Carcass characteristics and composition

The live weight and dressing out percentage of the cane rat (Table 5) exceed those of the giant rat and the domestic rabbit (*Oryctilagus cuniculus* L.). Robertson-Bulluck (1962) and Talbot *et al.* (1965) suggested the use of the relationship between gross weights, dressed carcass and visceral weights in assessing meat production of African wildlife. It appears that the grass cutter compares favourably with a number of domesticated species on these criteria.

The proximate composition of the cane rat carcass (Table 8) shows that there is less fat than on the giant rat as reported by S. S. Ajayi and O. O. Tewe (unpublished data). Data obtained from Kramlich *et al.* (1973) also indicate that beef, raw lamb and pork have higher fat contents than the cane rat. The protein percentage exceeds that of the giant rat and most other domestic livestock except for poultry in which it is slightly higher. It is, however, pertinent to note that since these grass cutters were randomly trapped and kept in captivity till they were slaughtered, their exact age was not known. It has been established that the age of an animal has a considerable effect on the protein and fat contents (Pond & Maner, 1974). It is, therefore, important to recognize this limitation in the present preliminary phase of domestication

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Numbers, distribution and habitat preference of large mammals in Bouba Ndjida National Park, Cameroon

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Summary

An aerial census of the large mammal populations of the Bouba Ndjida National Park, Cameroon was carried out, using systematic transect sampling. The park area was divided into six blocks with two in the high density stratum and four in the low density stratum. Total population estimates of the most abundant species have been compared with results of previous ground counts. Accuracy and precision of the estimates and applicability of light aircraft in these types of habitat are discussed. The locality of all recorded animals was plotted on a 1:100 000 vegetation map for preparation of distribution maps. Relative habitat preferences were calculated for four major vegetation types. Results are discussed and costs evaluated.

Résumé

Un recensement aérien des populations de grands mammifères du Parc National de Bouba Ndjida, au Cameroun, a été réalisé par itinéraires-échantillons systématiques. La surface du Parc fut divisée en six zones dont deux comprenant des strates à densité élevée et quatre à densité faible. Les estimations de la population totale des espèces les plus abondantes sont comparées aux résultats des comptages terrestres antérieurs. L'exactitude et la précision des estimations et l'usage d'un avion léger pour ces types d'habitats sont discutés. La localisation de tous les animaux recensés fut reportée sur une carte de végétation au 1: 100 000 pour l'élaboration de cartes de distribution. Les préférences relatives d'habitat furent calculées pour quatre types principaux de végétation. Les résultats sont discutés et les coûts évalués.

Introduction

The use of light aircraft in censusing large ungulate populations in East Africa is widespread, but in West Africa it is still rare. Animals are difficult to spot from the air during the greater part of the year in West Africa and light aircraft can be used only

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during the brief period when most trees and shrubs have lost their leaves and most of the tall grass cover has been burned.

In Bouba Ndjida National Park in Northern Cameroon, ground counts of larger mammal populations have been carried out since 1974 by staff and students of the College of Wildlife Management, Garoua (Van Lavieren & Bosch, 1977). However, only small areas of the park surface could be sampled from the ground.

This paper gives the results of an aerial survey of the park, the objective of which was to evaluate the suitability of light aircraft in these types of habitat, to gather data on animal distribution and to determine habitat preferences.

Study area

The Bouba Ndjida National Park is situated in the savanna woodland belt of Northern Cameroon between 8°21′ and 9°N and 14°25′ and 14°55′E. It covers 2200 km² of gently undulating terrain between 280 and 400 m above sea level. A mountain ridge along the southern boundary reaches 900 m, the two mountains inside the park reaching 502 and 610 m, respectively. A general description of the ecology of the area is given by Bosch (1976), a summary of which is given below.

Hydrology

A dense system of temporary streams (locally called 'mayos') drains the park from the east to the west during the rainy season. All major watercourses finally combine at the western boundary in the Mayo Godi, a tributary of the Benoue River which drains most of Northern Cameroon. Although most streams within the park are temporary, water is available throughout the year as most streams retain pools of permanent water during the dry season.

