SPATIAL-TEMPORAL VARIATION IN SEX RATIO AND GROUP SIZE OF OSTRICHES (*STRUTHIO CAMELUS*) IN THE SERENGETI NATIONAL PARK AND ENVIRONS IN NORTHERN TANZANIA

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ABSTRACT

A study was conducted on variation in sex ratio and group size of ostriches (Struthio camelus) in Serengeti National Park and adjacent partially protected areas in northern Tanzania. Data were collected for two years (2005- 2006), along 388 km of roads. The two areas were compared with respect to ostrich sex ratio (male: female) and group size. Seasonal variation of these variables (sex ratio and group size) was also determined. Repetitive sampling showed an overall female-skewed sex ratio, which was significantly different from unity. The sex ratio inside the National Park was also significantly skewed towards females, whereas that in the partially protected areas was skewed in favour of the males. There was a significant difference in sex ratios between the two areas (Chi square: $\chi^2 = 48.041$, DF = 2, $p<0.001$). The grand median group size was 3 birds and the same median group size was obtained both in the National Park and partially protected areas, and there was no significant difference in group sizes between the areas (Median test: $\chi^2 = 1.861$, DF = 1, $p = 0.173$) although bigger groups were observed in the park than in the partially protected areas. In addition, there was a tendency for ostriches to form significantly larger groups in the wet season than dry season in both areas ($p<0.05$). Natural predators of ostrich were found to be significantly higher inside the National Park than outside it ($p<0.05$). The presence of natural predators and seasonal variations may have influenced the present results.

Keywords: group size – ostrich – Serengeti – sex ratio – *Struthio camelus*

INTRODUCTION

Female-skewed adult sex ratios frequently occur in mammals (Fischer and Linsernmair 2002, Holland *et al.* 2002, Setsaas *et al.* 2007), and also occur in birds that exhibit polygamous behaviour (e.g. ostrich, *Struthio camelus*) or socially-monogamous mating systems with high female parental care (Donald 2007). However, these sex ratios are likely to change if the populations are strongly subjected to factors such as predation and trophy hunting (Donald 2007).

Indigenous to Africa, the ostrich is found in a variety of open habitat types (Brown *et al.* 1982), avoiding areas with thick bush or of heavy tree cover. Semi-arid, open and short grass plains are usually associated with high densities of ostriches. They tend most often to be solitary birds or in pairs, whereas large social groups, usually consisting of many females, are less frequent (Roberts *et al.* 1970, Bertram 1992).

Previous workers (e.g. Sauer and Sauer 1966, Hurxthal 1979, Bertram 1992) have reported a female-biased sex ratio in ostriches. Differential male mortality (Bertram 1992, Donald 2007) was a suggested reason for female-skewed sex ratios. Seasonal changes, quantity and quality of food may also influence distribution and grouping in birds (McNaughton and Georgiadis 1986, Skarpe and Bergström 1986). In the Serengeti ecosystem, little is known about the natural variation in adult sex ratios, although studies have indicated that predation (Nowell and

Jackson 1996, Packer *et al*. 2005) and wildlife exploitation (Herremans 1998, Ostrowski *et al*. 2001, Sinclair *et al*. 2002, Thiollay 2006) alter animal sex ratios.

This study examines variation in ostrich sex ratio and group size in relation to conservation status, season and predator abundance between the Serengeti National Park and adjacent partially protected areas. No previous studies on ostriches have compared demographic variations between the two areas. Partially protected areas (IUCN category ≤ IV) (UNEP-WCMC 2005) function as buffer zones to protected areas in eastern and southern Africa, and usually allow some form of consumptive use of natural resources within their boundaries whereas in the National Park there is total protection.

STUDY AREA AND METHODS

Study area

The study was conducted in Serengeti National Park (SNP) with an area of 14,763 km^2 and adjacent partially protected areas, Ikorongo (563 km^2) and Grumeti (416 km^2) Game Reserves and Ikoma Open Area (600 km^2), northern Tanzania (Fig. 1). In this study, partially protected areas and outside the National Park will be used interchangeably. The study was carried out between January 2005 and December 2006. In the south of SNP, there are short and long grass plains and an extensive block of *Acacia* savannah woodland is found at the centre of SNP (Herlocker 1976). The western part of SNP, which extends up to the edge of Lake Victoria, is a region of wooded grassland and woodlands dominated by *Acacia* species (Herlocker 1976). The climate is usually warm and dry with mean temperatures varying between 15°C to 25°C. The rains in the Serengeti ecosystem fall in a bimodal pattern, with the short rainy season between November and January and the long rainy season between March and May, when there are heavy downpours (Norton-Griffiths *et al*. 1975). In this study the dry season was from June to October and wet season was November to May.

