Preliminary results on the use of diagnostic ultrasonography as a management tool to quantify egg production potential in breeding ostrich (*Struthio camelus australis*) females

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ABSTRACT

An ostrich breeding flock, joined as individual breeding pairs (n = 136 pairs), was used to investigate the possibility of diagnostic ultrasonography as a method to predict the reproductive performance of ostrich females during a breeding season. Follicular activity was easily detected and quantified by using diagnostic ultrasonography. One to 8 follicles were recorded in 25 % of females scanned at the beginning of the 9-month breeding season. At the end of the breeding season, 1–3 follicles were observed in 28.7 % females. Females in which follicular activity was observed came into production earlier than those in which no follicles were observed, with the mean (±SE) number of days to the production of the 1st egg being 22.3 ± 12.5 and 87.4 ± 7.2 days, respectively. Females in which follicular activity was observed at the beginning of the breeding season, produced on average 181 % more eggs during the 1st month of the breeding season (P < 0.01) than females in which no follicular activity was observed (6.67 ± 0.70 *vs* 2.37 ± 0.41 eggs). Egg production over the first 2 months of breeding and over the entire breeding season were similarly affected (P < 0.01), with the mean number of eggs produced over the first 2 months of the breeding season being 14.7 ± 1.5 for females with observed follicular activity and 7.4 ± 0.9 eggs for females with no observed follicular activity. Females in which follicular activity was observed at the end of the breeding season produced on average 108 % more eggs (P < 0.01) during the last month of the breeding season than females in which no follicular activity was observed (2.77 ± 0.43 *vs.* 1.33 ± 0.27 eggs). There was a tendency (P = 0.06) for egg production over the last 2 months to be similarly affected (6.10 ± 0.85 *vs* 4.19 ± 0.54 eggs). No relationship with egg production over the entire breeding season was found for the end-of-the-breeding-season observations. Diagnostic ultrasonography can thus be used as a management tool to identify reproductively healthy ostrich females and also females with a higher egg production potential over a period of 2 months after or prior to assessment. Future studies should focus on the development of the technique to predict reproductive performance over entire breeding seasons for selection purposes.

Key words: breeding ostriches, diagnostic ultrasonography, flock breeding, follicular activity.

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INTRODUCTION

Egg production in commercially farmed ostriches was shown to be extremely variable[2,21]. Egg production over an 8-month breeding season was shown to vary from zero to more that 100 eggs per female. It is estimated that 70–80 % of ostrich eggs produced in South Africa originates from breeding flocks in free-ranging systems. Male and female ostriches are commonly kept in flocks with a size of 50–100 birds at a sex ratio of 6 males to 10 females[18]. Eggs are laid in communal nests and several females may visit and lay in a single nest. Commercially viable methods for the identification of eggs according to the female that produced them are presently not available. It is therefore difficult to determine either egg production on a per female basis or the parentage of the eggs produced. It is, however, most likely that the same large variation in egg production observed under pair-breeding conditions will prevail under flock mating conditions.

Breeder birds are fed a complete breeder diet during the breeding season, with the average daily feed consumption of ostrich females estimated at 2.5–3.0 kg feed (*c.* 3 % of live mass) per bird per day. It is evident that the maintenance of breeding birds is a major source of expenditure for commercial breeders and the maintenance of females with a poor egg production would be uneconomical. The repeatability of egg production in ostriches was shown to be fairly high ($t \approx 0.45$)[2,21], meaning that female ostriches would tend to achieve similar rankings for egg production both within and across production seasons. It is likely that feed costs may be reduced substantially without a marked reduction in egg production if poor producers in breeding flocks can be identified and culled. No practical system for this purpose is in place at present. The success of diagnostic ultrasonography in the determination of reproductive success in, for example, domesticated farm species[4–9,11,19,22], llamas[1] and camels[16] led to the idea of using diagnostic ultrasonography as a tool to assess the reproductive fitness of the ostrich under commercial farming conditions.

Against this background we investigated the feasibility of diagnostic ultrasonography for the quantification of egg production potential of adult breeding ostrich females. This paper presents preliminary findings with regard to the method as well as the relationship between ultrasonograms and female egg production.

