HATCHABILITY OF OSTRICH *(STRUTHIO CAMELUS)* EGGS IN RELATION TO DIFFERENT BREEDING SYSTEMS

BY

ZAKI, M.S.A.; *BYOMI, A.M. AND **HUSSIN, M.M.
Dept. of Hygiene & Animal Husbandry, Fac. Of Vet. Medicine, Zagazig University.
**Dept. of Hygiene, Behaviour & Zoonosaes, Fac. of Vet. Medicine, Menoufia University.*
***Dept. of Animal Hygiene& Ethology, Fac. of Vet. Medicine, Suez canal University.*

SUMMARY

This study was done to determine fertility and hatchability rates of ostrich eggs in relation to the different methods of breeding. Incidence of bacterial and fungal contaminants encountered from the un-hatched ostrich eggs were also evaluated. A total of 601 eggs laid by ostrich were collected from the different systems of housing as follows; intensive system with wire fence (179 eggs); intensive system with block fence (63 eggs); semi-intensive system (304 eggs) and extensive system (55 eggs). All of these eggs were incubated in a multi-stage incubator. Eggs which failed to hatch were opened to determined whether the egg was infertile or not and age at which any embryo had died. Sterile swabs were taken from dead embryos in the un-hatched eggs and were subjected to bacterial and fungal examination. The results showed that the overall fertility rate of all ostrich eggs set was 53.91% (324 out of 601). Forty-three out of 324 fertile eggs (13.27%) failed to hatch and showed embryonic mortality. Overall hatchability of all eggs set was 46.76% (281 out of 601), while hatchability rate of the fertile eggs was 86.73% (281 out of 324). The overall mean of all ostrich eggs weight (gm) was 1395.89±144.31. The average weight loss (water loss) from ostrich eggs during incubation was 14.19±2.14%. Of 43 un-hatched eggs, 12 (27.91%) showed bacterial and 10 (23.56%) fungal contaminants. A variety of bacteria and fungi were isolated from the un-hatched ostrich eggs that contain dead embryos. Among the studied systems of ostrich housing, extensive system showed the lowest percentage of fertility and hatchability in comparison with the other systems and this may be due to the higher microbial contamination, low water loss and poor nest hygiene. To prevent microbial contamination of ostrich eggs and in turn increasing fertility and hatchability rates, the high standards of nest hygiene should be maintained. In addition, periodic egg weighing must be given some attention to avoid excessive or decreasing percentage of water losses from ostrich eggs during incubation.

INTRODUCTION

The ostrich *(Struthio camelus)*, a member of the ratite of flightless birds, is the large living birds and is native to semi-arid and desert areas of Africa (Honnas et al., 1991). It has been in domestication since the mid-1880s, primarily in South Africa, but ostrich farms were established in various countries around the world (Hastings, 1991). Today, the ostrich remains in domestication for the leather, meat and feather, and is an important aspects of agriculture in South Africa, Nambia, Zimbabwe with interst growing in farming the bird in USA, Australia and Europe (Mellett, 1993 and Deeming, 1995a). The only way to maintain a healthy and profitable ostrich industry in long term is by implementation of comprehensive, practical and effective methods of management and preventive methods (Tully & Shane,1996).

Hatchability of artificially incubated ostrich eggs is generally low with many fertile eggs failing to hatch. Artificial incubation of ostrich eggs, an essential aspects of any commercial operation, has had limited success with only 50% of hatchability of all eggs set in South Africa (Mellett, 1993) and variable results from ostrich eggs imported into the UK from Namibia and Zimbabwe (Deeming et al., 1993a; and Deeming 1995a). Most mortality of artificially incubated ostrich eggs takes place in the last 7-14 days before hatching and represent a substantial loss of farms (Philbery et al., 1991; Bowsher, 1992 and Deeming, 1995a).

Ostrich eggs often have low hatchability rates because they don't loss sufficient weight during incubation. Moreover, eggshell porosity and thickness as well as length of pre-incubation egg storage are known to affect egg weight loss (water loss) during incubation and hatchability (Gonzalez et al., 1999). A poor understanding of the pattern of embryonic development, especially during hatching, is thought to contribute in part to such poor results (Deeming, 1993), although other factors such as infertility and egg contamination are significant problems (Deeming, 1995a). Environmental conditions also influence ostrich egg hatchability including temperature & humidity, gaseous environment and orientation of the eggs (Meijerhof, 1992 and Mellett, 1993). Hatchability in mechanical incubator is also affected by various factors such as turning of eggs during incubation (Deeming, 1989); nutritional status of female ostrich (Angel, 1995); nutrients of

ostrich eggs (Philbery et al., 1991) and microbial contamination of the eggs (Deeming 1996a).