Sex identification and group size

The line transect sampling method (Buckland *et al*. 2001) was used to record ostriches. The method based on records of ostriches from the line to each ostrich detected when the observer travels along the line (we scanned up to 1,000 m). Two observers were involved in observing ostriches covering a sector of 180° to the right and left sides of the transect, respectively. Ostriches were detected from a vehicle (Land rover pickup) travelling at 15–20 km/h. Upon detection a rangefinding binoculars (i.e. Leica Geovid 7 x 42 BDA) was used to determine the sex of the adult birds, size of the group and age (adult >2 years, juveniles <2 years or chicks <3 months). Each group of ostriches was recorded as one observation. The transects were systematically spaced and superimposed on the existing road system in the study area covering a total length of 388 km. Average length of the road was 77.6±44.8 (SD) km (range = 30-145 km). This was necessary due to the ruggedness of the terrain and because cutting new tracks was not allowed. A total of 5 transects were recorded, sampling was conducted once a week in different parts of the National Park and partially protected areas. Data collection normally began at 08h00 and ended at approximately 18h00. Ostriches prefer open habitat and therefore were easily seen. Vegetation type was categorized according to Kikula (1980) and Caro (1999).

Sex ratio is strictly defined as the proportion of males to females in a given population of breeding adults (Mayr 1939). In this study, therefore, immature ostriches, juveniles and chicks were excluded from the sex ratio analysis. Male and female ostriches at these ages are very similar in appearance and their sex can only be determined by examining

their sexual organs, though this examination can still be difficult (Samour *et al*. 1984, Gandini and Keffen 1985). Identification of adult ostriches based on plumage colour. The sexual dimorphic plumage is present after about two years of age; the feathers of adult males are mostly black, with white primaries and a white tail whereas females are greyish-brown (Bertram 1992).