Climate

The average annual precipitation is 1200 mm, mainly falling from May to October, the wettest months being August and September. Consequently, the dry season lasts from November to April.

The mean annual temperature is 28°C, the mean maximum is 35°C and the mean minimum 21°C. Mean monthly minimum is lowest in December (17°C) and mean monthly maximum is highest during March and April (39°C).

Mean monthly humidity is lowest in February (27%) and highest in August (80%). Harmattan, a north-easterly wind laden with dust from the Sahara, frequently occurs from January to April.

Soils

On more elevated areas, well drained, leached tropical ferruginous soils are found. Hydromorphic soils, which have a high clay content and are poorly drained, occur on less elevated areas. Both soil types are acidic and rest on gneiss and granite bedrock (Brabant, 1972; Martin & Segalen, 1966).

Vegetation

The entire park surface is covered with savanna woodland in which *Terminalia laxiflora* Engl., *Isoberlinia doka* Craib & Stapf and *Monotes kerstingii* Gilg. are the three most common species. A brief description of the four principal types is given below:

Terminalia laxiflora wooded savanna. T. laxiflora shrubs and trees are mixed with a variety of other small trees, generally not exceeding 3 m. Grass cover consists mainly of tall perennial Andropogoneae, which grow up to 3 m high during the rainy season and constitute the principal forage for the majority of large herbivores.

Isoberlinia doka woodland. This type of woodland, whose physiognomy resembles the 'miombo' of east-central Africa, is dominated by tall *I. doka* trees. It is found on deep, well drained ferruginous soils. The dominant grass species is the tall perennial *Andropogon gayanus* Kunth.

Isoberlinia doka—Monotes kerstingii woodland. In this vegetation type *Monotes kerstingii*, which locally forms pure dense stands on well-drained sandy ferruginous soils, is mixed with *I. doka* trees, mainly on higher areas.

Anogeissus leiocarpus fringing forest. A narrow belt of fringing forest, dominated by *Anogeissus leiocarpus* (DC) Guill. & Perr. has developed on hydromorphic soils along the principal watercourses. Being close to water, this vegetation type is intensively utilized by wildlife.

Larger mammals

There is a great variety of larger mammals in the park. The following species were considered during the aerial survey: black rhinoceros, *Diceros bicornis* (Linn.), elephant, *Loxodonta africana* (Blumenbach), warthog, *Phacochoerus aethiopicus* (Pallas), giraffe, *Giraffa camelopardalis* (L.), giant eland, *Taurotragus derbianus* (Gray), roan antelope, *Hippotragus equinus* (Desmarest), defassa waterbuck, *Kobus ellipsiprymnus unctuosus* (Laurillard), Bohor reedbuck, *Redunca redunca* (Pallas), Bubal hartebeest, *Alcelaphus buselaphus* (Pallas), korrigum, *Damaliscus lunatus korrigum* (Ogilby), common duiker, *Sylvicapra grimmia* (L.), oribi, *Ourebia ourebi* (Zimmermann) and buffalo, *Syncerus caffer* (Sparrmann).

Methods

An aerial survey was carried out from May 30 to June 2, 1977, just after the onset of the rainy season. After the first rains, visibility from the air was very good and animals contrasted clearly with the light green grass cover which had just started to appear. Due to the rains, animals were distributed fairly uniformly throughout the park. Only 1 : 200 000 topographical maps were available but no navigational problems were encountered as both navigator and observers were familiar with the area. The park was divided in two strata, a high density stratum (HDS) and a low density stratum (LDS), based on data on relative abundance of animals obtained during previous ground counts. For practical purposes, each stratum was divided into blocks which could be covered in one flight (Fig. 1). Six blocks were demarcated; two in the HDS and four in the LDS. Block areas and sampling intensities are given in Table 1.

