An Aerial Survey of Rhinoceros and Elephant in a Portion of the Chobe National Park and Surrounding Areas, Northern Botswana, September 1992

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ABSTRACT

A low intensity total count aerial survey, using two aircraft simultaneously, was undertaken specifically for black and white rhinos, and elephants, over 15057 km^2 of northern Botswana during the 1992 dry season. No black rhinos were recorded, while a total of 7 white rhinos were counted in the survey. Inclusion of a visibility correction factor of 1.017 for elephant raised the total number of elephant counted to 14758 individuals, an estimated density of 1.15 elephant/km^2. The search rate for elephant was estimated at 305 km^2/hr. The relatively low corrected rate for elephant carcass ratio of 3% was indicative of a population with a reduced mortality and/or increased immigration.

INTRODUCTION

Northern Botswana is one of the last refuges of free-ranging large mammal populations in southern Africa. It is home to a large and increasing elephant population estimated at 55,000 animals (A. Verlinden *pers. comm.).* However, the black Diceros *bicornis* and white *Ceratotherium* simum *simum* rhinoceros populations are in a more critical state.

Black rhinos, once relatively common in northern Botswana, were drastically reduced in number by past hunting and more recently by poaching activities. Less than 20 individuals were suspected to occur within the region in 1968 (Smithers, 1971), and even fewer towards the end of the 1980s (Potgeiter & Walker, 1989). Although the Botswana population was considered a separate subspecies D. *b. chobiensis,* based chiefly upon skull morphology (Rookmaaker & Groves, 1978), preliminary mitochondrial DNA analyses have revealed a closer affinity with the south-central ecotype D. *b. minor* than with the more arid-adapted southwestern ecotype D.b.bicornis (Harley, 1990), recognised by the African Rhino Workshop (Cincinnati, October 1986). Nonetheless, given the slight morphological differences found in the Botswana population, the conservation of this genetic stock would be advantageous for the sake of preserving genetic heterozygosity until further definitive taxonomic work can be undertaken.

White rhinos became extinct within Botswana by the end of the 19th century through hunting activities (Bryden, 1893). Through a reintroduction programme between 1967 and 1981, a total of 71 white rhinos were successfully re-established in Chobe National Park and Moremi Game Reserve in Botswana from Natal, South Africa (Hitchins, 1988). However, owing to recent poaching activities the population has again been greatly reduced (Gavor, 1988).

The tenuous state of the rhino populations, in particular that of the black rhino, prompted the need for an intensive aerial survey of those areas where they were last recorded to ascertain if they still existed and what their actual status and distribution was. The ultimate goal of the operation was to relocate the few remaining black rhinos to a sanctuary situated elsewhere in Botswana to form a safe breeding nucleus.

