The seasonal distribution of savannah elephants (*Loxodonta africana africana*) in Nazinga Game Ranch, southern Burkina Faso

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Abstract

Elephant wet and dry season distributions were compared at Nazinga Game Ranch in southern Burkina Faso. Dropping counts along line transects provided an index of occupancy at the end of each season: wet 2006, dry 2007 and dry 2008. We expected that the distribution of elephants would differ between the dry and the wet seasons, with elephants concentrating around water sources in the dry season and spreading out across the landscape during the wet season. Elephants were found to be clumped in both wet and dry seasons, although the degree of aggregation was much greater in the dry seasons, especially in the drier year of 2008. Human populations have increased dramatically around Nazinga in the last 15 years, and we speculate that the increasing abundance of crops outside in the wet season may influence the distribution of elephants inside the ranch area.

Key words: Nazinga, Burkina Faso, elephants, distribution, wet season, dry season

Résumé

Les distributions d'éléphants des saisons pluvieuse et sèche, ont été comparées au Ranch de Gibier de Nazinga. L'indice d'occupation des éléphants dans le ranch à été estimé au moyen des mesures de déjections le long des transects, en fin de saison pluvieuse 2006 et en fin de saisons sèches 2007 et 2008. Les attentes étaient que la distribution des éléphants en saison sèche soit différente de celle de la saison pluvieuse; avec un regroupement des éléphants autour des points d'eau en saison sèche, puis leur dispersion dans les paysages de toute l'aire du ranch pendant la saison pluvieuse. Il a été observé que les éléphants étaient regroupés aussi bien en saison sèche qu'en saison pluvieuse; même si le degré d'agrégation était plus important en saison sèche particulièrement en 2008 qui était l'année la plus sèche. La densité des populations humaines a augmentée considérablement autour de Nazinga, pendant les 15 dernières années; nous soupçonnons que la disponibilité des cultures hors du ranch pendant la saison pluvieuse, pourrait influencer la distribution des éléphants à l'intérieur du ranch.

Introduction

The African elephant (*Loxodonta africana*) is a water dependent species. In arid habitats the elephants tend to aggregate near permanent water holes during the dry season when water is scarce; while during the wet season, they disperse (Jachmann 1988; 1992; Barnes et al. 2006; Kioko et al. 2006; Canney et al. 2007; Leggett 2009). Therefore, we expected that elephant distributions at Nazinga would differ between seasons, with a clumped distribution in the dry season and a random (Poisson) distribution in the wet season. The objective of this paper is to describe and compare the elephants' seasonal use of the landscape in the Nazinga Game Ranch during the wet and dry seasons.

Study area

The Nazinga Game Ranch lies in southern Burkina Faso between 11°1' and 11°18' N and between 1°18'and 1°43' W. It covers an area of about 98,100 ha. A portion of its southern boundary runs along the international border between Burkina Faso and Ghana (Fig. 1). The area is relatively flat with a mean altitude of 300 m (Spinage 1984), and is traversed by the valley of the Sissili River and two of its tributaries, the Dawevélé and the Nazinga Rivers, which flow seasonally. Soils in the ranch are primarily lithosols on ironstone pavements and reworked tropical ferruginous soil above sandy clay material at depth (Brown 1987).

Nazinga lies in the soudanian zone (Founier 1991), and in the East Black Volta phytogeographic district of the southern soudanian sector (Guinko 1984) where climate is characterized by a dry season running from October to May and a rainy season from June to September. The mean annual rainfall is about 900 mm. Figure 2 shows the total wet season rainfall (June to September) for each year. The vegetation consists of tall grass tree/shrub savannah, showing mainly riverine forest, savannah woodlands and shrub savannah (Guinko 1985).

