ESTIMATION OF LARGE MAMMAL NUMBERS IN THE AKAGERA NATIONAL PARK AND MUTARA HUNTING RESERVE, RWANDA

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The Akagera National Park lies between latitudes 1° 00' and 2° 00' S, and longitudes 30° 20' and 30° 50' E. It is roughly 250,000 ha in extent, of which at least one quarter comprises the swamps and lakes of the Kagera River system, and a further 5,000 ha are settled; leaving a total of 182,500 ha. The area is adjoined on its western side by the 61,200 ha Mutara hunting reserve. Both areas are described elsewhere (Spinage and Guinness 1972).

No previous objective assessment of the large mammal numbers in this area could be traced, although De Leyn (1960) refers to systematic counts in the Mutara commencing October 1959. The only previous total estimate found was that of Verhulst (1947), quoted by Akeley (1950), who estimated there to be 4,000 impala (*Aepyceros melampus* Lichtenstein) ; 2,000 topi (*Damaliscus korrigum* Ogilby) ; 2,000 zebra (*Equus quagga boehmi* Matschie) ; 1,000 buffalo (*Syncerus caffer* Sparrman) ; 1,000 sitatunga (*Limnotragus spekei* Sclater) ; 700 eland (*Taurotragus oryx* Pallas) ; 500 waterbuck (*Kobus defassa ugandae* Neumann) and 150 roan antelope (*Hippotragus equinus* Desmarest). Hazaert and Verschuren (Verschuren 1965) conducted a number of track counts but did not extrapolate their results to the entire area. Despite Verhulst's conservative assessment popular literature and local opinion have exaggerated the numbers of animals present ; perhaps partly attributable to species such as eland, topi and zebra, aggregating in small areas at certain times of the year. The present paper reports an objective assessment of the numbers of major ungulates in the area made between July 1968 and October 1969.

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METHODS

Methods used to assess numbers were total counts within randomly selected quadrats, and total area air counts.

Quadrat counts

Lack of time precluded an initial appraisal of the region to determine whether stratified random sampling should be employed. Simple randomly chosen quadrats were used, obtained by placing

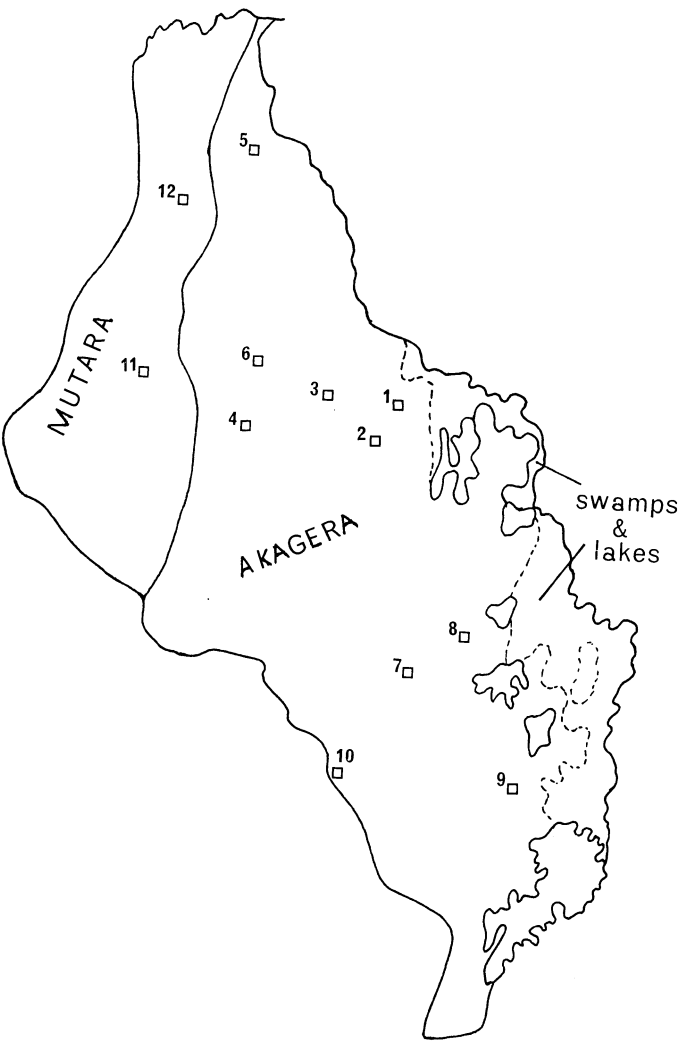

Fig. 1. — Dispositions of the 12 random study areas.

a trace of numbered squares over a map of the area, and selecting ten pairs of numbers from a table of random numbers for the Akagera sector, and two for the Mutara area. Those squares seen to be inaccessible on the ground were rejected, and the next pair of numbers taken. The distribution is shown in Figure 1.