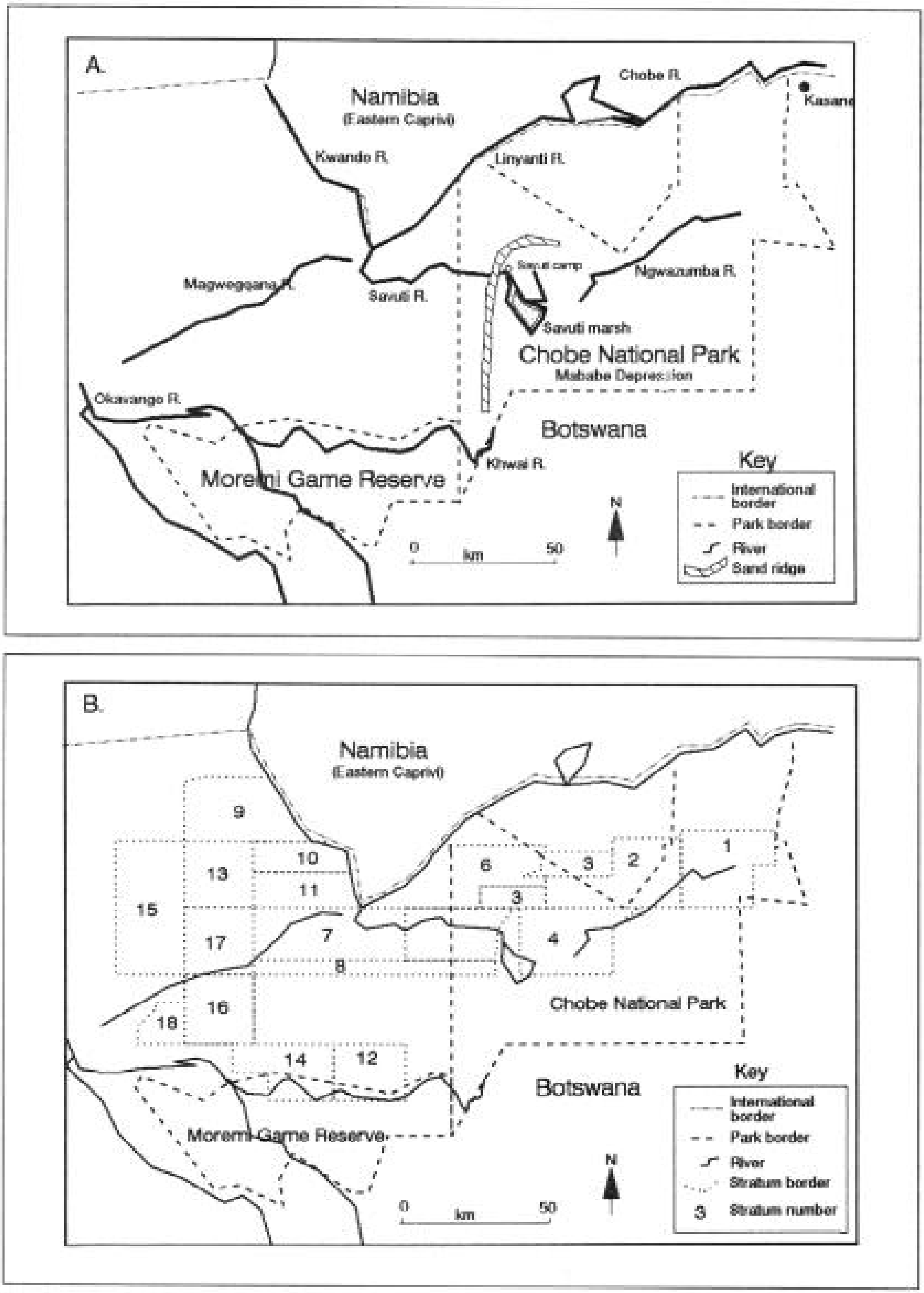
To make the survey that much more beneficial, it was decided to incorporate counts of white rhino and elephant *Loxodonta africana* within the study.

STUDY AREA

The survey area incorporated the Chobe National Park (CNP) (except the area north of the 18 and the area between the northern border of the Moremi Game Reserve, and the Caprivi Strip, Namibia (Figure lA).

With the exception of a few hills in the Savuti area, the flood plains of the Kwando and Linyanti rivers in the north and the Okavango delta ito the south, the vast majority of the survey area was flat and featureless (Figure 1). The perennial Kwando and Linyanti rivers formed the north western border of

Figure lA & B. The study area (A) with survey strata (B) in and around the Chobe National Park, Botswana.



the survey area while the Khwai river (part of the Okavango Delta) formed the southern border. The predominantly dry Savuti channel and Magwegqana (or Selinda spillway) run from the Linyanti swamps and Okavango delta, respectively. The former river periodically drained into the Savuti 'marsh', part of the larger Mababe Depression. Similarly, the ephemeral Ngwezumba river also drains into the Depression in exceptionally high rainfall years. Bisecting the study area is a sand ridge that runs from the northern side of the Mababe Depression, southwards to the eastern side of the Okavango delta.

The region receives between 400-800 mm of rain between October and March, with the greatest proportion falling in the latter half of the summer season. The remainder of the year is dry.

The vegetation consists predominantly of deciduous dry woodland and scattered grasslands on either Kalahari sands or shallower clay soils. The vegetation consists of open grasslands in association with large pans in the east. From this, a northern band of open stands of *Baikiaea plurijuga*, *Burkea africana* and *Pterocarpus angolensis* on deep Kalahari sands stretches to the western extreme of the study area. Large areas of the southern sections of the survey area, north of the Khwai river, consist of *Colophospermum mopane* on shallower soils with a higher clay component.

Along the Savuti channel large trees of *Acacia erioloba*, *A.nilotica*, *A. nigrescens* and *Combretum imberbe* were found. The riparian vegetation along the Kwai, Linyanti and Kwando rivers appeared similar with stands of *Kigelia africana*, *Ficus natalensis*, *A. nilotica*, *Hyphaene benguellensis* and *Phoenix reclinata* in association with short green grazing lawns.

METHODS

FLYING AND COUNTING PROCEDURE

The principle aim of the survey was to locate black rhinos. The survey was undertaken in the late dry season (September) when the visibility is least impaired by the vegetation. The selection of areas most likely to have black rhinos was based upon past sighting records of animals or their tracks (M. Slowgrove, L. Wilmot, G. Calef, M. van der Waller and D. Joubert pers. comm.), the availability of dry season drinking water supplies, and the absence of human settlements. Aerial coverage did not extend beyond 30 km from waterholes the maximum foraging distance black rhinos were noted to forage water in the dry season (Joubert & Eloff, 1971).