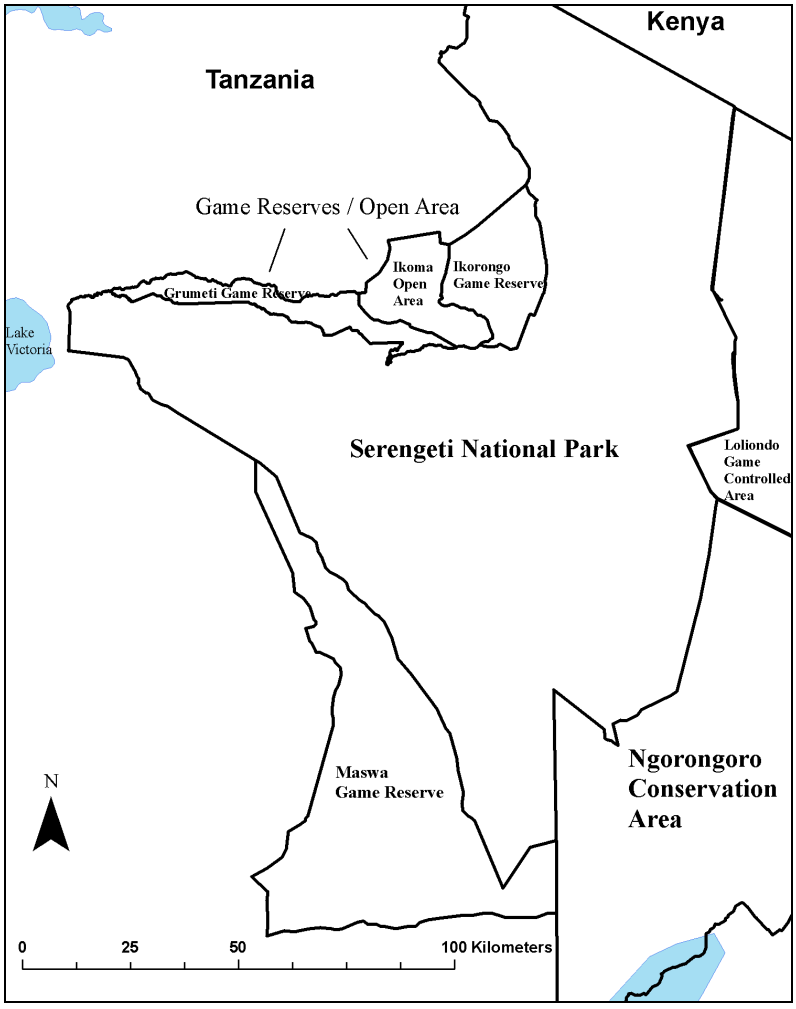

Figure 1 Map showing the Serengeti National Park, Grumeti and Ikorongo Game reserves and Ikoma Open Area.

Predators

Predators were recorded in a similar manner to ostriches upon their sighting, by stopping the car and recording the group size and species along the established road networks. The main ostrich predators are lion (*Panthera lion*) and hyena (*Crocuta crocuta*) (Kruuk 1972, Schaller 1972, Bertram 1992), although cheetah (*Acinonyx jubatus)*, leopard (*Panthera pardus)* and wild dog

(*Lycaon pictus*) can be a threat (Sinclair *et al*. 2003). For comparing the abundance of main ostrich predators and their influence on ostrich sex ratios and group sizes, only hyena and lion were recorded.

Statistical analyses

The χ^2 test was used to examine variation in sex ratio between the seasons and areas. The group size data was positively skewed due to some large values that drastically changed the mean group size, therefore, the median was used as a measure of central tendency. The *Median test* (Mood 1950) was used to test spatio-temporal differences between the median group sizes. The procedure involved determination of the grand median for all the data in both samples and then a 2x2 contingency table was set. This contingency table was them analysed by Chi square test. Chi-square analysis of contingency tables was also used to test association between group sizes (i.e. solitary individuals and two or more individuals) and season (i.e. dry and wet) and group size and area (inside and outside the park). The Student's *t* test for independent samples was used to determine the variation in abundance of predators between the two areas. SPSS 15.0 (SPSS 2006) and MS *Excel 2007* were used for analyses. The results were recorded as significant at $P \leq 0.050$.

RESULTS

Sex ratio

A total of 2632 observations was obtained. The apparent overall sex ratio for the study area was female-biased (1:1.4) and was significantly different from unity (Chi square: $\chi^2 = 196.43$, n = 6815, DF=1, $P < 0.001$). The sex ratio inside the National Park was biased towards females (1:1.5, n = 6160, Chi square test: $\chi^2 = 238.46$, DF = 1, $P<0.001$) and in the partially protected area the sex ratio was biased in favour of males (1:0.85, n = 655, Chi square test: $\chi^2 = 4.618$, DF = 1, P = 0.031). In the sampled population the ratio of males to females was not the same between the park and the partially protected area (Chi square test: $\chi^2 = 48.041$, n = 6815, DF = 1, $P<0.001$). However, there was no significant difference in sex ratios of ostriches between wet and dry seasons within the areas i.e. National Park and partially protected areas, indicating that seasonal variations have no influence in the sex ratios.

Group size

Although ostriches frequently occurred singly, they also formed groups. The grand median group size was 3 birds and the same median group size was obtained both inside and outside the National Park. The median test showed that the two samples (inside and outside the park) came from populations with identical medians ($\chi^2 = 1.861$, DF = 1, p = 0.173). This indicates that ostrich group formation is more or less similar inside and outside the park. Most groups of ostriches had fewer than five individuals in a group, but there were also some very large groups particularly inside the National Park as well as in the wet season (Fig. 2). Despite similar median group sizes in the wet and dry seasons (Fig. 2) the median test indicated that there tended to be larger groups in the wet than dry season both inside ($\chi^2 = 31.32$, n = 1177, DF = 1, p = 0.001) and outside ($\chi^2 = 5.12$, n = 107, DF = 1, p = 0.02) the National Park.