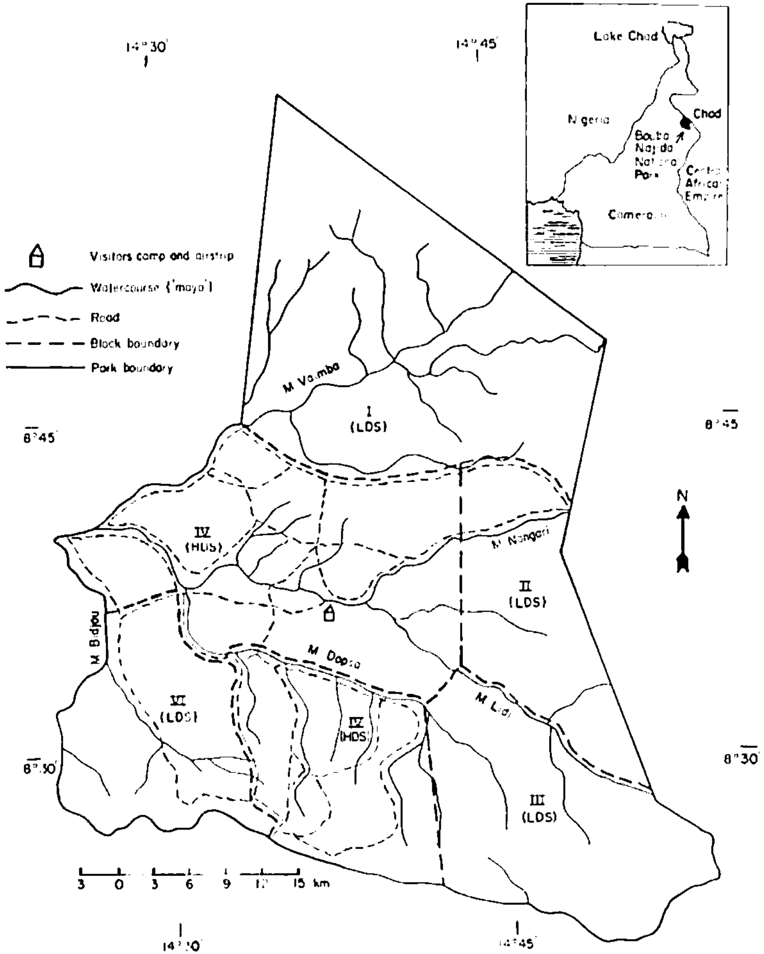

Fig. 1. Bouba Ndjida National Park, block and strata boundaries. HDS: high density stratum, LDS: low density stratum. Inset: location of Bouba Ndjida National Park.

Table 1. Aerial sample count Bouba Ndjida National Park: stratification, block and sample sizes

Block	Stratum	Area (km²)	No. of transects sampled	Sample-area (km²)	Total no. of transects possible	Sample size (%)
I	LDS	636	28	60·20	280	9·47
II	LDS	250	10	17·20	120	6·88
III	LDS	343	12	19·24	180	5·61
IV	HDS	504	42	62·80	300	12·46
V	HDS	224	18	25·96	140	11·59
VI	LDS	243	18	21·36	160	8·79
Total		2200	128	206·76	–	9·34

Transect: one strip of 100 m on both left and right side of the aircraft
LDS: low density stratum.
HDS: high density stratum.

Although, for statistical reasons, random sampling would have been preferable, systematic transect sampling was chosen to permit distribution mapping. Transects were spaced 1·5 km apart in the HDS and 2 km apart in the LDS.

A Cessna 206 Stationair six-seater aircraft was used. The census team consisted of a pilot and a navigator in the front, two observers sitting side by side in the second row and an extra observer/trainee in the rear. The aircraft was flown at 65 mph (105 km/h) at a constant altitude of 300 ft (91 m). No radar-altimeter was available and altitude was maintained by means of a barometric altimeter. Since the park's surface slopes gently from 400 m.a.s.l. in the east to 320 m.a.s.l. in the west over a distance of 45 km, errors due to deviations from the 300 ft flying height are considered small. The altimeter was zeroed regularly at the airstrip in the centre of the park.