The boundaries of the quadrats on the ground were largely determined by guesswork as an odometer was not available, and there was not time to survey them. Subsequently it was found that only 3.8 % (9,150 ha) had been covered, but this was as much as a team of two could conveniently sample each month.

Usually four transects, designed to give 500 m viewing on either side, were driven in each quadrat on N-S or E-W compass bearings, which were found to be difficult to maintain in some of the country encountered. In wooded areas the number of transects was increased. Twelve areas were counted at monthly intervals for six months from August 1968 to January 1969. Counts in four of the areas, representative of the different habitats, were continued for the next six months.

Air counts

Two air counts were made, using a Cessna 182 high-wing monoplane. The first count covered the park only, the second the Mutara area as well.

The first count was flown between the 17 and 25 October 1968, just after the commencement of the short rains, when the vegetation was very green giving good contrast. After an initial flight counting hippopotamus (*Hippopotamus amphibius* L.) only, it was decided that due to the low densities of animals seen, all species could be counted in a single flight plan. This took 10 days to complete in 34 flying hours, a number of potential flying hours being lost due to bad weather.

Flying was in N-S « sectors of convenience » at an altitude of 120 m above ground, landmarks being taken as boundaries. Subsequently it was decided this was an unsatisfactory method as it necessitated a lot of unproductive positioning flights.

The second survey was flown between the 10 and 18 February 1969 at the beginning of the long rains, when the grass was high and bushes and trees in full leaf giving impaired visibility. The entire area was covered in 33 flying hours using N-S transects which, although more economical of flying time, made subsequent comparisons between the two counts difficult (Fig. 2).

In the first count two observers were used, but only one was available for the second count. Direct counts were made of all animals seen, and herds of 30 and over were photographed obliquely with a hand-held camera, the photographs subsequently being counted at leisure.

RESULTS

Quadrat counts

The monthly cumulative means for the first six months' counting, that is

$$n, \frac{n + n^1}{2}, \frac{n + n^1 + n^2}{3} \ldots\ldots\ldots n^6$$

were showing reasonable uniformity (Table 1), so the counts were altered from 12 areas to 4, to continue observation of seasonal changes. Monthly fluctuations in the total numbers counted of

TABLE 1

Cumulative monthly averages of animals counted in the 12 study areas.

Species	Aug	Sep	Oct	Nov	Dec	Jan
Buffalo	57	172	155	211	279	268
Zebra	64	155	141	209	207	233
Topi	280	325	324	364	408	356
Roan	7	9	7	6	6	7
Eland	31	52	60	48	44	43
Impala	1 196	1 114	938	1 090	1 304	1 347
Waterbuck	53	51	43	47	49	50
Warthog	99	110	116	131	135	126
Oribi	77	81	89	96	90	77
Duiker	16	24	24	24	22	20
Reedbuck	20	29	31	37	34	30
n	1	2	3	4	5	6

main species are shown in fig. 2. From the similarity in the fluctuations between the 12 areas and the 4 of these areas for the first 6 months, it was considered reasonable to use the figures obtained from the 12 areas for the first 6 months to estimate total numbers. As the areas sampled in the Akagera sector amounted to 1/25 th, and in the Mutara area to 1/33 rd, the totals for the Akagera and Mutara areas were multiplied by 25 and 33 respectively, for an estimate of the total numbers of animals present (Table 2).

Air counts

The results are shown in Table 3. The means can only be taken as working totals, with the knowledge that the real totals may be much higher for some species.

TABLE 2

Population totals estimated from six ground counts of ten study areas in the Akagera Park.