The Nazinga Game Ranch is a protected area and harbours one of the most important savannah elephant populations in West Africa (Blanc et al. 2007). The most recent estimate of the elephant population by means of direct foot count along line transects was 2173 (95% confidence interval: 882, 5355) (Hema et al. 2009). The main management activities in the ranch include game hunting inside the ranch, game viewing, education and community-based activities, law enforcement, habitat management and research. There are 10 villages in the immediate limits of the ranch. With fewer than 10 inhabitants per km^2 the Nazinga Ranch and its surrounding areas have one of the lowest human densities of the country. However, since the Sahelian drought in the 1970s, the area has been subject to increased immigration from northern populations, representing 76% of the national total internal migration (Ouedraogo 1997; Kessler and Geerling 1994). The 2006 census data, which is available at the local level (prefecture of Bieha and Sia health centre), estimated the human population of the 10 villages at 8148 inhabitants. The main activity of the communities is agriculture with the most important food crops being maize, sorghum, millet, yams, groundnuts, cotton and beans.

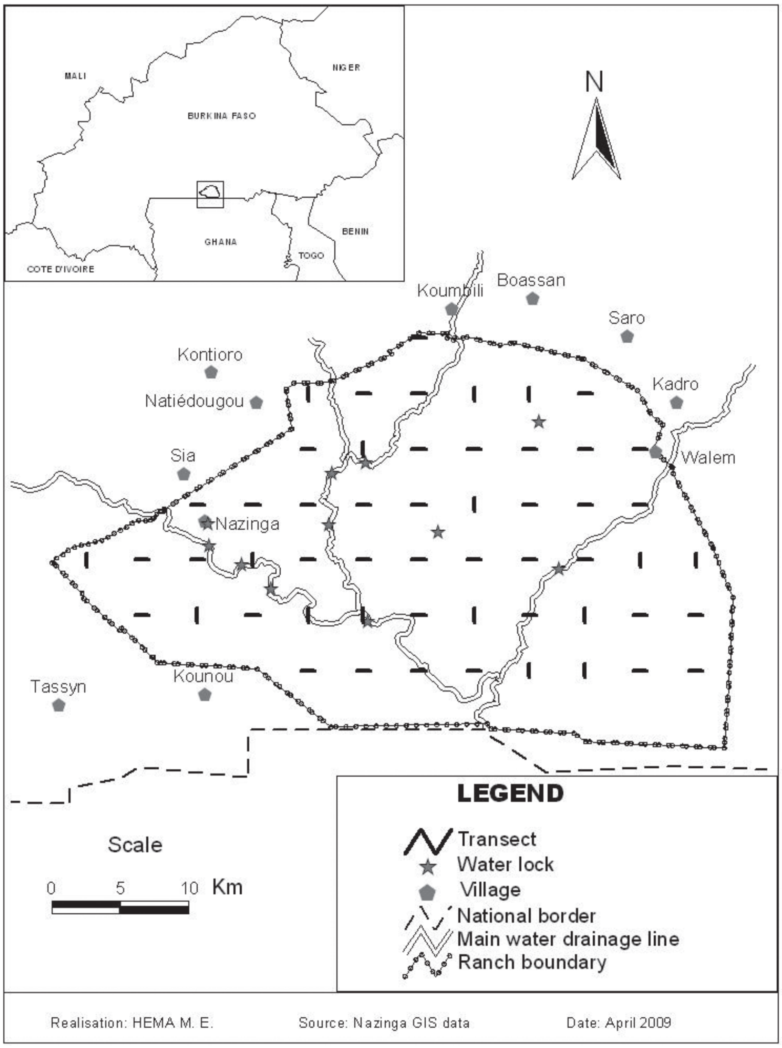

Figure 1. Location of Nazinga Game Ranch in Burkina Faso (inset) and map of the ranch showing the distribution of transects.

Methods

Map and Field

We used a Geographic Information System (ArcView 3.2) to prepare all maps. Rainfall data were collected at the meteorological station of Pô, about 15 km from the ranch. Human population data for 2006 were collected at the prefecture of Bieha for the villages of Boala, Tassyan and Kounou, and at the Sia health centre for the others. All the population data prior to 2006 were collected at the Institut National de la Statistique et de la Démographie library in Ouagadougou.