A transect width of 100 m was delineated on each side of the aircraft by means of streamers on the wing struts. The streamers were positioned as described by Pennycuick & Western (1972) and stabilized during flight by funnels attached to the end. The strip width was verified by flying at 300 ft above 100 m markers placed on the airstrip. Transects were flown in a north/south direction with the exception of block V where a south-east/north-west direction was chosen for navigational reasons. Where a transect was not flown accurately, the finishing point was marked on the map and the transect length adjusted accordingly. Counts were made from 07·00 to 10·00 hours and from 15·30 to 17·30 hours. The weather was clear and there was almost no crosswind during the survey. A total of 15 hr were flown. All animals were counted visually, photographs were unnecessary to verify estimates of large herds as the herd size exceeded twenty on only four occasions.

With the exception of roan antelope, giant eland, bubal hartebeest and buffalo, population sizes were estimated using Jolly's Ratio Method (method 2) for unequal-sized sample units (Jolly, 1969). The use of this method with species which, as in this case, are not fully randomly distributed, results in a slight over-estimate of the variance (Pennycuick *et al.*, 1977). Population estimates for roan antelope, bubal hartebeest, giant eland and buffalo were calculated from the mean number of herds per unit area (km²) and the average herd size on the assumption that herds rather than individuals approached a random distribution.

The time at which animals were seen along the transect line was noted using

Table 2. Population estimates ($\hat{Y}$) of some large mammals in low density stratum (LDS) and high density stratum (HDS), Bouba Ndjida National Park

Species	Block/stratum	Density km² ($\hat{R}_i$)	Population estimate ($\hat{Y}_i$)	S.E.
Common duiker	I-LDS	0·37	235	58·3
	II- ,,	0·47	118	35·5
	III- ,,	0·78	268	54·6
	VI- ,,	0·89	214	48·4
	IV-HDS	0·40	202	42·9
	V- ,,	1.08	242	41·9
Elephant	I-LDS	0·02	13	—
	II- ,,	0·17	43	—
	III- ,,		—	—
	VI- ,,	—	—	—
	IV-HDS	0·35	176	—
	V- ,,	—	—	—
Giraffe	I-LDS	—	—	—
	II- ,,	—	—	—
	III- ,,	0·10	34	—
	VI- ,,	0·05	12	—
	IV-HDS	0·19	96	—
	V- ,,	0·12	27	—
Korrigum	I-LDS	—	—	—
	II- ,,	—	—	—
	III- ,,	—	—	—
	VI- ,,	0·23	55	—
	IV-HDS	0·33	116	—
	V- ,,	0·08	18	—
Oribi	I-LDS	0·81	515	78·7
	II- ,,	1·63	407	93·0
	III- ,,	2·81	964	116·8
	VI- ,,	1·03	248	47·0
	IV-HDS	2·42	1220	174·4
	V- ,,	2·81	629	120·5
Reedbuck	I-LDS	0·65	413	93·0
	II- ,,	1·28	320	70·1
	III- ,,	1·72	590	137·5
	VI- ,,	1·40	337	79·4
	IV-HDS	1·85	932	107·6
	V- ,,	2·81	629	102·5
Rhinoceros	I-LDS	0·02	13	
	II- ,,	—	—	—
	III- ,,			—
	VI- ,,	—		—
	IV-HDS	0·08	40	—
	V- ,,	—	—	—
Warthog	I-LDS	0·51	324	57·4
	II- ,,	0·99	248	114·7
	III- ,,	0·36	124	100·4
	VI- ,,	0·56	135	55·3
	IV-HDS	0·22	111	41·9
	V- ,,	0·66	148	60·5
Waterbuck	I-LDS	0·35	223	
	II- ,,	1·05	350	
	III- ,,	0·73	250	
	VI- ,,	0·05	12	—
	IV-HDS	0·81	408	—
	V- ,,	—	—	—

stop-watches and converted into distance from the starting point of the transect. The distributions of the species were then plotted on a 1:100 000 vegetation map of the park.