Ostrich egg contamination due to microbial agents is a major health concern of ostrich production (Khafagy & Kamel, 2001). However, microbial spoilage of hatching eggs is a problem in poultry causing, for example, a loss of about 13% of the parent broiler eggs and is a particular problems among older flocks (Bruce & Drysdale, 1991).

There was a lack of information about fertility and hatchability of ostrich *(Struthio cameleus)* eggs in Egypt and it is not known to what extent microbial contaminants contributes to poor hatchability in ostrich eggs. So, this study sought to answer these questions by determining fertility and hatchability of eggs laid by the ostriches under different methods of breeding. Incidence of bacterial and fungal contaminants encountered from the un-hatched eggs were also evaluated.

MATERIALS & METHODS

This study was carried out at ANA'AM Egptian Saudi company for ostrich breeding in Ismalia governorate, Wady El-Molak. Ostriches were fed ad libitum. The diet were offered everyday morning. For one ostrich, the amount of diet composed of : poultry breeder dry ration (100 gm); meat (100 gm); corn (200 gm); Lettuce (100 gm); Carrot (100 gm); Bean (500 gm); Eggs (2) and bread (100 gm).

The poultry breeder dry ration was that produced by Cairo company for table egg production. It was made of yellow corn, Soya bean cake, bran, lime stone, vitamins and mineral mixture. This ration contains crude protein (not less than 18%); Crude fat (not less than 2.9%) and crude fiber (not less than 2.7%). Tap water was offered to the ostriches in a drinking basin ad libitum. The basin was cleaned daily and provided with fresh water. Eight to 12 weeks before the beginning of breeding season, the sexes are separated (camping off) for ensuring good average number of eggs in the following seasons with high fertility rate. This break will give the ostrich a well deserved rest (Tuckwell & Rice, 1997).

The breeding systems in the ostrich farm were classified into three systems and each one was composed of breeding units (Hulton, 1989).

Intensive system: Each unit (5x30m^2) included one cock and two hens. The breeding unit was surrounded by a wire mesh or block fence.
Semi-intensive system: Each unit (10x40m^2) included one cock and three hens. The breeding unit was surrounded by a block fence.
Extensive system: Each unit (one acre) included six cocks and twelve hens.

The age of both cocks and hens were about 4 years old. The litter in the previous systems was sand except in the intensive system which included different types of litters (sand, concrete or both).

A total of 601 eggs laid by ostrich were collected from the different systems of housing as follows; intensive system with wire fence (179 eggs); intensive system with block fence (63 eggs); semi-intensive system (304 eggs) and extensive system (55 eggs). All of these eggs were stored for 7 days and were incubated in a multi-stage incubator (Nature Form Co., USA) set at 36-36.5°C and 25-36 % relative humidity. The eggs were weighed before setting and every 7 days thereafter, up to transfere to the hatcher at 35-39 d. in order to calculate weight loss (water loss) from ostrich eggs up to 41-42 days (external piping). The eggs were also candled 7 days after the start of incubation and every 7 days thereafter in order to asses development of fertile eggs and to identify contaminated eggs, so that they could be removed from incubator (Deeming, 1995b).

Eggs which failed to hatch were opened to determined weather the egg was in fertile and age at which any embryo had died. Hatchability rate was calculated from all eggs set in the incubator and from fertile eggs.

Sterile swabs were taken from dead embryos in the un-hatched eggs and inoculated onto tube containing nutrient broth for enrichment and incubated at 37°C for 24 hours. The incubated growth was streaked into following solid media; MacConkey's agar for coliforms (Cruickshank et al., 1975); Starch-Ampicillin agar (SAA) for *Aeromonas* (Palumbo et al., 1985); Baird-Parker (CM 275, oxoid) for *Staphylococci* (Thatcher & Clark, 1978) and Enterococcus Selective Differential medium(E.S.D)for *Streptococci* (Efthymiou & Joseph, 1974). Suspected growth was purified and identified as previously described (Cruickshank et al., 1975; Krieg & Holt, 1984 and Koneman et al., 1994). For isolation of *Salmonella*, Selective-F-browth was used as selective enrichement

media (Edward & Ewing, 1972), then streaked onto MacConkey's agar and Salmonella-Shidella agar (Koneman et al., 1994). Serological identification of the isolated Salmonellae was done according to Kauffmann (1978).

For fungal examination, sterile cotton swabs were taken from dead embryos of the un-hatched ostrich eggs. Isolation and identified of fungi were performed as the previously described methods (Koneman & Sera, 1971 and APHA, 1987).