In order to maximize the chances of detecting black rhinos, it was decided to use two aircraft simultaneously to scan along each transect. Two Cessna 210 aircraft were used in the survey, with the flying formation consisting of the leading aircraft flying at low level (70 m above ground level [AGL]). The second aircraft flew at 140 m AGL and maintained a track approximately 300 m to the right of the leading aircraft and trailed by 600-700 m (or a 10 sec separation). Both aircraft maintained a ground speed of approximately 90 knots. It was intended that the lower flying lead aircraft would flush any black rhino for the trailing aircraft to detect.

The leading aircraft was manned by a pilot, navigator, and three or four observers, two of whom were always seated on the right-hand side of the aircraft looking into the track of the trailing aircraft. The leading aircraft's objectives were to navigate the predetermined transects for both aircraft, flush any rhinos potentially obscured by vegetation or directly under the aircraft for the second aircraft to detect, as well as observe animals (both alive and dead). All navigation was done with the aid of a Global Positioning System (Garmin 100 ADV). The objective of the second aircraft with pilot, observer! recorder (seated directly behind the pilot), the three or four observers (one of whom was always seated on the left-hand side behind the recorder) was to record all sightings of rhinos, noting their positions on a separate GPS system. The positioning of the second aircraft was designed to cover the obscured zone beneath the leading aircraft. The flying formation thus allowed four observers to scan the 300 m between the two aircraft.

As the estimation of animal densities was not a specific task of the survey, all black and white rhinos and elephants seen from the second aircraft within the unbounded transects were recorded. Thus the survey could be described as a low intensity total count. The maximum detection range for large conspicuous species such as elephants in the open, leafless savanna was estimated to be about 900 m on either side of the second aircraft. This was estimated on the ground by measuring the distance to recognizable features during trial runs. As transects were 2 km apart, the chances of double counting were therefore considered remote.

The survey area of 15057 km^2 was subdivided into 18 strata, ranging in size from 547 to 142 km^2 (Figure 1 B). Transects were orientated in an east to west direction and the strata were flown in sequential order from east to west.

On spotting a rhino, the second aircraft would maintain its altitude and circle the position while guiding the lower aircraft in to determine the sex and age of the animal and take photographs.

VISIBILITY BIASES

Although the counts were not within defined strips, an indication of potential visibility biases between observers, particularly with respect to counting elephants, was determined using the Petersen markrecapture method (Seber, 1982), as modified by Marsh & Sinclair (1989). This entailed the observer/ recorder of the second aircraft noting what elephant groups he detected (SF), what groups the second observer directly behind the recorder saw (Sr) and what they both observed (B). A perception correction factor (C) for groups of elephants per stratum was calculated by:

C=((Sf+B) (Sr+B))/(B(Sf+Sr+B)

with the coefficient of variation (Cp) calculated by:

Cp=((Sf+Sr)/(Sf+Sr+B))* √((Sf*Sr) (B((Sf+B) (Sr+B)))).

An elephant herd was defined as any aggregation showing some form of cohesion that was separated from other groups or individuals by a clear break that was greater than the diameter of the herd in question.

CARCASSES

The coordinates were recorded for every rhino and elephant carcass seen by either of the two aircraft. Communications between the two aircraft reduced the chances of double counting carcasses. The carcasses were categorised as:

1. 'Old': white scattered and bleached bones.

2. 'Fresh': skin covering the skeleton. With a closer inspection from the air, the age was more precisely estimated in either weeks or months depending upon: the presence of scavengers (vultures, jackals and spotted hyenas); signs of blood or body fluids around the carcass; the degree of bloat and the open patch around the carcass through trampling and the concentration of body fluids. Where possible, the presence or absence of ivory, or horns in the case of rhinos, was also noted.

A carcass ration, calculated as a percentage of the combined total number of carcasses and the alive animals counted per strata was calculated. As no correction factor for the under-counting of elephant carcasses was estimated, the three times correction suggested by Dublin & Douglas-Hamilton (1987) was used.

DISTRIBUTION OF PANS

All pans with a diameter greater than 50 m across their flat unvegetated surface were noted for the presence of drinking water. The coordinates of those holding water were recorded on the GH S system.