Mammal droppings survey

A survey of mammal droppings and woody vegetation was conducted at the ranch between 2006 and 2008. We used a systematic transect design with a random start (Buckland et al. 2001). A grid with sides measuring 2 km was placed over the study area; then from a random start, 54 transects were laid at 4–km intervals; such that they ran through the centre of each selected cell (i.e. every other cell). Each transect was 1 km long and oriented north-south or east-west in order to cut across the drainage lines (Fig. 1).

On each transect three mammal dropping counts were conducted. The first was carried out between 1 November and 12 December 2006, corresponding to the start of the dry season. The distribution of dung-piles was therefore a measure of elephants' use of space during the last few weeks of the wet season. The second was executed between 1 April and 6 May 2007, corresponding to the end of dry season. The third was conducted between 5 April and 3 May 2008, also at the end of the dry season.

The line transect survey method (Buckland et al. 1993; 2001) was used to estimate dungpile abundance (Barnes 1993; Barnes and Jensen 1987; Buckland et al. 1993). The survey team consisted of three members: the compass reader, a scribe and a research assistant. All team members searched for dung, but the scribe and the research assistant were the principal observers. The survey team walked in a straight line on a pre-determined compass bearing. The observers walked slowly, scanning the ground on either side. Each time a pile of droppings was observed, the following parameters were noted: distance along the transect, stage of decomposition and perpendicular distance from the transect centre-line.

Analysis

The mean density of elephant dung for a transect (E_j) was estimated from the equation (Burnham et al. 1980):

$$E_j = \frac{n_j.f(0)}{2.L_j}$$

where n_j was the number of dung-piles recorded on the jth transect, L_j was the length of that transect; and f(0) was the reciprocal of half the effective strip width for survey, calculated using DISTANCE 4.1.2 (Thomas et al. 2003). The hazard-rate key adjusted cosine fitted best the data for 2006, and the half-normal key adjusted cosine fitted best the data for 2007 and 2008.

We estimated the mean elephant dung density for each transect and used ArcView 3.2 to map the elephant distribution for each season. An elephant concentration area was defined as a place where the elephant dung density was greater than the mean density for the ranch.

Within each season we assumed visibility and therefore the effective strip-width was constant across the study area. Therefore we assumed the number of droppings seen in each transect is a measure of elephant occupancy. The frequency distributions of dung-piles between seasons were

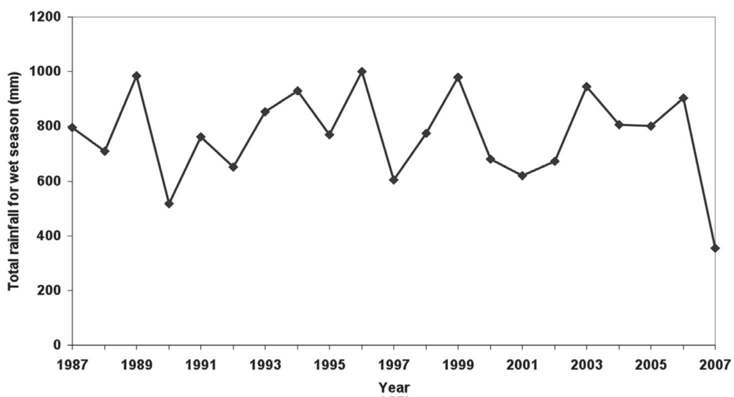

Figure 2. Total wet season rainfall (June to September) for each year since 1987. The low rainfall of the 2007 wet season preceded the 2008 dry season.

Table 1: Measures of dispersion of elephant dung-piles during the three seasons.

Year	2006	2007	2008
Month	Nov–Dec	April- May	April- May
Season	Wet	Dry	Dry
Rainfall in preceding 3 months (mm)	568.5	0	5.4
Median number of dung-piles on transect	5	31.5	52
Variance:mean ratio	12.33	49.66	131.40
Standardized Morisita's index, I_p	0.512	0.509	0.517
Number of transects	54	54	54

compared by the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981).