RESULTS AND DISCUSSION

It is evident from Table (1) and Fig. (1) that the overall fertility rate of all ostrich eggs set was 53.91% (324 out of 601). The highest fertility rate was recorded in the eggs laid by ostrich under semi-intensive system of housing (69.08%), followed by intensive with block fence (57.14%), intensive with wire fence (34.64%) and lastly from extensive system (20.09%). Nearly similar previous finding was recorded (Khafagy & Kamel, 2001), while higher figures (86.07; 81.8; 78.8; 68.01; 88.0 and 80.0%) were also cited by Deeming et al., 1993a; Krawinkel, 1994; Deeming, 1995a; Simon, 1996; Ahmed & Mokhtar, 1999; and Nahm, 2001 respectively.

From Table (1), one can easily conclude that fertility rate varied between ostrich eggs under different methods of breeding. Moreover, the number of fertile eggs increased significantly under the semi-intensive system, followed by intensive with block fence (Fig. 1). This may be attributed to the design of housing which eliminate the effect of visual stimuli coming from adjacent pen through block fence. On the other hand decreased fertility rate of eggs collected from ostrich under extensive system or semi-intensive with wire mesh fence may be due to social stress of males which may result in the presence of complete mating and in turn, lowering fertility rate (Mohamed et al., 2003).

It is obvious from Table (1) that 43 out of 324 fertile eggs (13.27%) failed to hatch and showed embryonic mortality. Most of these mortalities occurred at the late stage of incubation (day 35) and were related to percentage of water loss which cause severe edema and later mass deaths. Broken shell, severe edema, malposition and microbial contamination were the predominant causes of chick mortalities (Brown et al., 1995 and Khafagy &

Kamel, 2001). In addition, mortality of the late stage embryos was related to the percentage of water loss and mass specific water vapor conductance of the shell, with extremes of the ranges of values causing the highest mortality (Deeming, 1995a).

Hatchability results of ostrich eggs in relation to different types of housing are presented also in Table (1) and Fig. (1). Hatchability rates were calculated as a percentage of hatched eggs from all eggs set and from fertile eggs. Overall hatchability of all eggs set was 46.76% (281 out of 601). Nearly similar rate (48.2%) was previously reported (Krawinkel, 1994). In Australian and England ostrich farms, hatchability of all eggs set was reported to be less than 50.0% (Philbery et al., 1991 and Deeming, 1996b). In South Africa, hatching success is very variable between farms from about 35-90%, but is usually closer to lower figure (Burger & Bertram, 1981). In USA, Bowsher (1992) reported losses of fertile eggs set on three of the largest ostrich farms to amount to 28-50%. However, higher previous figures (60.0; 67.0; 68.0; 54.0; and 63.3%) were also reported by Deeming et al. (1993a); Simon (1996); Ahmed & Mokhtar (1999) and Nahm (2001), respectively. Lower findings (37.2 and 10.0%) were also previously recorded (Deeming, 1995a and Khafagy & Kamel., 2001).

It is clear from Table (1) that hatchability rate of the fertile eggs was 86.73% (281 out of 324). lower previous figures (76.0; 79.2 and 58.2-69.2%) were found by Nahm (2001), Horbanczuk (1999) and Deemning et al. (1993a).

It could be concluded from the results of hatchability presented in table (1) and Fig. (2) that the highest hatchability values calculated from all eggs set was recorded in the eggs collected from ostriches kept in the semi-intensive system (58.55%), followed by intensive with block fence (50.79%), then intensive with wire fence (31.84%) and lastly extensive system (25.46%).

Regarding hatchability rates of the fertile eggs, there was no difference in the results obtained from all systems of ostrich housing except extensive system which showed the lowest percentage (35.90%) in comparison with the other systems (Fig. 2).

From the hygienic point of view, hatchability of ostrich eggs was low compared with poultry and resulted in part from high rates of infertility and embryonic mortality caused by excessive periods

of storages (Deeming, 1995a). Moreover, Environmental conditions and microbial contamination of eggs may influence ostrich eggs hatchability (Meijerhof, 1992; Mellett, 1993; Deeming, 1989; Philbery et al., 1991; Angel, 1993 and Deeming, 1996a).

Table (2) declares that the overall mean of all ostrich eggs weight (gm) was 1395.89±144.31 (range was 1010-1688 gm). These results were nearly similar to those previously recorded for ostrich eggs (Deeming et al., 1993a; Krawinkel, 1994; Deeming, 1995b; Brown et al., 1996 and Khafagy & Kamel, 2001). There was no unconditional association between egg fertility and either egg weight at start of pre-incubation, season of the lay, or the duration of egg storage prior to incubation. Moreover, egg hatchability was conditionally associated with egg weight (Simon, 1996). On the other hand, hatchability decreased markedly when eggs weighed below 1200 gm (Horbanczuk, 2000). According to previous results, egg weighing 1300-1700 gm had the best hatchability (Jost, 1993), while egg size and weight had a significant effect on the hatching rate (Krawinkel, 1994).