MATERIALS AND METHODS

Animals, management and recordings

The ostrich breeding flock (n = 136 breeding pairs) at the Klein Karoo Agricultural Development Centre, Oudtshoorn, was used in the study. The flock, its origin and management are well documented in Van Schalkwyk *et al.*[9,21] The entire breeding flock was subjected to a 3-month rest period, before being joined as breeding

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pairs in 0.25-ha camps. The breeding birds received a balanced breeder diet at 2.5 kg/bird/day and had free access to clean drinking water. The breeding season commenced on 24 May 1999 (day 1) and ended on 29 February 2000 (day 281). The ages of the females in this study varied between 2 and 13 years.

Females were subjected to diagnostic ultrasonography at the beginning and end of the 1999/2000 breeding season[11]. A Pie Medical 100LC Vet scanner fitted with a 3.5/5.0 MHz dual-frequency curved-array transducer (Philips South Africa (Pty) Ltd.) was used for this purpose. Females were scanned at a frequency of 3.5 MHz and ultrasound coupling gel was used during each scanning procedure to ensure sufficient lubrication between the surface of the transducer and the body of a female. The transducer was placed on the ventral, non-feathered area, caudal to the right thigh of each female. During each scanning procedure, as many as possible follicles in the scanning field (*i.e.* a single-plane image) were captured and stored on disc for later analysis. Each ultrasonogram was printed out at 100 % of the size of the on-screen version and was used to count the number of follicles and to measure follicle diameter. The presence and number of discernible follicles were noted for each individual ultrasonogram, and the average diameter (in millimetres) of the observed follicles was measured and calculated for each case.

Eggs were collected daily during the afternoons and were recorded on an individual basis for each female.

Fig. 1: **Ultrasonogram of a breeding ostrich female, showing 5 distinct follicles. The largest follicle has a diameter of 63 mm.**

Statistical analyses

Monthly egg production rates were averaged for all breeding females. Average egg production of females with different numbers of follicles discernible at the beginning of the breeding season were calculated for the 1st month of production, the first 2 months of production, and the entire 9-month breeding period. One-way analysis of variance procedures were used for this purpose[17]. The average subsequent egg production of females where two or more follicles were observed was also compared to that of females where no follicles could be discerned. The same procedure was followed for relating ultrasonograms at the end of the breeding season to egg production during the last month of breeding, the last 2 months of breeding and during the entire breeding season.

RESULTS

Follicles (or ova) of different sizes and stages of maturity were detected in the ostrich females during scanning. The different views obtained during the imaging are depicted in Figs 1 and 2 that represent ultrasonograms of ovaries with an extensive degree of follicular development. A developing follicle appears as a round anechoic image with a slightly more hyperechoic central area in the middle of the follicle. This hyperechoic area appears to be the developing follicle's attachment to the ovary. A 'normal' ostrich ovary will contain a number of follicles of different sizes, ranging from 12.6 to 120 mm in diameter. The extent of follicular development of an ovary determined the number of follicles that could be captured in each field.

One or more follicles could be discerned in 34 females (25 %) at the beginning of the breeding season and in 39 females (28.7 %) at the end of breeding season.

Fig. 2: **Ultrasonogram of a breeding ostrich female, showing 5 distinct follicles. The largest follicle has a diameter of 58 mm and the smallest follicle a diameter of 18 mm.**

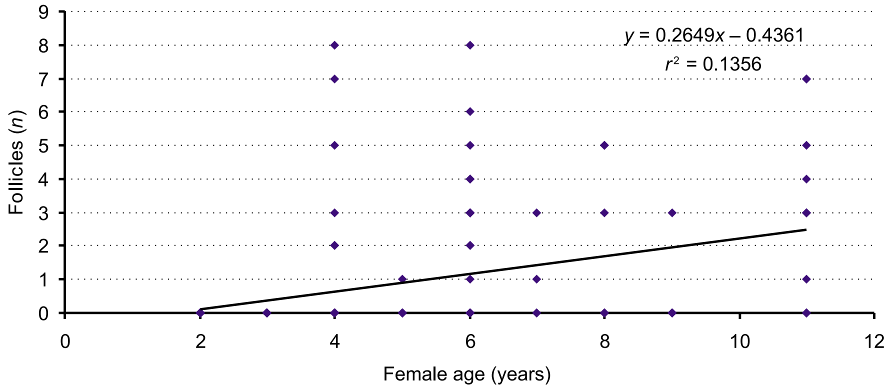

Fig. 3: **Relationship between female age and number of follicles noted with diagnostic imaging at the beginning of the 1999/2000 breeding season.**

At the beginning of the breeding season, females of three years and younger generally showed considerable less follicular development than females aged 4 years and older, with no follicles observed in 2-year-old females (Fig. 3). The number of follicles was unrelated to female age when assessed at the end of the breeding season.