The standardized Morisita's index of dispersion (I_p) was used as a measure of the spatial pattern. I_p ranges from -1.0 to +1.0. Random patterns (Poisson distribution) give an I_p of zero; while uniform patterns have I_p below zero and clumped patterns an I_p above zero. Values of I_p below -0.5 or above +0.5 are significantly different from a random pattern (Krebs 1989)

Results

At the end of wet season 2006 elephants concentrated towards the west, the south-west, and the east (Fig. 3a). At the end of dry season 2007 they aggregated mostly in the west with one isolated concentration area in east-central (Fig. 3b). At the end of dry season 2008 they were most evenly aggregated along a line from west to north-east (Fig. 3c).

The standardized Morisita's index of dispersion was greater than 0.5 in all three surveys (Table 1), showing that elephants were clumped significantly in both wet and dry seasons. However, the frequency histograms show large differences between seasons in the way elephants were distributed (Fig. 4). For example, the variance:mean ratios show that the dry season distributions were more clumped than the wet season (Table 1). The distribution of dung-piles in the wet season differed from that in the 2007 dry season (Kolmogorov-Smirnov two-sample test: $D = 0.59$, $n_1 = 454$, $n_2 = 2583$, $P<0.001$) and from that in the 2008 dry season ($D_{max} = 0.65$, $n_1 = 454$, $n_2 = 3819$, $P<0.001$).

There was no difference in dung-pile distribution between the two dry seasons ($D_{max} = 0.02$, $n_1 = 2579$, $n_2 = 3819$, NS).

For those villages with data for both 1975 and 2006, the human population increased from 940 to 4,665 (Table 2). This is a mean rate of 5.3% per annum.

Discussion

The wet and dry season dung samples are not strictly comparable. The wet season samples represent the distribution of elephants during the preceding three or four weeks, depending upon the intensity of rainfall, while the dry season samples represent the accumulated occupancy for the preceding months when decay was negligible. The distribution of dung-piles between transects within each season concerns us here.

A random or Poisson distribution would give a variance:mean ratio of unity, and an I_p value of zero. Both measures indicated that elephants were aggregated or clumped in all seasons. The variance:mean ratio, as well as the median numbers of dung-piles, showed that the dry season 2008 sample was more clumped than the dry season 2007 sample which was in turn more clumped than the wet season sample. However, I_p did not show this ordering: it indicated that the degree of clumping of the wet season sample was between the two dry seasons. Different indices vary in the way they measure clumping (Krebs 1989). Another measure is the negative binomial, but we could not use it here because it works best when the populations of dung-piles are of similar size (Krebs 1989).

We expected elephants to be clumped during the dry seasons because they congregate near permanent water. This expectation was confirmed. However, dung-piles appeared to be more clumped in 2008 than in 2007, although the difference was not significant. For example, a very large concentration of dung-piles in one transect was recorded only in 2008 (Fig. 4c).