The variation in fresh egg weights in ostriches means that this effect has to be taken into account when deciding when to finish the hatch because the large still viable eggs may require slightly longer to incubate than smaller eggs in the same machine (Deeming et al., 1993a).

The average weight loss (water loss) from ostrich eggs during incubation was 14.19±2.14%. It was varied from 11.48-15.345% (Table 2). The lowest percentage of water loss (11.48%) was recorded in the eggs laid by ostriches under extensive system, while the highest value (15.34%) was found from eggs collected from semi-intensive system. In comparison the results of water loss from ostrich eggs in relation to different systems of housing, there was a significant decrease in the water loss from eggs laid by ostriches under extensive system, while other systems of ostrich housing showed no significance in the percentage of water loss.

The average weight loss (14.19%) from ostrich eggs in our study was unreasonable considering that eggs may hatch with weight loss of 13.2% (Wilson et al., 1997), 11.0 to 12% (Burger & Betram, 1981) compared with the 15% required for higher hatchability. As previously cited, mortality of late stage embryos was related to the percentage of water loss (Deeming, 1995a). On the other hand, relationship between hatchability and water loss

was curvilinear, fertile eggs were most likely to hatch during incubation of between 12 and 15% of egg weight at the beginning of incubation (Simon, 1996). Although a loss of 15% of initial weight to piping is useful goal, ostriches are like other birds in showing that variability in the percentage of weight losses at which they will hatch. These weight losses can be attained by keeping eggs in relative humidity of less than 30-35% (a wet bulb temperature of less than 23.5°C). In the hatcher, higher humidity was required in order to restrict the weight loss to around 6.0-10.0% after the shell is broken (Deeming et al., 1993a). In addition, Deeming(1995_b) demonstrated the importance of water loss during incubation. Hatchability was high (at least 50.0%) when water loss was between 8.0 and 18.0% or 10.0 and 20.0%, but was low for eggs with lower (embryonic death caused by hypoxia) or higher (embryonic mortality caused by dehydration) water losses. These authors found also that embryonic mortality was still not uniformly spread across this weight loss range. However, in eggs with a low weight loss (below 10.0%) producing chick that are oedematous, sluggish and frequently have unabsorbed yolks (Bowsher, 1992 and Deeming, 1993a).

The incidence of microbial contamination was investigated in the un-hatched ostrich eggs in relation to different methods of housing. Table (3) reveals that microbial spoilage affected 51.16% (22 out of 43) of the un-hatched ostrich eggs. Both bacterial and fungal contaminants were observed. Of 43 un-hatched eggs, 12 (27.91) showed bacterial and 10 (23.56%) fungal contaminants. These results were higher than those previously recorded (Deeming, 1996a and Khafagy & Kamel, 2001). So, the microbial contaminants isolated from un-hatched eggs may be considered as one of the main causes of dead embryos. The present study confirmed that high percentage of microorganisms isolated from un-hatched ostrich eggs may play a part in decreasing hatchability rate. High incidence of microbial contamination in ostrich eggs was correlated with high percentage of water loss which indicate high shell porosity (Deeming, 1995a), suggesting that shells with larger diameter pores or those which normally thin, are more prone to spoilage. It was interesting that fungal growth and indeed microbial growth generally, may have occurred post mortem. On the other hand, bacterial infection may not have been an important cause of incubation failure (Simon, 1996).

A variety of bacteria were isolated from those un-hatched ostrich eggs containing dead embryos (Table 4). Bacterial genera included *E. coli* (10.26%); *Enterobacter cloaceae* (5.13%); *Enterobacter aerogens* (5.13%); *Citrobacter diversus* (2.56%); *Citrobacter freundii* (2.56%); *Klebsiella oxytoca* (2.56%); *Klebsiella pneumonae* (7.69%); *Proteus vulgaris* (7.69%); *Proteus mirabilis* (5.13%); *Providencia species* (2.56%); *Serratia marcescens* (2.56%); *Salmonella pullorum* (7.69%); *Pseudomonas aeruginosa* (5.13%); *Aeromonas species* (5.13%); *Streptococcus intermediate* (2.56%); *Streptococcus faecalis* (12.82%); *Staphylococcus aureus* (5.13%) and *Staphylococcus epidermidis* (7.69%). Most of these bacterial species were previously isolated from ostrich eggs, although percentage of isolates were varied (Brown, 1996; Deeming, 1996a; Gulahan et al., 1999 and Khafagy & Kamel, 2001).

From the hygienic aspects, bacterial contamination of ostrich eggs may be related improper cleaning of eggs from faecal matter in the farm (Bruce & Drysdale, 1991).