Singletons versus groups

Solitary ostriches commonly occurred during the dry season and their frequency decreased in the wet season (Fig. 3). The test for independence of groups and seasons and groups and area showed a significant association. Ostriches tended to occur as singletons in the dry season and groups in the wet season both inside ($\chi^2 = 38.603$, DF = 1, n = 2427, $p<0.001$) and outside the park ($\chi^2 = 37.018$, DF = 1, n = 205, $p<0.001$), indicating that more singletons are found during the dry season, with ostriches aggregating during the wet season, which is

the breeding season. In addition, the occurrence of singletons and formation of groups occurred independently of the area (χ^2=1.089, DF = 1, n = 2632, p = 0.297) i.e. ostriches had a similar pattern of forming groups inside and outside the park.

Predators

There were larger numbers of lions (t = 3.337, DF=74, P<0.0010) and hyenas (t= 24.448, DF = 126, P<0.0005) inside the National Park than outside the Park.

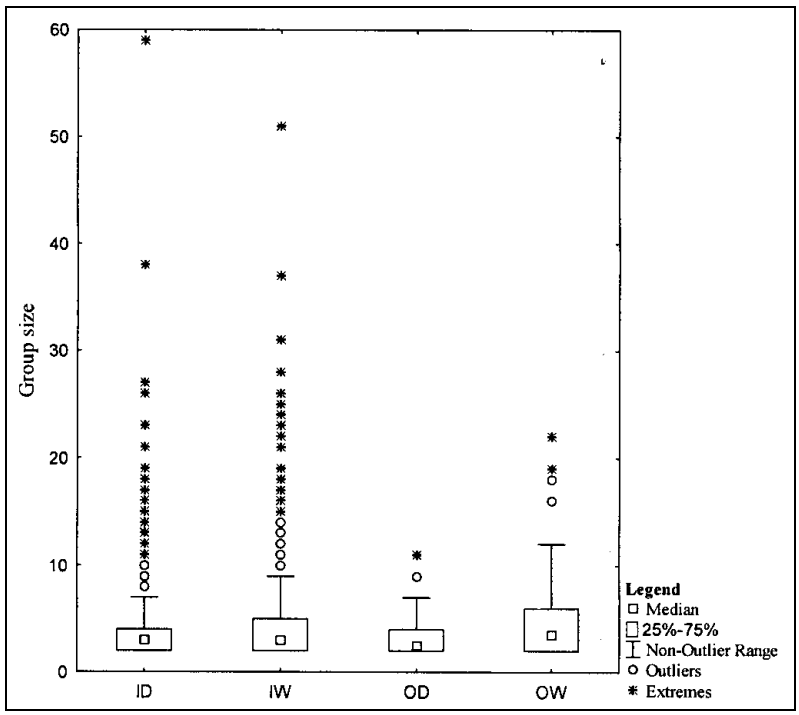

Figure 2: Seasonal comparison of group sizes inside and outside the Serengeti National Park, Tanzania, Jan 2005- Dec 2006. (ID = inside the park in the dry season, IW= inside the park in the wet season, OD= outside the park in the dry season and OW= outside the park in the wet season. The thick lined inner box represents the median, the thin lined box the interquartile range, and the vertical lines span the range of the values lying between the interquartile and 1.5 times the interquartile range. Outliers and extremes beyond this are represented by circles and asterisks respectively. The difference in group sizes was statistically significant between seasons both inside and outside the National Park (the median test, $p < 0.05$).

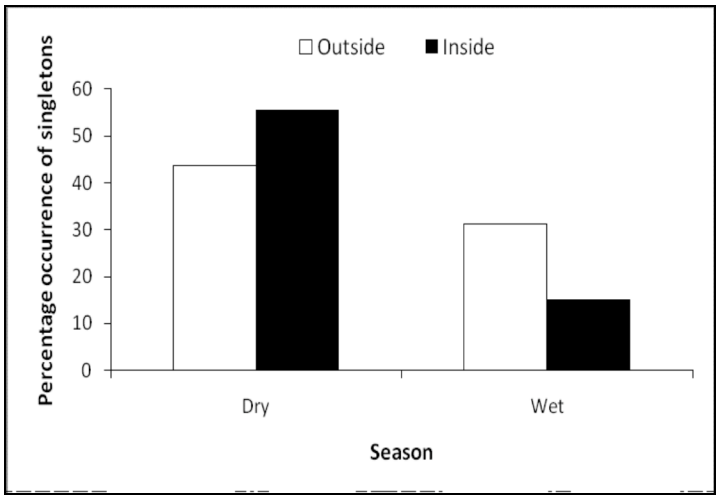

Figure 3: Seasonal occurrence of single ostriches inside and outside the Serengeti National Park, Tanzania, Jan 2005- Dec 2006.