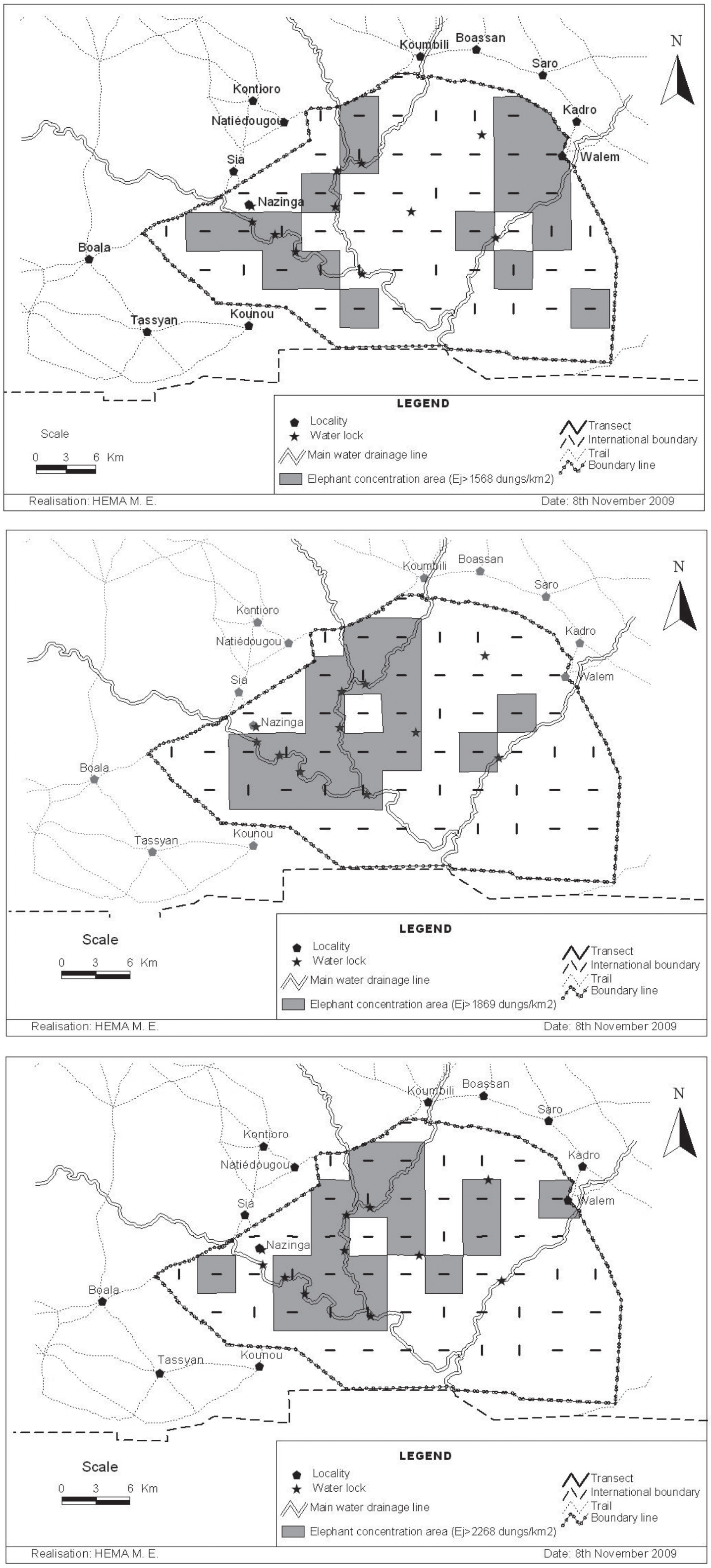

Figure 3. Maps of elephants' concentration areas at Nazinga; (a) Wet season 2006; (b) Dry season 2007; (c) Dry season 2008.

Table 2: Populations of the villages around Nazinga from 1975 to 2006

Village	1975	1985	1996	2006
Boala	233	331	691	738
Boassan	43	-	-	746
Kounou	87	-	-	236
Kountioro	106	190	-	577
Koumbili	-	210	265	3,483
Natiedougou	61	-	911	495
Saro	93	112	195	666
Sia	16	217	-	284
Tassyan	239	-	-	620
Walem	62	-	153	303
Total for villageswith data for both 1975 and 2006	940	-	-	4,665