It is clear from Table (5) that fungal contaminants isolated from dead embryos in the un-hatched ostrich eggs were recognized as *Asperigillus fumigatus* (20.0%); *Asperigillus flavus* (15.0%); *Asperigillus niger* (10.0%); *Mucor* (15.0%); *Cladosporium* (5.0%); *Scedosporium* (10.0%); *Penicillium* (10.0%); *Alternaria* (5.0%) and *Stemphylium* (10.0%). Most of these fungal species were previously isolated from ostrich eggs with different percentages (Deeming, 1995a; Deeming 1996a; Gulahan et al., 1999 and Khafagy & Kamel, 2001).

The results reported in our study indicated that fungal penetration might occur within hatching ostrich eggs either to kill embryo, if present or to contaminate egg white leading to spoilage. As previously cited, ostrich eggs appear susceptible to penetration by fungal spores (Deeming, 1995a), and this may reflect the lack of shell cuticle. As previously mentioned, the hyphae of mould may weaken yolk membrane, enough to cause its rupture, after which the growth of moulds stimulated by the food released from the yolk and deteriorate the eggs (Aman et al., 1991).

On conclusion, high rater of infertility, very long storage period without appropriate conditions and spoilage of ostrich eggs may contribute to lower hatchability rate. Other factors may be also contributed in lower hatchability rate including systems of ostrich

housing, excessive water losses of the ostrich eggs during incubation period, increase percentage of dead embryos. Microbial contamination of ostrich eggs is a significant problem in lowering hatchability rate of ostrich eggs under different methods of housing especially extensive system. The higher incidence of microbial contamination of eggs laid by ostriches under different methods of breeding may be attributed to poor nest hygiene in the farming environment. To prevent microbial contamination of ostrich eggs and in turn increasing fertility and hatchability rates, the high standards of nest hygiene should be maintained and more attention is needed in both breeder bird and nest management. In addition, periodic egg weighing must be given some attention to avoid excessive or decreasing percentage of water losses from ostrich eggs during incubation.

REFERENCES

Ahmed, E.A.N. and Mokhtar, N. (1999): An evaluation of the reproductive performance of the ostrich *(Struthio camelus)* in Malaysia. Journal of Tropical and Food Science. 27 (2): 265-268.

Aman, I.; El-Shinawy, S. and El-kholy, A. (1993): Incidence of aflatoxegenic strains of *Asperigillus flavus* and *parasiticus* in table eggs. Beni-Suef Vet. Med. Res. Vol. III No. 1: 210-219.

American Public Health Association "A.P.H.A"(1987): Standard Methods For Examination of Dairy Products. 14th Ed. Washington, D.C., USA.

Angel, R. (1993): Ostrich nutrition research update.pp.135-146 in: Ostrich Odyssey. Proceeding of the meeting of the Australian Ostrich Association Inc. (Vic.). No. 217. D. I. Bryden, Ed. University of Sydney, Sydney, Australia.

Bowsher, M.W. (1992): Improvement of reproductive efficiency in the ostrich: Characterization of late embryo mortality. Ph.D. Thesis. Texas A&M University.

Brown, C.R.; Peinke, D. and Loveridge, A. (1996): Mortality in near term ostrich embryo. Br. Poult. Sci.. 37 (1): 73-85.

Bruce, J. and Drysdale, E.M. (1991): Egg Hygiene: Routes of infection. Pages 257-267 in: Avian Incubation. S.G. Tullett, ed. Butterworth-Heinemann, London, UK.

Burger, A.E. and Bertram, B.C.R. (1981): Ostrich eggs in artificial incubators: Could their hatching success be improved?. S. Africa. J. Sci. 77: 188-189.

Cruickshank, R; Dugid, J.R.; Marmoin, B.P. and Swain, R.H.A. (1975): **Textbook of Medical Microbiology. 12th Ed. Chirchill, Livingstone. Edinburgh and New York.**

Deeming, D.C. (1989): **Characteristics of unturned eggs. Critical period, retarded embryonic growth and poor albumin utilization. Br. Poult. Sci. 30: 239-249.**

Deeming, D.C. (1993): **The incubation requirements of ostrich *(Struthio camelus)* and embryos, in: Bryden, D.L. (Ed.). Ostrich odyssey:**

Proceeding of the Meeting of Australian Ostrich. Inc. (Vic). No. 217, pp1-66. Sydney University, Sydney, Australia.

