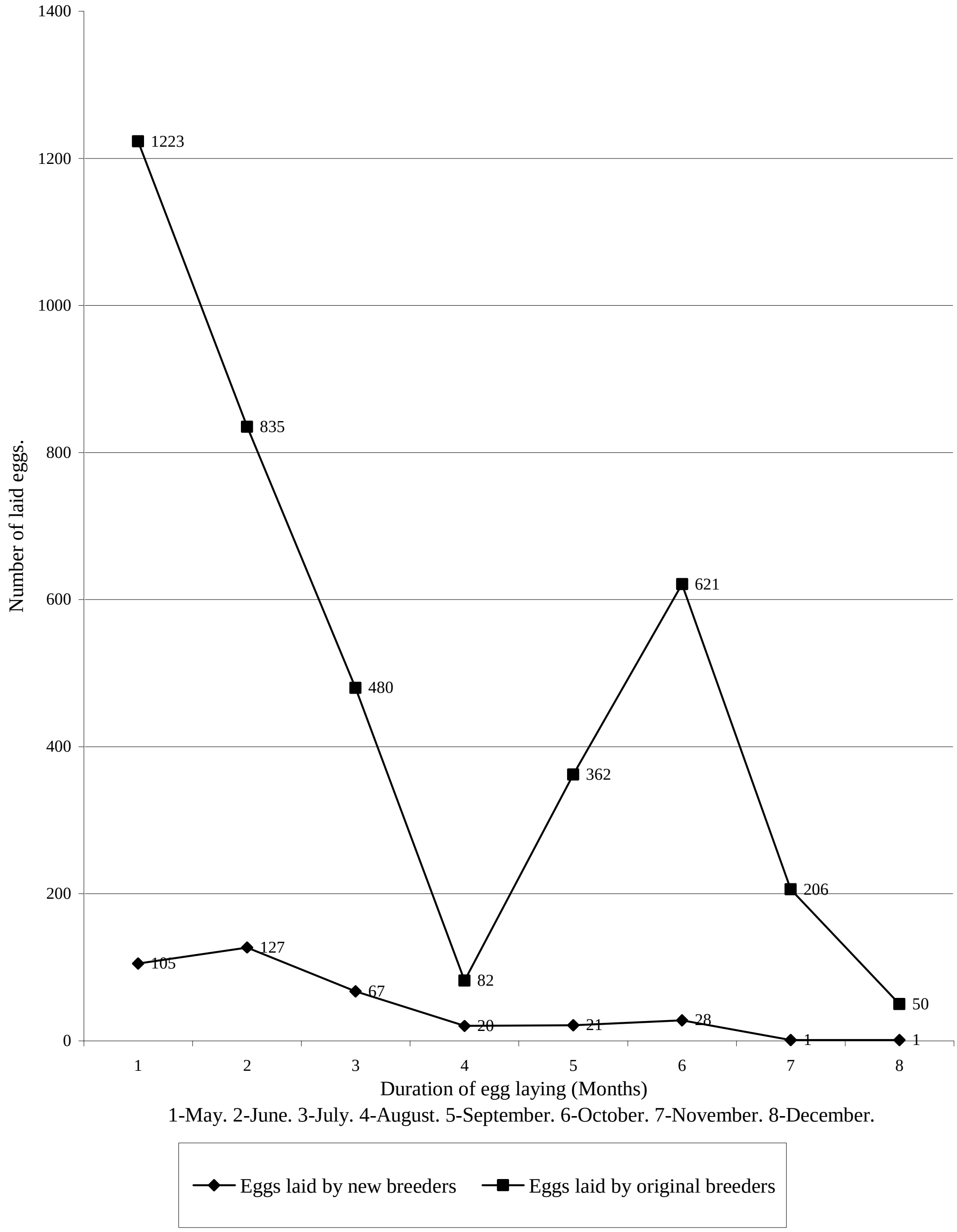
Fig. 1. Persistency of ostrich egg laying in Farm A.