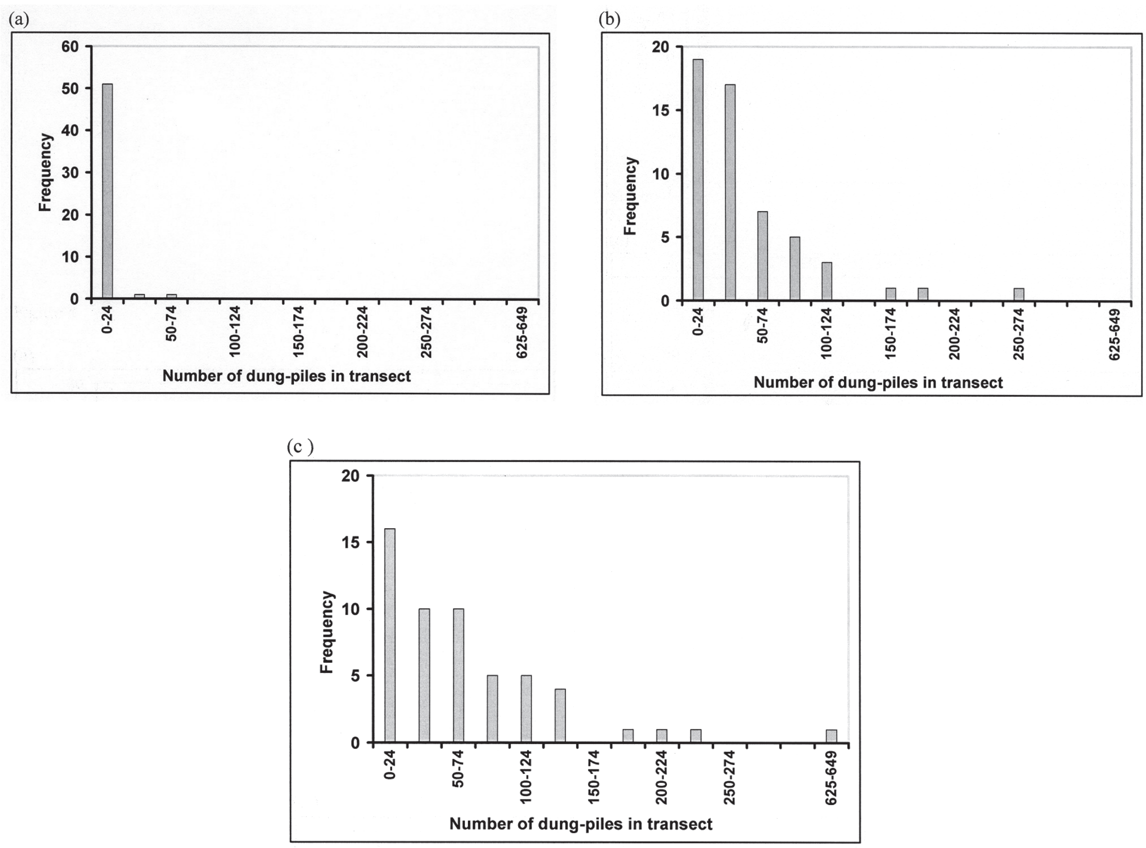

Figure 4. Frequency distributions of dung-piles during each season; (a) Wet season 2006; (b) Dry season 2007; (c) Dry season 2008.

This can be explained by the unusually low rainfall in the preceding wet season of 2007 (Fig. 2). Consequently, the vegetation was much drier in 2008 and there was less surface water available.

Jachmann (1988, 1992) reported that elephants at Nazinga dispersed throughout most of the ranch during the mid- and late-wet season when water was abundant and widespread.Therefore we expected elephants to be randomly distributed across the study area in the wet season. However, we found them to be clumped, albeit less concentrated than in the dry seasons. This suggests that they might have been attracted to certain features of the habitat.

The increasing human populations around the periphery of the ranch over the last two decades (Kessler and Geerling 1994; Ouedrago 1997) may explain the observed clumped distribution in the wet months. For example, Vermeulin (2001) noted that in the village of Sia the migrant population doubled between 1989 and 1990, and then doubled every five years between 1990 and 2000. The average rate of growth of 5% per annum recorded for most of the nearby villages (Table 2) indicates that the human population is doubling every 14 years.

These dramatic increases in human density immediately outside the ranch have brought about changes in the surrounding landscape as fields have been cleared for agriculture. In the wet season the expanses of maize, millet and sorghum are very attractive to elephants. Therefore one might predict elephants to be more common just inside the ranch's periphery. On the other hand, there will be more activity and human disturbance around the villages. In addition, farmers may actively repel elephants from their farms. So another possibility is that in the wet season elephants will be less common towards the edges of the ranch. For example, Chase and Griffin (2009) found that human settlements caused elephants to aggregate in the centre of Sioma Ngwezi Park in Zambia during the wet season. We suggest that the changing patterns of human settlement and land use outside the ranch influence elephant behaviour and seasonal distribution within the ranch. A subsequent paper will examine these hypotheses.

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