Egg production over the 1st month and the first 2 months generally increased ($P < 0.05$) in females where 2 or more follicles were observed during scanning at the beginning of the breeding season. When females with least 1 follicle (Group A) were pooled, this group deviated from those with no follicles (Group B) (Table 1). Group A came into production earlier than Group B, with the mean (±SE) period in days from the commencement of the breeding season to the production of the 1st egg being 22.3 ± 12.5 and 87.4 ± 7.2 days, respectively. Group A produced on average 181 % more eggs during the 1st month of breeding (mean ± SE) than Group B ($P \leq 0.01$; 6.7 ± 0.7 *vs.* 2.4 ± 0.4 eggs). Egg production over the first 2 months of breeding and over the entire breeding season were similarly affected ($P < 0.01$). The mean number of eggs produced over the first 2 months of the breeding season were 14.7 ± 1.5 for Group A, compared to 7.4 ± 0.9 eggs produced by Group B. Corresponding means for the entire season were respectively 48.5 ± 4.4 and 35.3 ± 2.5 eggs produced over a breeding period of 281 days.

The number of eggs produced during the last month of the breeding season, during the last 2 months of the breeding season and during the entire breeding season in relation to the number of follicles observed at the end of the breeding season are presented in Table 2. Fewer follicles, but with a larger diameter, were observed at the end of the breeding season. Females where follicular activity was observed at the end of the breeding season produced on average 108 % ($P < 0.01$) more eggs during the last month of the breeding season than females with no follicular activity (2.8 ± 0.4 *vs.* 1.3 ± 0.3 eggs). There was a tendency ($P = 0.06$) for egg production over the last 2 months to be similarly affected (6.1 ± 0.9 *vs* 4.2 ± 0.5 eggs). Egg production over the entire season was unrelated ($P \geq 0.05$) to the number of follicles at the end of the breeding season.

The number of follicles observed was negatively correlated ($P < 0.01$) with mean follicle diameter, with the correlation between number of follicles observed and mean follicle diameter amounting to –0.69 at the beginning of the breeding season and –0.72 at the end of the breeding season. The phenotypic correlation between the number of follicles observed at the beginning of the breeding season and that observed at the end of the breeding season was relatively low ($r = 0.20$; $P < 0.05$).

DISCUSSION

Follicle activity in ostrich females was clearly discernible when diagnostic ultrasonography was used. During imaging, it is impossible to capture all possible follicles in 1 image field and in each case, as many as possible follicles were captured and stored on disc for later analysis. As only a limited number of follicles (*i.e.* fewer than what was actually observed in each female) could be captured in each ultrasonogram, each female was given a

Table 1: **Mean** (±SE) **number of eggs produced during the 1st month of the breeding season, during the first 2 months of the breeding season and during the entire breeding season, when classified according to the number of follicles observed by diagnostic ultrasonography at the beginning of the breeding season.**

Number of follicles observed	Number of ostriches	Number of eggs		
		First month	First 2 months	Entire season
0	102	2.4 ± 0.4	7.4 ± 0.9	35.1 ± 2.5
1	4	2.8 ± 2.0	7.5 ± 4.3	41.3 ± 12.7
2	4	7.5 ± 2.0	16.5 ± 4.3	52.0 ± 12.7
3	12	6.3 ± 1.2	14.3 ± 2.5	43.4 ± 7.4
4	3	10.0 ± 2.4	23.3 ± 5.0	66.0 ± 14.7
5	5	9.0 ± 1.8	16.6 ± 3.9	42.8 ± 11.4
6+	6	6.0 ± 1.7	13.2 ± 3.5	53.3 ± 10.4

Table 2: **Mean** (±SE) **number of eggs produced during the last month of the breeding season, during the last 2 months of the breeding season and during the entire breeding season, when classified according to the number of follicles observed by diagnostic ultrasonography at the end of the breeding season.**

Number of follicles observed	Number of ostriches	Number of eggs		
		Last month	Last 2 months	Entire season
0	97	1.3 ± 0.3	4.2 ± 0.5	37.4 ± 2.6
1	18	3.3 ± 0.6	7.8 ± 1.3	40.7 ± 6.1
2	8	2.4 ± 1.0	4.8 ± 1.9	44.8 ± 9.2
3+	13	2.2 ± 0.7	4.5 ± 1.5	38.0 ± 7.2

score in terms of the extent of ovary development. These data, however, will be presented elsewhere. In this study, females were scanned on the right side only. Although the ovary is located in the left half of the female's body, better ultrasonograms have been obtained in most cases from the right hand side. In the next phase of this study, females will be scanned on both sides to determine the correlation between ultrasonograms obtained from the left and right side of a female.