TREE DAMAGE

An estimate of 'tree damage' (defined as felled trees only), assumed to have been caused by elephant, was determined during the latter half of the survey. A roughly five, minute scan interval was used in which the proportion of felled trees were categorised into one of four subjective categories: nil (0-10 **%),** light (11-25 **%),** moderate (26-50 **%),** and heavy (>50 **%),** depending upon the percentage of felled trees to those standing. A tree was defined as being greater than 5 m in height.

RESULTS

BLACK RHINO

No black rhinos were seen during the survey.

WHITE RHINO

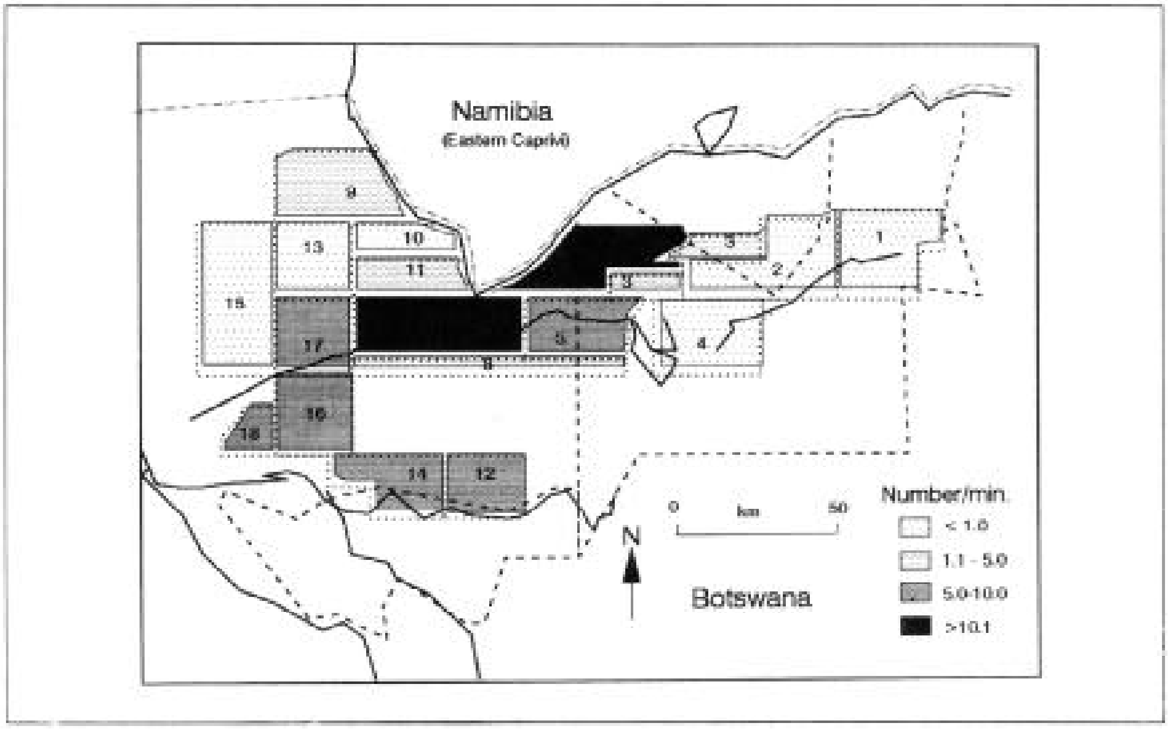
A total of seven white rhinos, in four groups, were counted during the survey. Two individuals (an adult male and female) were found in northern Moremi Game Reserve, while the remaining five animals (two adult females, one unsexed subadult and two unsexed immature individuals) were located in eastern Chobe National Park.

A single fresh white rhino carcass was also located in eastern Chobe, from which the horns were noted to have been removed.

Table I. Stratum areas, flying times and the number of elephants counted in each stratum.

Date	Stratum No.	Area (krn2)	Flying time (h)	Elephants counted	Elephants counted / min. flying
19.9.92	1	1,065	3.5	195	0.9
20.9.92	2	1,318	3.5	53	0.3
20.9.92	3	785	1.2	108	1.5
21.9.92	4	1,080	3.0	125	0.7
21.9.92	5	660	1.8	783	7.4
22.9.92	6	1,114	3.1	4,717	25.4
23.9.92	7	1,158	3.5	2,751	13.1
23.9.92	8	533	1.4	168	2.0
24.9.92	9	1,084	2.8	311	1.9
24.9.92	10	399	1.5	56	0.6
25.9.92	11	480	1.9	212	1.9
26.9.92	12	596	1.9	657	5.8
27.9.92	13	726	2.1	117	0.9
28.9.92	14	757	2.9	861	4.9
29.9.92	15	1,452	2.4	45	0.3
30.9.92	16	726	2.5	869	5.8
1.10.92	17	726	2.1	977	7.8
2.10.92	18	547	0.8	435	8.9
Mean (±SD)					5.0± 6.3
Total		15,057	41.9	13,440	

Figure 2. The distribution and number of elephants counted per minute flying time in and around Chobe National Park.