Densities for each 64 km² square were plotted for oribi, bohor reedbuck, bubal hartebeest, roan antelope and defassa waterbuck. No density maps were made for the other species because of the small numbers encountered on the transects. Instead, the location of individuals or herds along the transects have been plotted and in the case of elephant, giraffe, rhinoceros and giant eland, also those individuals occasionally seen outside the transect-strip.

To evaluate habitat preference, the relative frequency of species occurring in each vegetation type was calculated as the density of a species in the type compared to the total density of the species in the park. Departure from a uniform distribution was tested by χ^2.

Results

Population estimates

Population estimates for thirteen species for both LDS and HDS are given in Tables 2 and 3. Standard errors have been calculated for six species. It is possible to verify from the densities given in Tables 2 and 3 whether stratification was accurate. Strata boundaries seem correct for hartebeest, roan, reedbuck and oribi, for which mean densities in the HDS-blocks are consistently higher than in the LDS-blocks, except for oribi in block III. There is no apparent need for stratification for common duiker or warthog, which were found in more or less equal densities throughout the park.

Table 3. Population estimates (Y) from herd counts of bubal hartebeest, roan, giant eland and buffalo in low density stratum (LDS) and high density stratum (HDS), Bouba Ndjida National Park

Species	Block/stratum	Herds/km²	Mean herd size	s	Pop. est. $\hat{Y}_i$	S.E.
Bubal hartebeest	I- LDS	0·38	4·61	0·78	1114	148·8
	II + III-LDS	0·33	6·15	1·54	1203	301·3
	VI- ,,	0·37	11·38	2·77	1023	247·0
	IV- HDS	0·70	6·78	0·80	2392	282·1
	V- ,,	0·58	7·12	1·46	925	189·7
Buffalo	I- LDS	0·02	8·00	—	102	—
	II + III- ,,	0·33	10·10	5·13	1976	—
	VI- ,,	0·14	22·80	10·60	776	—
	IV- HDS	0·11	11·49	6·76	637	—
	V- ,,	0·27	13·89	7·10	840	—
Giant Eland	I- LDS	—	—		—	—
	II + III- ,,	0·03	18·00		320	—
	IV- ,,	0·09	6·50		142	—
	VI- HDS	0·02	33·0	—	333	—
	V- ,,	0·04	20·00	—	179	—
Roan	I- LDS	0·30	4·83	1·14	922	145·0
	II + III- ,,	0·30	6·91	1·22	1229	217·0
	VI- ,,	0·19	4·20	3·20	194	146·6
	IV- HDS	0·41	5·09	0·99	1052	204·5
	V- ,,	0·62	5·88	1·30	817	108·5

The smallest standard errors were obtained for oribi, reedbuck and common duiker (Table 4.) Because their distribution tends to be uniform, systematic transect sampling of these species results in fairly precise estimates. However, counting bias for these smaller species in these woodlands is certainly high and our estimates are very negatively biased according to the data from ground counts (Table 4).

Table 4. Total population estimates of some large mammals of the Bouba Ndjida National Park and comparison between aerial and ground sample counts

	Aerial sample count				Ground counts	
Species	LDS	HDS	Total	95% C.I. (% of total)	Total	95% C.I.
Buffalo	2854	1477	4331		1500–2000	—
Common duiker	835	444	1279	±228(18)	5400	—
Elephant	56	176	232		150–300	—
Giant eland	462	512	974	—	800–1100	—
Giraffe	46	123	169	—	75–150	
Hartebeest	3340	3319	6659	±1248(19)	6988	±2663
Korrigum	55	184	239	—	100–200	
Oribi	2134	1849	3983	±539(14)	11736	±2538
Reedbuck	1660	1561	3221	±484(15)	5663	±2525
Rhinoceros	13	40	53		25–50	—
Roan	2245	1869	4114	±794(19)	4356	±396
Warthog	831	259	1090	+367(34)	2196	—
Waterbuck	835	408	1243	—	1383	—