Deeming, D.C. (1995a): **Factors affecting hatchability during commercial incubation of ostrich *(Struthio camelus)* eggs. Br. Poult. Sci. 36: 51-65.**

Deeming, D.C. (1995b): **The hatching sequence of ostrich *(Struthio camelus)* embryos with notes on development as observed by candling. Br. Poult. Sci. 36: 69-78.**

Deeming, D.C. (1996a): **Microbial spoilage of ostrich *(Struthio camelus)* eggs. Br. Poult. Sci. 37: 689-693.**

Deeming, D.C. (1996b): **Production, fertility and hatchability of ostrich *(Struthio camelus)* eggs on a farm in the United Kingdom Animal Sci. 63: 329-336.**

Deeming, D.C.; Ayres, L. and Ayres, F.J. (1993a): Observation on the first commercial production of ostrich *(Struthio camelus)* eggs in the UK: Incubation. Vet. Record. 132: 602-607.

Edward, P.R. and Ewing, W.H. (1972): Identification of Enterobacteriaceae. 3rd Ed. Burgess Publishing Company, Minneoplis, 15, Minnesota.

Efthymiou, C.J. and Joseph, S.W. (1974): Development of Selective Enterococcus medium based on manganese ion deficiency, sodium azide and alkaline pH. Appl. Microbiol. 28: 411.

Gonzalez, A.; Satterlee, D.G.; Moharer, F. and Cadd, G.G. (1999): Factors affecting ostrich egg hatchability. Poult. Sci. 78(9): 1257-1262.

Gulahan, D.B.; Mehra, K.N.; Chaturvedi, V.K. and Dhanesar, N.S. (1999): Bacterial and fungal floraof dead in shell embryos. Indian Vet. J. 76 (8): 750-751.

Honnas, C.M.; Jensen, J.; Cornick, J.L.; Hicks, K. and Kuesis, B.S. (1991): Proventriculotomy to relieve foreign body impaction in ostriches. J. Am. Vet. Med. Assoc. 199: 461-465.

Horbanczuk, J.O. (2000): Improving the technology of artificial incubation of ostrich (Struthio camelus) with reference to biological aspects. Prace I Materialy Zootechniczne, Zeszyt Specjalny. No. 10, 1-90 pp.

Horbanczuk, J.O.; Sales, J.; Celeda, J. and Zieba, G. (1999): Effect of relative humidity on hatchability of ostrich *(Struthio camelus)* eggs. Zivocisna Vyroba. 44 (7): 303-307.

Hulton, J.M. (1989): Brief report Topaz members on an ostrich seminar held at Texas AM University, 8th and 9th Junuary.

Jost, R. (1993): Ostriches and their commercial use. Investigations at an ostrich farm in Namibia. Justus-Liebig-Universitat Giessen, Germany. 220 pp.

Kauffmann, F.(1978): Kauffmann-White scheme. WHO BD/1, Rev.2.

Khafagy, A.A.R. and Kamel, A.M. (2001): Microbial contamination and other hatching problems causing dead-in shell in ostrich *(Struthio camelus)* eggs during artificial incubation. Vet. Med. J., Giza. Vol. 49, No. 3: 401-411.

Koneman, E.W. and Sera, F.E. (1971): Practical Laboratory Mycology. 6th Ed. Library Congress Catalog. No.78: 176121.

Koneman, E.W..; Allen, S.D.; Janda, W.M.; Schreckenberger, P.C. and Winn, W.C.Jr. (1994): Introduction to Diagnostic Microbiology. Lippincott, J.B. Company. Philadelphia, Pennsylvania 19106. pp.117-123.

Krawinkel, P. (1994): Investigations on different factors affecting natural and induced hatching in the African ostrich *(Struthio camelus)* and on other data on ostriches. Justus-Liebig-Universitat Giessen, Germany. 165 pp.

Krieg, N.R. and Holt, J.N. (1984) Bergey's Manual of Systemic Bacteriology. Vol. I. Wiliams and Wilkins Co., Baltimore, M.D. 21202, USA.

Meijerhof, K.H. (1992): Pre-incubation holding of hatching eggs. World's Poult. Sci. J. 48: 57-68.

Mellett, F.D. (1993): Ostrich production and products.pp.187-194 in: Livestock Production Systems; Principles and Practice. C. Maree and N.H. Casey, ed. Agri Development Foundation, Pretoria, UK.

Mohamed, M.A.; Fares, I.M.; Khalil, A.M. and Akmal, H.H. (2003): A behavioral vision in analysis of ostrich performance under various systems of breeding. Assiut Vet. Med. J. Vol. 49 No. 97: 78-87.

Nahm, K.H. (2001): Effect of storage length and weight loss during incubation on the hatchability of ostrich eggs *(Struthio camelus).* Poult. Sci. 80: 1667-1670.

Palumbo, S.A.; Maxino, F.; Williams, A.C.; Buchanan, R.L. and Thayer, D.W. (1985): Starch Ampicillin Agar for the quantitative detection of *Aeromonas hydrophyla.* Appl. Environ. Microbiol. 50: 1027-1030.