ELEPHANT

The rate (number counted/min flying time) at which elephants were counted varied greatly between strata (Table 1 and Figure 2). Strata 6 and 7 had the largest number of elephants counted (4717 and *2751),* plus the highest count rates of 25.4 and 13.1 elephant/min flying time, respectively, well above the average of *5.0±6.3* elephants/min. The largest concentrations of elephants (> 5 elephants counted/min flying) were found in association with riverine or swamp vegetation types with predictable supplies of permanent drinking water, as opposed to those areas with rather unpredictable supplies of water in the many scattered pans.

ELEPHANT HERD COMPOSITION

Breeding herds, which were on average larger than bull herds, were found to represent about 90.8 % of the

Figure 3A & B. The frequency distribution of breeding (A) and bull (B) herd sizes in vicinity of Chobe National Park, Botswana.

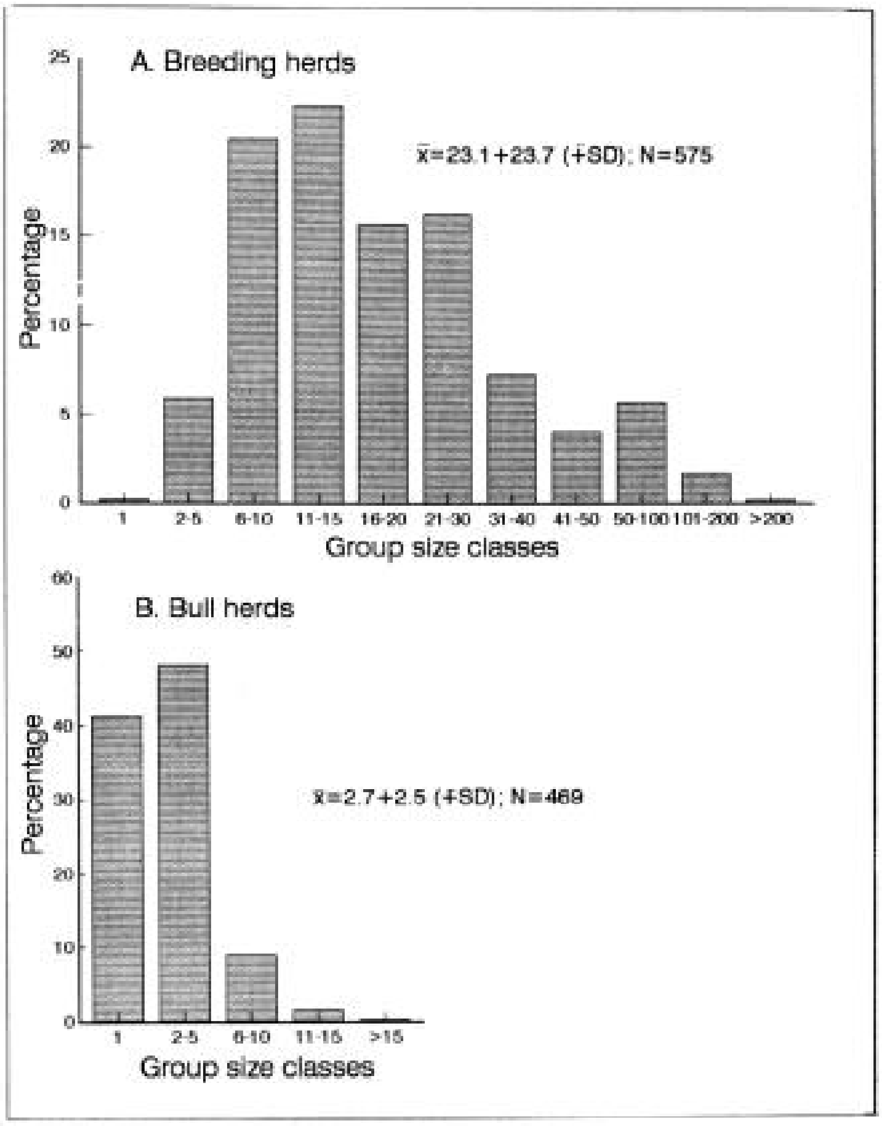
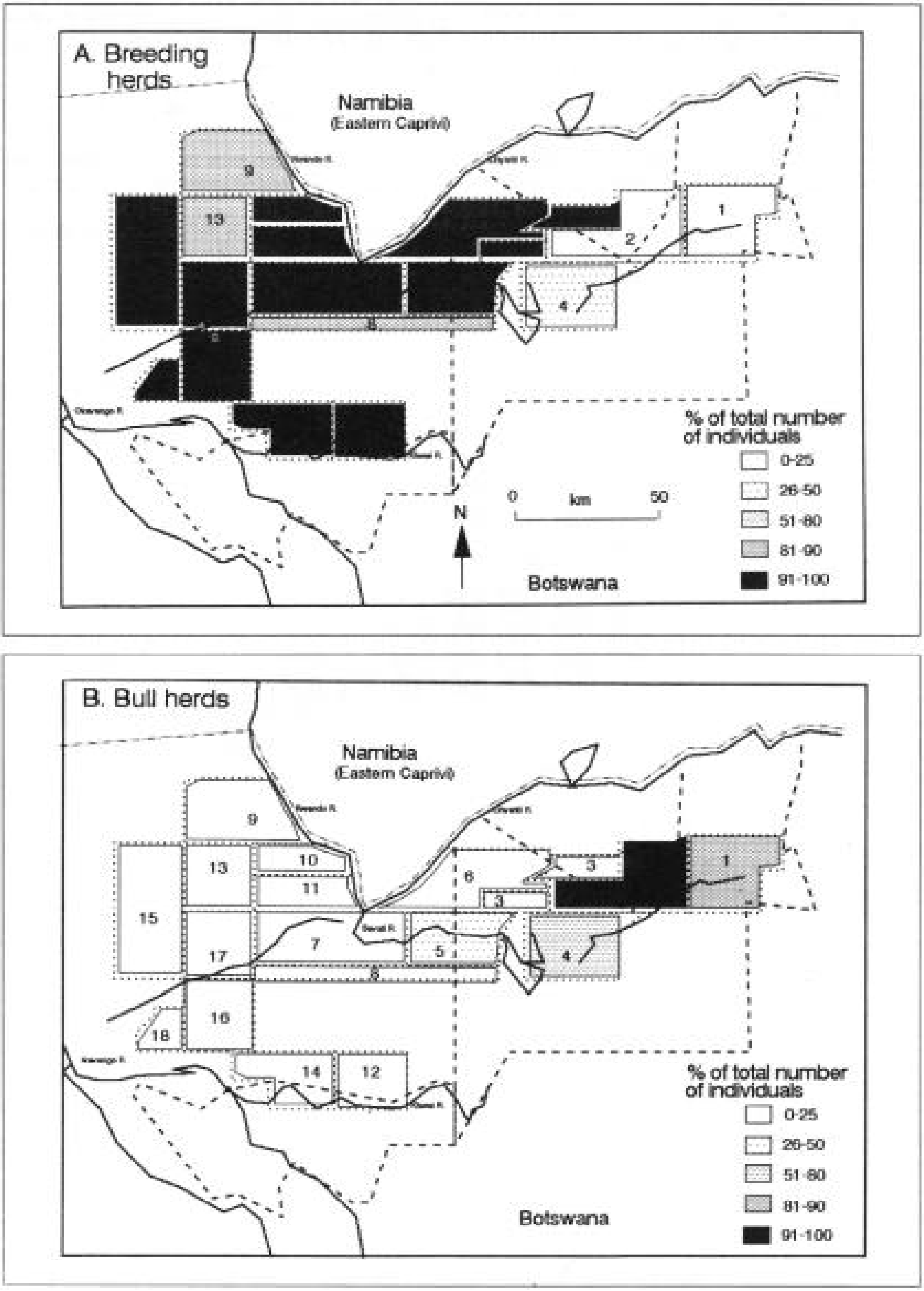


Figure 4A & B. The distribution of elephant breeding (A) and bull (B) herds in and around the Chobe National Park.



surveyed population (Figure 3). Although the mean breeding herd size was 23±24, the median herd size appeared to be between 11-15 individuals. It was noted that as the proportional representation of bulls within a stratum increased, so did the herd sizes ($r=0.488$; $N=16$; $P<0.05$). No similar relationship was detected for the breeding herds ($r=0.306$; $N=16$; $P>0.05$).

During this late dry season survey; breeding herds were noted to be predominantly concentrated within strata that had permanent riverine water supplies (Figure 4A), while a large proportion of the bulls was found well away from the riverine water supplies in strata 1, 2, 4 and 5 (Figure 4B).