Species	Mean	95 % conf limits	SE as %	Mean/ km2	Esti-mated total [a]	± SE
Impala	1 259	± 408	16.6	16.6	31,475	± 5,225
Topi	337	126	19.2	4.6	8,425	1,618
Buffalo	268	145	27.5	3.5	6,100	1,678
Zebra	221	104	24.0	3.1	5,525	1,326
Warthog	121	28	11.9	1.9	3,025	360
Oribi	53	28	17.8	0.8	1,325	236
Waterbuck	50	9	9.6	0.8	1,250	120
Eland	43	21	25.1	0.6	1,075	270
Reedbuck	21	8	20.0	0.3	525	105
Duiker	16	6	19.6	0.2	400	78
Roan	6	2	21.6	0.08	150	32
Lion	3	—	35.9	0.04	75	27
Population totals estimated from six ground counts of two study areas in the Mutara Reserve.						
Impala	88	27	15.7	4.8	2,904	456
Oribi	25	15	31.4	1.4	825	260
Topi	22	17	38.6	1.2	726	280
Zebra	13	14	58.5	0.7	429	251
Reedbuck	10	5	30.0	0.5	330	99
Warthog	4	5	59.8	0.2	132	79
Duiker	4	2	20.5	0.2	132	27
Roan	0.8	—	20.3	0.04	26	5
Eland	0.5	—	—	0.03	17	
Lion	1.5	—	—	0.08	50	
Buffalo	0	0	0	0	0	
Waterbuck	0	0	0	0	0	

a. For the Akagera Park the mean is multiplied by 25, the portion of the total area counted ; and for the Mutara Reserve by 33.

The second count gave consistently lower totals with only two exceptions, zebra and hippopotamus. In the case of zebra others could have moved in from the Mutara area. Hippopotamus are difficult to count as some may be under the surface, or ripple may obscure visibility. It seems likely that buffalo were overcounted in the first survey as there was a greater possibility in the first flight

TABLE 3

Total counts of animals seen in two air counts.

Species	Oct 1968	Feb 1969	% difference	Mean	Mutara [a]
Buffalo	8,538	4,721	— 44	6,630	450
Impala	5,445	5,167	— 5	5,306	250
Topi	1,528	1,507	— 1	1,518	70
Zebra	1,299	1,441	+ 10	1,370	330
Hippopotamus	506	671	+ 24	589	80
Warthog	500	377	— 25	439	55
Eland	531	184	— 65	358	120
Waterbuck	299	122	— 60	211	30
Roan	83	31	— 63	57	10
Rhinoceros	6	3	— 50	5	0

a. Counted in February only.

plan of a herd running from one transect to the next. Some eland may have moved into the Mutara area, accounting for the difference in totals. The small differences between three major species, impala, topi and zebra, lend confidence, however, to the results.

DISCUSSION

Quadrat counts

The graphs (Fig. 2) can be divided into those showing large species equally visible throughout the year, and small species which may become obscured by long vegetation. In the former category are buffalo, zebra, topi, eland, roan, waterbuck and impala. The buffalo and zebra numbers suggest random fluctuation, but the topi show a marked decline during the long dry season and again in the short dry season. Roan numbers appear to show random fluctuation, but this could be attributable to small sample size. The impala show a steady decline in the long dry season and reach a peak in numbers at the end of the rains ; while waterbuck is the only species to show little fluctuation.

In the second category warthog (*Phacochoerus aethiopicus* Pallas), reedbuck (*Redunca redunca wardi* Thomas) and oribi (*Ourebia ourebia* Zimmerman), all show a similar pattern. This is a rise in observed numbers after the June to August grass burning, followed by a decline in numbers as the grass becomes high again. Ideally, if the species were all randomly distributed throughout the study areas as the method of sampling implies, we would not expect