Philbery, A.W.; Button, C.; Gestier, A.W.; Munro, B.E.: Glastonbury, J.R.W.; Hindmarch, M. and Love, S.C.J. (1991): Anasarca and myopathy in ostrich chicks. Austr.Vet. J. 68: 237-240.

Reissbrodt, R. (1996): Ferrioxamine, E. Supplemented-enrichment and enrichment media improve various isolation methods for salmonella. Int. J. Food Microbiol.

Simon, M.J. (1996): The performance of farmed ostrich egg in eastern Australia. Prev. Vet. Med. 29 (2): 121-134.

Thatcher, F.S. and Clark, D.S. (1978): ICMSF, Microorganisms in Food I. Academic Press, New York, USA.

Tuckwell, C. and Rice, S. (1997): The Australian Ostrich Industry. Copyright. ISSN No. 1039-639X.

Tully, T.N. and Shane, S.M. (1996): Ratite management. Medicine and Surgery. 1st Ed. Krieger Publishing Co., Malbar, Florida, USA.

Wilson, H.R.; Eldred, A.R. and Wilcox, C.J. (1997): Storage time and ostrich egg hatchability. J. App. Poult. Res. 6 (2): 216-220.

Table (1): Fertility and hatchability of ostrich eggs under different methods of breeding.

System of Housing	No. of Eggs	Infertility		Fertility		Dead* embryos		Hatchability		
		No.	%	No.	%	No.	%	No.	H.I %	H.II %
Intensive with wire fence	179	117	65.36	62	34.64	5	8.07	51	31.84	91.94
Intensive with block fence	63	27	42.86	36	57.14	4	11.11	32	50.79	88.89
Semi-intensive	304	94	30.92	210	69.08	32	15.24	178	58.55	84.76
Extensive	55	39	70.91	16	29.09	2	12.5	14	25.46	35.90
TOTAL	601	277	46.09	324	53.91	43	13.27	281	46.76	86.73

H.I.=Hatchability rate of all eggs set.
H.II.=Hatchability of fertile eggs.
*=Dead embryo rates = percentage of the un-hatched fertile eggs.

Table (2): The mean and standard error (SE) for the initial weight and percentage of water loss from ostrich eggs in relation to different systems of housing.

System of Housing	No. of eggs	Initial weight (gm)		Water loss (%)	
		Mean ± SE	Range	Mean ± SE	Range
Intensive with wire fence	179	1419.5±167.4	1195-1688	14.86±1.98	14.36-15.12
Intensive with block fence	63	1405.8±143.6	1086-1675	14.58±2.10	14.12-15.08
Semi-intensive	304	1398.9±138.8	1115-1680	14.32±2.07	13.85-15.34
Extensive	55	1359.7±128.3	1010-1674	12.98±3.11	11.48-13.82
TOTAL	601	1396±144.3	1010-1688	14.19±2.14	11.48-15.34

Table (3): Incidence of bacterial & fungal contaminants of un-hatched ostrich eggs in relation to various housing systems.

System of Housing	No.	Bacteria		Fungi		TOTAL	
		No.	%	No.	%	No.	%
Intensive with wire fence	5	2	40.0	1	20.0	3	60.0
Intensive with black fence	4	2	50.0	1	25.0	3	75.0
Semi-intensive	32	8	25.0	7	21.88	15	46.88
Extensive	2	0	0.0	1	50.0	1	50.0
TOTAL	43	12	27.91	10	23.56	22	51.16

Table (4): Frequency distribution of the isolated bacterial species from dead embryos.

Bacterial species	No.	%
E.coli	4	10.26
Enterobacter cloaceae	2	5.13
Enterobacter aerogens	2	5.13
Citrobacter diversus	1	2.56
Citrobacter freundii	1	2.56
Klebsiella oxytoca	1	2.56
Klebsiella pnemonae	3	7.69
Proteus vulgaris	3	7.69
Proteus mirabilis	2	5.13
Providencia species	1	2.56
Serratia marcescens	1	2.56
Salmonella pullorum	3	7.69
Pseudomonas aeruginosa	2	5.13
Aeromonas species	2	5.13
Stereptococcus intermediate	1	2.56
Streptococcus faecalis	5	12.82
Staphylococcus aureus	2	5.13
Staphylococcus epidermidis	3	7.69
TOTAL	39	100.0

Table (5): Incidence of the isolated fungal species from dead embryos.