ELEPHANT CARCASSES

An average uncorrected carcass ratio of 1 % was estimated for the entire survey area (Table 2). Certain areas, particularly strata 2, 15, 10, 11 and 1, had the highest ratios. A ratio of 41:59 fresh:old carcasses was recorded for the survey area. There appeared to be no link between the distribution of old and fresh carcasses, as old carcasses tended to be concentrated in strata 1 and 2, while the fresh ones were predominantly found in strata 10 and 11. The majority of the fresh carcasses were estimated to be less than three weeks of age. The carcasses tended to occur individually except for one cluster of four that appeared to have had their tusks removed. Only one other fresh carcass was noted to have had the tusks removed, more than likely indicative of poaching activities.

No relationship was detectable between the number of fresh and old carcasses and the total number of pans and the proportion of pans with drinking water.

Table 2. The number of fresh and old elephant carcasses, and carcass ratio in Chobe National Park and the surrounding area. Nmbers in parentheses had tusks removed.

Stratum	Elephant Carcasses			
	Old	Fresh	Number/h flying	Carcass ratio
1	13	0	3.7	6.3
2	19	0	5.4	26.4
3	5	0	4.2	4.4
4	9	0	3.0	6.7
5	4	0	2.2	0.5
6	0	1(1)	0.3	0.0
7+8**	0	11	2.3	0.4
9	0	4	1.4	1.3
10+11**	2	28 (4)	8.8	10.1
12**	4	0	2.1	0.6
13**	0	3	1.4	0.3
14	0	1	0.4	0.1
15**	2	0	0.8	11.8
16	3	0	1.2	0.3
17	0	0	0.0	0.0
18	8	0	10.0	1.8
Total	69	48		
Mean (±SD)	4.3±5.5	3.0±7.4	3.0±2.9	0.8

**Strata with river frontage

PERCEPTION CORRECTION FACTOR

With a total of 63, 68 and *435* elephant groups seen by the front, rear and both observers, respectively, the perception correction factor for elephant groups within the unbounded transects was 1.017, with a low coefficient of variation (CV) of 0.2 % over the entire survey. This is indicative of little variability between the two observers in detecting elephant groups. Assuming that the maximum detectable range of elephants was 900 m, a relatively high overall coverage of 85.5 % (range 40.2 - 99.2 %) of the area was obtained while counting elephant. Using the perception correction factor and the average elephant group size of 13.9±20.4 (±SD) (N=1044), the corrected number of elephant directly counted would be 14758, 9.8 % greater than the actual number counted.

ESTIMATED TREE DAMAGE BY ELEPHANT

Within the. 10 strata surveyed for tree damage by elephants, heavy damage was recorded in only 5.3 % of scans (N=l 86). This was restricted predominantly to strata 7, 8 and 18 that were associated with the Savuti and Magwegqana rivers. Nil to limited damage was recorded in the strata north and west of Kwando and Magwegqana rivers, respectively. A significant positive relationship (r=0.80; n=1 0; P<0.0 1) was found between the number of elephant (represented as the number seen/ min. flying) and the combined percentages of scans with heavy and moderate tree damage.

DISCUSSION

I. RHINOS

Although no black rhinos were actually detected during the relatively intense survey, some individuals may still exist within northern Botswana. The vastness of the area and the poor detectibility of this species in most aerial surveys (Goddard, 1967; Kiwia, 1989) may have allowed a small population to go virtually undetected. Nevertheless, the longterm survival of this population is clearly in great jeopardy, unless action is undertaken to find and relocate the few remaining animals (Hitchins, 1992). Instead of undertaking further aerial surveys, it is recommended that those pans holding rain-water during the late dry season, particularly within the more likely north western areas of the survey range, should be checked on the ground for rhino tracks.

The few sightings of white rhinos confirm that the population in northern Botswana is at an extremely low level. From the present survey and other sporadic reports during the survey, Hitchins (1992) estimated the white rhino population in Moremi and northern Botswana to be about 27 individuals. This estimate is about 13 % of the expected population size of about 216 animals since reintroduction, that is with normal recruitment and the total absence of poaching. The presence of a freshly poached white rhino found during the survey reiterates the danger that this small population is on the brink of extinction, albeit for the second time in Botswana. The urgency of the situation resulted in a capture and relocation programme of four white rhinos from eastern Chobe to a safe, fenced sanctuary elsewhere in Botswana. However, the fact that one of the animals subsequently died from bullet wounds inflicted by poachers prior to the capture operation further emphasises the seriousness of the poaching threat facing this and other rhino populations in the rest of southern Africa.