Distribution

Distribution maps are shown in Figs 2–4. The highest densities of most species were found in the central and central-southern parts of the park, animals becoming less abundant towards the periphery, particularly in the north and in the south-western corner. There is a notable scarcity of buffalo, eland, waterbuck and roan in the north, where the park boundaries form the international boundary with Chad. This might be explained by the presence just across the boundary, of a number of villages. During the survey, two temporary villages of nomadic pastoralists and their herds were seen within the park area. Locally there are signs of deterioration of grass-cover and, along watercourses, advanced stages of accelerated erosion, which is probably the result of too frequent accidental burning (C. Geerling, personal communication).

Most of the east, west and south is bounded by hunting zones which are intensively used from December till May. Hunting pressure may explain the absence of most species from along the boundaries, particularly in the south-west corner, as was suggested by Bosch (1976). There is trophy hunting in the area adjacent to the south-west corner of the park and most of the waterbuck there are females. The impact of illegal hunting is certainly most important along the park boundaries.

The most widespread species are oribi, common duiker and to a lesser extent warthog and reedbuck. Hartebeest and roan are more concentrated in the central area, whereas buffalo is most abundant in the south-east corner of the park, where vegetation consists mainly of *I. doka–M. kerstingii*-savanna woodland. Most rhinoceros

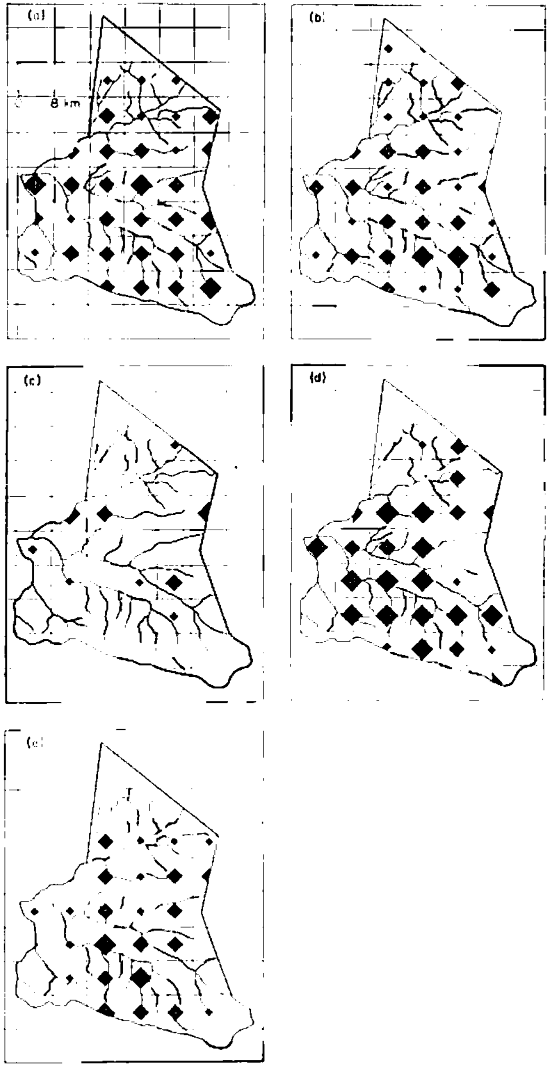

Fig. 2. Density distribution maps of some large mammals in the Bouba Ndjida National Park (30.5.77–2.6.77). (a) Oribi; (b) reedbuck; (c) waterbuck; (d) bubal-hartebeest; (e) roan antelope. Large blocks > 3/km²; medium blocks 1–3/km²; small blocks < 1/km².