Fungal species	No.	%
Aspergellus fumigatus	4	20.0
Aspergellus flavus	3	15.0
Aspergellus niger	2	10.0
Mucor	3	15.0
Cladosporium	1	5.0
Scedosporium	2	10.0
Peniccilium	2	10.0
Alternaria	1	5.0
Stemphylium	2	10.0
TOTAL	20	100.0

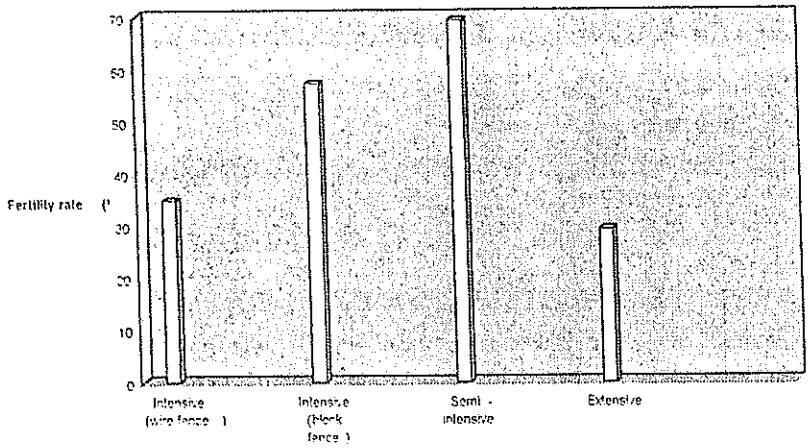
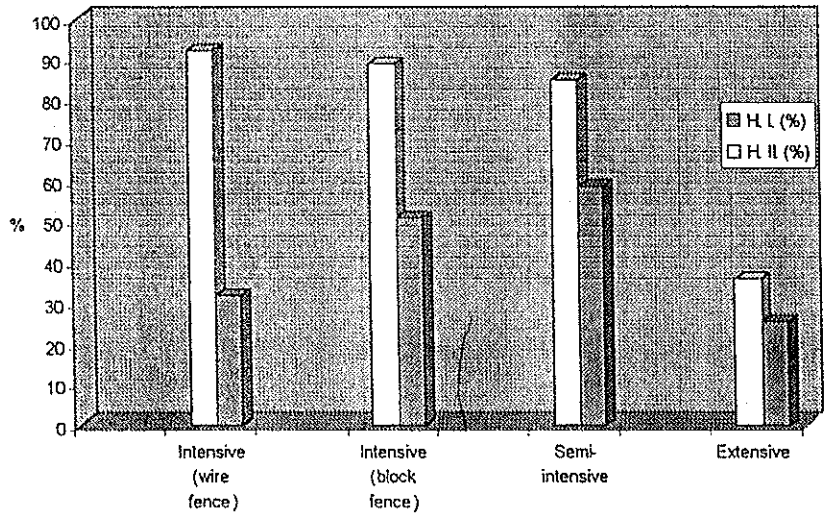


Fig. (1): Fertility rate of ostrich eggs under different housind systems.



H.I.: Hatchability of all ostrich eggs set . H.II. Hatchability of fertile eggs

Fig. (2): Hatchability of ostrich eggs in relation to various methods of breeding.

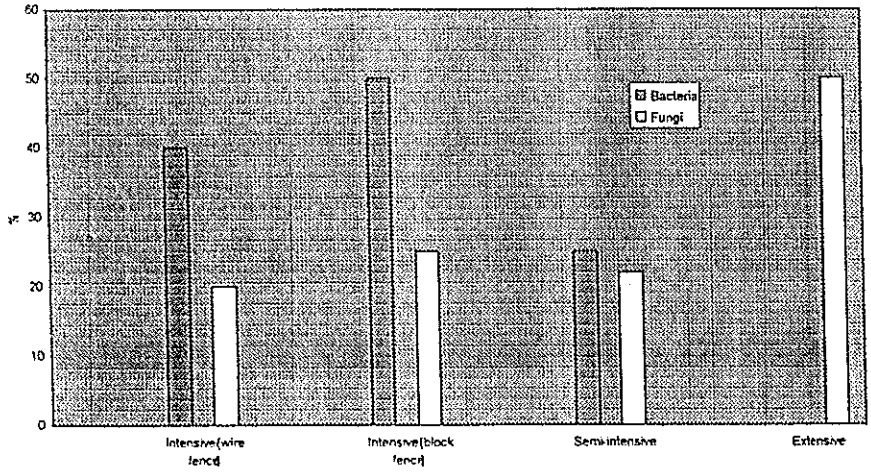


Fig. (3): Microbial contaminants of the dead embryos.

كمـــية المـــياه المفقـــودة من البيض وعدم الرعاية الصحية لمساكن النعام. ولكى نحد من التلوث البكتـــيرى والفطـــرى لبـــيض الـــنعام و بالـــتالى زيادة معدلات الخصوبة والفقس يجب الاهتمام بالـــرعاية الصـــحية للمســـاكن، بالاضافة الى الاهتمام بوزن البيض كل فترة لكى نتجنب الزيادة أو النقص فى معدلات فقد المياه منه أثناء فترة التحضين.

****