The number of follicles observed was related to the egg production of individual females over the short term, *i.e.* within 1 or 2 months of assessment at the beginning of the breeding season. Selection based on the visibility of 1 or more follicles at the onset of the breeding season would have resulted in marked improvements in egg production over the first 2 months following assessment. A similar conclusion was reached with regard to scanning at the end of the breeding season. Although lower levels of egg production were attained during the last month of the breeding season, it was still possible to identify females with higher levels of egg production over the last month prior to scanning. However, the ability to accurately identify highly productive individuals over a slightly longer term (2 months) was compromised to some extent.

This study agrees with previous reports that egg production in ostriches is highly variable.[2,3,21] The wide variation in egg production within female age groups is clearly illustrated in Fig. 3. The fact that no follicles were observed in the 2-year-old females that were in their 1st breeding season, forced the regression of number of follicles scanned on female age in a positive direction. The absence of follicular activity in 2-year-old females at the beginning of the breeding season and their consistently lower egg production can probably be ascribed to an age threshold that young females have to pass in order to be reproductively mature to enter a breeding flock. Culling of ostrich females solely on egg production and/or ultrasonograms is therefore likely to discriminate against young females under circumstances where flock breeding is practiced, especially when their age is unknown. Previous results have shown that egg production of ostrich females at a young age predicted subsequent egg production fairly well[21] and that egg production generally increased with age to reach a maximum at approximately 9 years of age.[2] It is advisable to take this information into account under conditions where ostrich females of unknown age are scanned for egg production.

The correlation between ultrasonograms obtained at the beginning and end of the breeding season was relatively low (r = 0.20). Factors contributing to this observation is that older, highly productive birds entered a natural rest period at the end of the breeding season, and the 2-year-old females only came into production towards the end of the breeding season.

Two aspects remain as cause for concern with regard to the practical application of the technique. First, in the present study only a small percentage of females that were scanned actually showed follicular activity at assessment. It is clearly not viable to retain such a minority of the total number of females available when breeding under commercial conditions. The only possible exception may be a breeding operation with an almost unlimited access to resources in terms of female breeding birds. Given the high cost of growing and finishing breeder birds, such conditions are unlikely. Second, the ability to predict egg production over the entire breeding season was limited, especially when the females were scanned at the end of the breeding season. Based on the results in the present study, diagnostic ultrasonography can be used to identify reproductively healthy females but cannot be used as a selection tool to cull females at the end of a breeding season.

In order for the practice of diagnostic ultrasonography to become viable in the management of commercial ostrich breeding flocks, these issues need to be addressed. It is also necessary to ensure that a greater proportion of the breeding females is at a stage of ovulation when scanning is performed. The objective should thus be to find ways of strategically stimulating ostrich females to higher levels of sexual activity at the beginning of a breeding season. This could be done, *e.g.* by delaying the onset of the breeding season, when natural sexual activity ought to be higher. Alternatively, other practices like teasing and flushing that were found to enhance sexual activity in other livestock species[13–15] can also be considered. These practices are also widely advocated in the ostrich industry.[10,18]

CONCLUSION

Diagnostic ultrasonography can be used to identify reproductively healthy females and can be used as a diagnostic tool to identify potentially highly productive females at the beginning of a breeding season. However, certain issues should be addressed before it can be applied on a large scale commercially. In the present study, only a small proportion of females displayed follicular activity when scanned, making these results less suitable for selection purposes under most conditions where only small numbers of breeding females are available. It was also complicated by the fact that younger females were less likely to show follicle development.

Farming practices to maximise and synchronise ovulation and egg-laying cycles at the commencement of the breeding season should also be investigated. The investigation of teasing and flushing effects on ostrich egg production may not only provide clarity with regard to the importance of these practices to efficient production systems, but may also prove indispensable in the practical application of diagnostic ultrasonography in the broader industry. It is also necessary to address the need to improve long-term predictions regarding egg production for ostrich females, based on a single scanning measurement. These aspects should be addressed in the further development and adaptation of diagnostic ultrasonography as a management tool to improve reproduction efficiency in commercial ostrich breeding flocks.

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