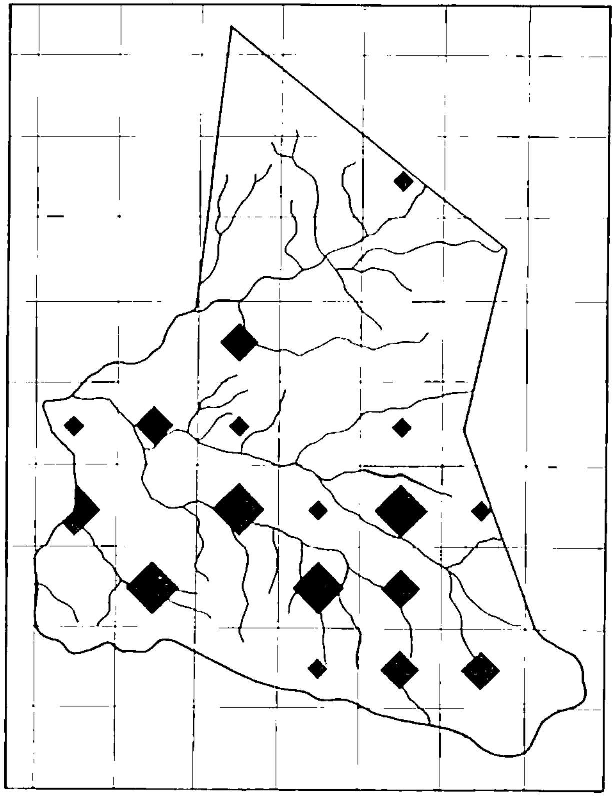

Fig. 3. Distribution of buffalo in the Bouba Ndjida National Park (30.5.77–2.6.77). Large blocks, high density; medium blocks, medium density; small blocks, low density.

were found in the west-central park area, in thickets on the foothills of the two mountains in the park.

Habitat preference

Relative habitat preferences of eight species, as derived from animal distributions plotted on a 1:100 000 vegetation map of the park, are given in Table 5.

Neither oribi nor reedbuck show a significant habitat preference, although reedbuck seems to have a much higher preference for *Anogeissus*-fringing forest close to water. The table suggests a small significant preference for *Terminalia laxiflora* wooded savanna by common duiker, but the low percentages for the two denser vegetation types (*Isoberlinia–Monotes* savanna woodland and fringing forest) might well reflect observer bias rather than habitat preference. Warthog seems to prefer fringing forests, which is probably explained by the fact that at the time of the survey,

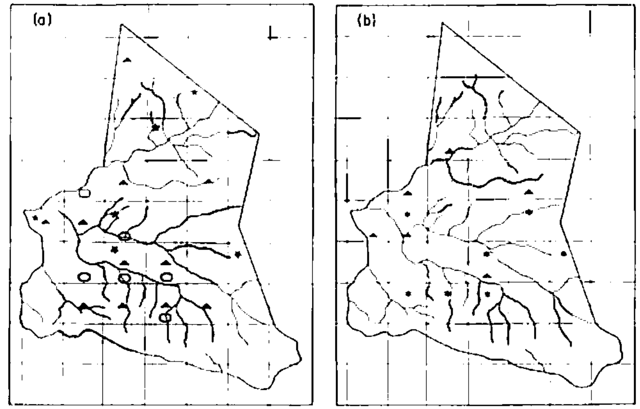

Fig. 4. Distribution of some large mammals in the Bouba Ndjida National Park; (a) giraffe (▲), korrigum (○), elephant (★); (b) rhinoceros (▲), giant eland (★).