2. ELEPHANTS

While the survey was primarily designed to optimise the detection of rhinos, a reasonably accurate low intensity total count of elephant was obtained. The open, dry and leafless tree savanna, characteristic of the late dry season, against which elephants were easily detected, more than likely accounted for the relatively wide strips of about 1.8 km. This provided an estimated maximum 85 % coverage of the survey area for elephant. This suggests that the searching rate was in the order of 305 km^2/hr and can thus be classified as a T3 total survey (Anon 1993).

Although total counts offer reasonable precision, albeit on the conservative side, they fail to offer any indication of accuracy as no confidence intervals result from the analysis, that is unless replicates are undertaken. Additional problems relate to the efficiency of counting animals in unbounded transects, particularly as smaller groups are generally more difficult to detect farther from the aircraft, thus biasing one’s count towards the closer and larger groups (Burnham, Anderson & Laake, 1980). Having wide transects leads to an under-representation of smaller groups farther from the aircraft. The use of additional narrower, demarcated strips - as is done in most aerial surveys - would improve the accuracy of the population estimate (Caughley & Goddard, 1975; Western & Lindsay, 1984). However, the relatively small visibility correction factor calculated in the present survey indicated that few elephant groups were in fact missed by the observers. Using the correction factor and an assumed 85 % coverage, the average elephant density for the survey area was 1.15 elephant/km^2. This falls well within the range of dry season elephant densities estimated for the study area as recorded. from low intensity aerial surveys undertaken by the Department of Wildlife & National Parks, Botswana (Craig, 1990). Furthermore, the concentration of elephant in the vicinity of the Linyanti and Savuti rivers in the present survey reflects the normal dry season pattern (Craig, 1990).

The majority of elephants, and predominantly breeding herds, were found to be associated with permanent drinking water along the Linyanti, Khwai, Savuti and Magwegqana rivers. Along the Kwando river, relatively few elephants were recorded, possibly a result of disturbance from hunting operators and close proximity of human settlements in Namibia. The fact that a disproportionately large segment of the bull population (41%) was found well away from the riverine water supplies in strata 1, 2, 4 and 5 that amounted to about 27% of the survey area suggests a degree of concentration by the bulls in these areas. As natural supplies of drinking water were rare within these strata, the animals probably relied heavily upon the few borehole-fed waterholes.

The tendency of breeding herds to concentrate along the river-lines more than likely relates to their larger group sizes, relatively higher mass-specific energy demands (owing to a smaller body size) and the need for better quality food required for themselves (to sustain lactation and pregnancy) and dependent calves (Barnes, 1983). By contrast, the bulls could remain within the interior, where limited food and water was available, by virtue of their smaller herd sizes and the need for only enough food to meet maintenance requirements.

Increases in elephant populations can result in greater incidences of elephant 'damage' or restructuring of the vegetation (Croze, 1974; Thompson, 1975). However, other studies have noted that elephant damage in Sengwa, Zimbabwe (Anderson & Walker, 1974) and northern Botswana (Ben Shahar, 1993) was specific to habitats and plant species, and independent of local elephant densities. In the present study, a positive relationship existed between elephant density and the incidence of 'heavily' and 'moderate' tree damage sites. These areas, and particularly the heavily damaged sites, occurred along watercourses where elephants traditionally concentrate during the dry seasons. The process of restructuring the vegetation should possibly be seen as a natural negative feed-back mechanism through the vegetation in response to localised concentrations of elephants. Inclusion of the under-counting factor of 3 for elephant carcasses counted from the air (Dublin & Douglas-Hamilton, 1987) raised the carcass ratio to 3 % for the present survey area. This was comparable with areas experiencing a 'normal' to slightly lower mortality and increased immigration (Dublin & Douglas-Hamilton, 1987), phenomena suggested to be occurring in the Botswana population (G. Calef, per. comm.). The fact that carcasses still with their tusks tended to be found singly but restricted to specific areas (strata 2, 10, 11 and 15) suggests that either disease or poisoning (from plants) may have been the cause of death. The former factor may have accounted for the relatively high fresh to old carcass ratio of 1:1.4, the majority of which were restricted to a limited area in strata 10, 11, 7 and 8 (P. Morkel, pers. comm.). Poaching of elephant appeared to have accounted for 10% of the fresh carcasses and they were predominantly restricted to strata 6, 10 and 11, all situated along the northern border with Namibia, relatively close to human settlements.

The vastness and largely featureless expanse of northern Botswana, one of southern Africa's true last wilderness areas, appears to offer no escape to threatened rhino populations. Without intense protection within smaller sanctuaries, the species may continue to fall easy victim to poachers. On the other hand, the elephant population appears to be on the increase, possibly through a combination of a low natural mortality and increased immigration from Namibia, Angola and Zimbabwe.

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PERSONAL COMMUNICATIONS

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