DISCUSSION

Sex ratio

The present study supports previous findings that there is an overall female-biased sex ratio among adult ostriches (Sauer and Sauer 1966, Hurxthal 1979, Bertram 1992). However, the sex ratio in the partially protected areas was biased towards males. The observed results can be attributed to the presence of more predators inside the National Park than outside. Many large predators are confined to protected areas or occur in regions remote from human activities (Nowell and Jackson 1996, Nyahongo 2004, Packer *et al*. 2005). During data collection, two male ostrich carcases were recorded inside the National Park with lion footprints nearby (Magige, Pers. Obs.), a possible indication of lion predation. During the breeding season, males commonly sit on nests at night (Bertram 1992) and since lions tend to hunt mostly by night or in the early mornings chances of male ostriches being predated are high. Records of differential predation on male ostriches by lions are also available elsewhere (Pienaar 1969, Schaller 1972, Rudnai 1974, Bertram 1992). In addition, ostriches are also hunted by villagers located in the west of Serengeti National Park and the white male feathers have been used as ornaments (Magige *et al.* 2009a). Although sex ratios might be explained by differential predation on males, other factors such as hunting, and egg collection might be important determinants of this variable (*ibid.*).

Group size

The chicks and juveniles are strictly gregarious and always remain in compact groups (Bertram 1992). Adults are semi gregarious and tend to be attracted to each other for short periods. They were often solitary, particularly during the non breeding season and large groups were quite rare, a situation that has also been observed by Roberts *et al*. (1970) and Bertram (1992). Despite the fact that very large groups were observed in the National Park, the grouping pattern of ostriches for small groups was found to be more or less similar inside and outside the National Park. The frequency of single individuals decreased during the wet season indicating that formation of groups was associated with seasonality and breeding. More and larger groups were found in the wet season than in the dry

season both inside and outside the park. In Serengeti ecosystem, ostriches start to breed late in the dry season (Bertram 1992, Magige *et al*. 2009b), and a similar trend has been observed in other parts of Africa (Sauer and Sauer 1966, Jarvis *et al.* 1985). Large groups inside the National Park could be attributed to the presence of high populations of their natural predators causing the ostriches to aggregate as an anti-predator strategy. Sociality is related to predator defence (Elgar 1989), but there are other advantages to living in groups, such as protection from predators through dilution (Hamilton 1971) and detection effects (Pulliam 1973), improvement of foraging, and efficiency of energy expenditure (Bertram 1980, Hammer and Parrish 1998). Furthermore, there are more ostriches inside than outside the park and therefore formation of large groups inside the park could also be attributed to their large number particularly during wet season when they have chicks.

Illegal hunting is more widespread outside than inside the National Park (Arcese *et al*. 1995, Holmern *et al*. 2006) although there is also some illegal hunting inside the park (Kalternborn *et al*. 2005). The reaction of birds to human approaches can be equated to the perceived threat of predation (Lima and Dill 1990), since wildlife reacts to humans and predators in similar ways (Frid and Dill 2002). Birds were expected to form large groups in partially protected areas as a means of anti-predator defence but Fig. 2 indicates that the biggest groups outside were smaller than the biggest groups inside the park, indicating that ostriches did not respond to increased hunting pressure by forming large groups outside the National Park.

CONCLUSION

Adult sex ratios are difficult to estimate in an unbiased way due to differences between sexes in their behaviour and ecology (Vanderkist *et al*. 1999). However, skewed adult sex ratios have been found in wild bird populations and are probably due to differential mortality between the sexes as suggested by Donald (2007). Although the results suggest absence of human influence on group size, detailed studies are recommended in a long run on the demography of birds in the partially protected areas.

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