Table 5. Relative habitat preference of some larger mammals, Bouba Njdida National Park. s = Significant habitat preference; n.s. = non-significant habitat preference

	Relative preference (%)				
Species	*T. laxiflora* wooded savanna	*Anogeissus leiocarpus* fringing woodland	*Isoberlinea Monotes* savanna woodland	*Isoberlinea doka* savanna woodland	*P*
Buffalo	30	16	45	9	s ($P < 0.001$)
Common duiker	35	19	17	29	s ($P < 0.05$)
Hartebeest	29	16	19	36	s ($P < 0.05$)
Oribi	30	17	22	31	n.s ($P < 0.1$)
Reedbuck	30	29	17	24	n.s ($P < 0.1$)
Roan	36	9	25	30	s ($P < 0.01$)
Warthog	23	38	25	14	s ($P < 0.01$)
Waterbuck	6	85	3	6	s ($P < 0.001$)

the clayey soils were locally covered with monocotyledons with bulbous roots, a preferred food item that had become available after the rains had softened the soil. Warthog seems to avoid *I. doka*-woodland to a certain degree. As expected, waterbuck was found predominantly in the fringing forest, close to the principal streams. No waterbuck was seen more than 2·5 km away from major watercourses.

Hartebeest shows a significant preference for *I. doka*-woodland and tends to avoid the fringing forest.

Roan antelope, being more of a browser than hartebeest in this region (C. Geerling, personal communication) shows a preference for *Terminalia laxiflora* wooded savanna and, to a lesser extent, for *I. doka*-savanna woodland. Roan seems to avoid the fringing forest even more than hartebeest.

Buffalo have a clear preference for *Isoberlinia–Monotes*-savanna woodland and, similar (tall perennials) and constitute excellent grazing for this species. It is not clear why they seem to avoid *I. doka*-woodland.

Discussion

Comparison of aerial and ground sample counts

Annual ground sample counts of the park have been carried out since 1974 (Van Lavieren & Bosch, 1977). The results of these counts are compared with the present data in Table 4.

There is no evidence that animal numbers have changed significantly during the last 3 years.

There is a great discrepancy between the aerial and ground estimates for the smaller species, the difference being pronounced for oribi, common duiker and warthog. Estimates for these species obtained from aerial counts are subject to negative counting bias: the table suggests that only 34%, 24% and 50% of oribi, common duiker and warthog, respectively, were seen from the air as compared to ground counts. One could alternatively assume an equally important positive bias in the estimates derived from ground counts, but this is unlikely since the four different ground census methods which were simultaneously carried out (King's census method, road-strip counts, 'mean-visibility'-method and sample drive counts) did not give significantly different estimates (Van Lavieren, 1979). The difference is less pronounced for reedbuck, although our estimates seem negatively biased. It is suggested that aerial sample counts for the above mentioned species in these types of habitats are not to be recommended. The validity of this conclusion for warthog is doubtful, as census results for this species are always subject to unknown counting errors. Thus, depending on weather and time of the day, a varying number of individuals hiding under thick cover or in burrows will be missed during the census.

The results for the larger antelopes agree much more closely; there is no significant difference for hartebeest and roan ($P > 0{\cdot}05$). For most other species listed in the table, the estimates are in good agreement. However, more than twice as many buffalo were estimated from the air but neither aerial nor ground sample counts are suitable to estimate numbers of highly gregarious animals like buffalo and eland.

Aerial transect sample counts are recommended for larger herbivores, buffalo and eland excepted. For these species, total counts or sample counts are more appropriate (Norton-Griffiths, 1975; Van Lavieren, 1976).

Cost

No data exist on costs of aerial surveys in West African National Parks or other wildlife reserves. Costs often are the limiting factor for low-budget Wildlife Departments in most West African countries. An estimate of the costs of this survey was made, including only the actual flying time and transport of fuel. The aircraft was hired from the capital, some 800 km from the survey area. Pilot salary and fuel costs were included in the hourly rent of the aircraft (23 000 francs CFA, about US \$93), but no further personnel costs were considered. Total costs amount to 484 300 francs CFA (= US \$1953), which is less than US \$1.00 per km². Of this 27% are costs of positioning flights, 57% are costs of the actual count and 16% of the total were costs of fuel transport.

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