1-May. 2-June. 3-July. 4-August. 5-September. 6-October. 7-November. 8-December.

Fig. 2. Hatchability rates of ostrich eggs in Farm A and B.

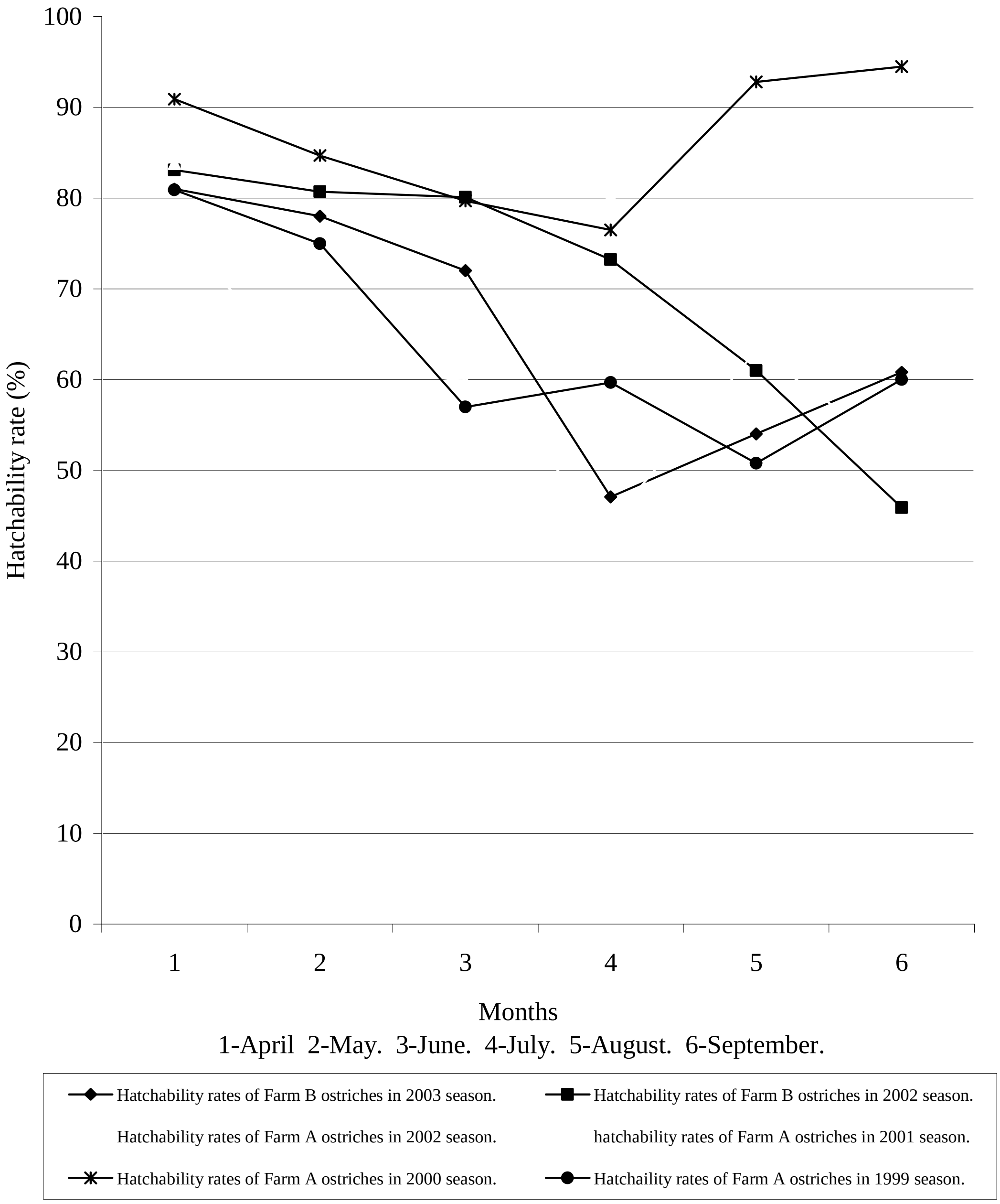


Table 1. Causes and relative frequencies of egg defects in Farm A and B (N=2044).

Cause of defect	Defective eggs			
	Farm A		Farm B	
	No.	%	No.	%
Holes	430	26.9	197	44.1
Undersize	551	34.5	21	4.7
Chalky eggs	260	16.3	47	10.5
Cracks	128	8.0	37	8.3
Dirty shell	118	7.4	31	6.9
Rough shell	45	2.8	110	24.6
Oversize	34	2.1	0	0
Elongated eggs	31	2	4	0.9
Total	1597		447	

Table 2. Fertility rates of ostrich eggs in Farm A and B.

Month	Fertility rates (%)					
	Farm A				Farm B	
	1999	2000	2001	2002	2002	2003
January	14.29	No eggs	49.71	54.01	No eggs	No eggs
February	21.74	36.47	53.68	47.92	No eggs	No eggs
March	27.07	42.18	52.57	50.89	No eggs	No eggs
April	35.06	45.20	57.11	57.50	39.16	70.31
May	37.23	56.70	61.87	60.04	50.90	79.57
June	46.99	64.44	62.55	68.14	50.82	66.77
July	42.18	65.03	69.30	65.85	50.69	62.18
August	51.21	67.56	61.26	68.48	54.77	60.70
September	15.62	65.17	65.92	72.04	52.65	60.17
October	No eggs	63.34	60.53	66.67	52.54	No eggs
November	No eggs	57.85	66.22	No eggs	No eggs	No eggs
December	No eggs	47.68	67.35	No eggs	No eggs	No eggs
Season mean fertility rates (%)	32.4	55.6	60.7	61.2	50.2	66.6
Overall mean fertility rates	52.5 %				68.6 %	

Table 3. Monthly frequency of hatched ostrich chicks and hatchability (%) in Farm A and B.

Month	Number of chicks and hatchability (%) of ostrich eggs											
	Farm A								Farm B			
	1999		2000		2001		2002		2002		2003	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
January	0	83.3	0	0	81	78.2	21	81.1	0	0	0	0
February	3	70	0	78.1	146	86.3	39	84.1	0	0	0	0
March	10	74.1	10	91.9	153	90.2	48	83.3	0	0	45	79.9
April	41	80.9	71	90.9	171	75.1	169	83.8	15	83.1	50	83.8
May	82	75.0	255	84.7	412	61.6	427	84.2	19	80.7	390	78.0
June	102	57	419	79.7	449	59.9	667	87.5	254	80.1	555	72.0
July	74	59.7	555	76.5	596	44.3	785	80.2	188	73.2	628	47.1
August	32	50.8	395	92.8	394	63.2	311	84.5	207	61.0	200	54.0
September	44	60	129	94.5	146	51.7	45	81.6	152	45.9	144	60.8
October	0	0	155	93.1	71	65.2	249	54.8	104	49.0	112	64.3
November	0	0	216	87.1	274	51	141	80.3	80	68.5	19	62.2
December	0	0	141	88.2	248	48.5	37	81.1	19	66.9	0	0
Total No. of chicks (mean hatchability)	393 (67.9%)		2346 (87.1%)		3141 (64.6%)		2939 (80.5%)		1038 (67.6%)		2143 (66.9%)	
Overall mean hatchability rates	75%								67.3%			

Table 4. Embryonic mortality in ostrich eggs in Farm A (1999 - 2002).

Season	Dead embryos	Early mortality		Late mortality	
		No.	%	No.	%
1999	184	87	47.3	97	52.7
2000	384	141	36.7	243	63.3
2001	337	147	43.6	190	56.4
2002	582	191	32.8	391	67.2
Total	1487	566 (38.1%)		921 (61.9%)	