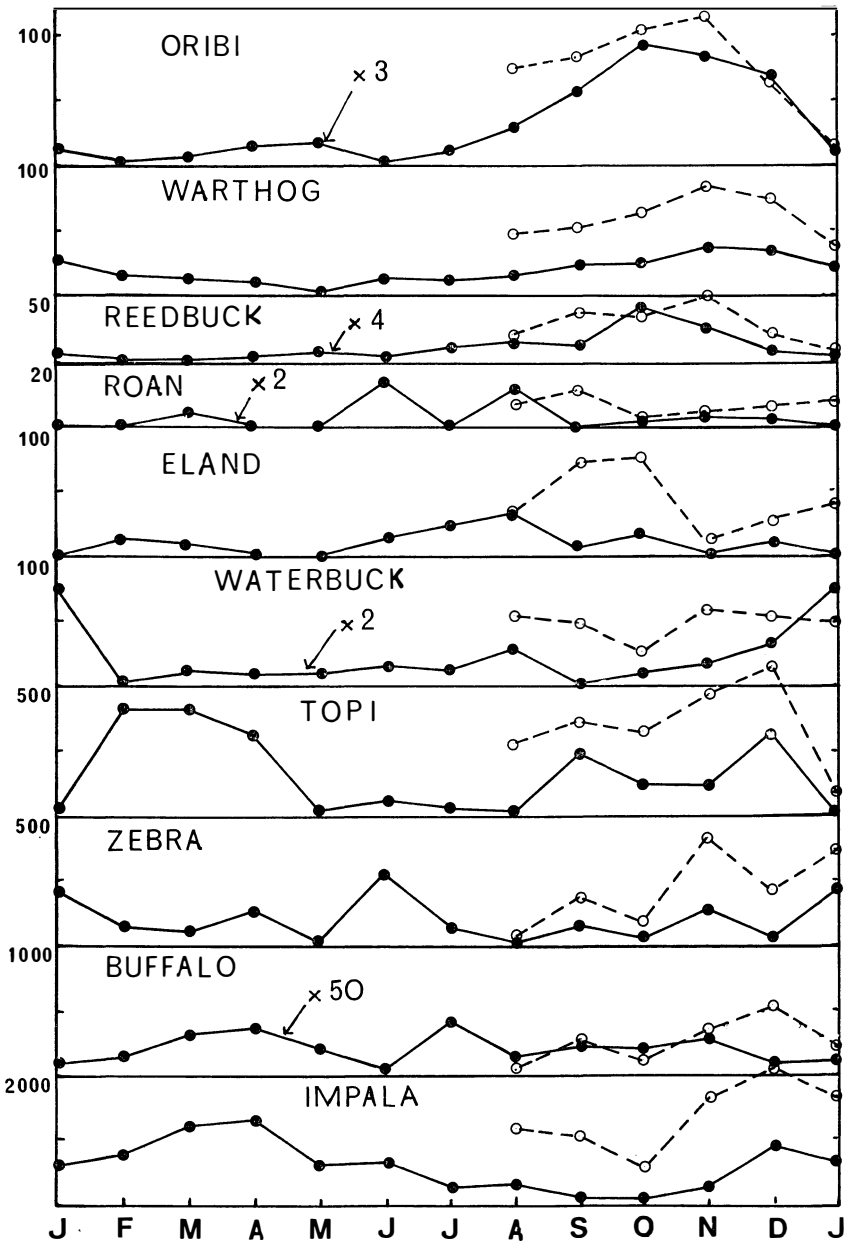

Fig. 2. — Monthly fluctuations in the total numbers of animals counted in the study areas. Continuous line, four areas for twelve months ; broken line, twelve areas for six months.

to find any marked seasonal fluctuation in numbers, other than amongst the small species.

Also if the populations were randomly dispersed then the frequency of occurrence would be expected to conform to a Poisson distribution, and the variance should be more or less equal to the mean. Table 4 shows that this was not so. A high variance indicates a contagious distribution, whereas a regular distribution has a variance equal to, or less than, the mean. However the ratio of the variance to the mean decreases with decreasing population size and at very low densities it is difficult to distinguish randomness from aggregation. In column 3 (Table 4) the results have been tested for the index of dispersion, which helps to clarify the relationship between the variance and the mean and enables the significance of results to be calculated. When « I » equals unity the species is randomly distributed, when it is less than unity the species is regularly distributed, and if it is greater than unity then the species is aggregated. With the exceptions of roan and duiker (*Sylvicapra grimmia* L.), all the species in table 4 show a high level of aggregation. To reduce the variance the data for some species would require more correction, that is larger sampling, than others. Impala stand alone, while we might treat the others in three groups ; topi and waterbuck ; zebra, eland and warthog ; buffalo, oribi and reedbuck. But Cole (1946) considers that contagion makes it « extremely hazardous to use sample collections in esti-

TABLE 4

Ground counts. Comparison of the mean ($\bar{x}$), variance (s^2), and index of dispersion (I), for each species per sampling area, mean of the six observations in the Akagera Park. Y shows the factor by which the total population estimate is greater than the air count total.

Species	$\bar{x}$	s^2	I	Y
Impala	126.0	11,859	94.1	5.9
Topi	33.6	1,645	44.5	5.6
Waterbuck	4.9	195	39.8	5.9
Warthog	11.6	176	15.2	7.0
Zebra	22.1	199	9.0	4.0
Eland	4.3	38.5	8.9	3.0
Buffalo	26.8	1,347	5.0	1.0
Oribi	5.3	27	4.7	—
Reedbuck	2.1	7.3	3.5	—
Roan	0.57	0.56	1.02	2.6
Duiker	1.56	1.4	0.9	—

mating any larger population. Even in a mildly contagious distribution this factor may be of considerable importance ».

Air counts

In estimation analysis the factors are the same whether the count is performed on the ground or in the air. Both methods have their specific operational errors, but air counts mean that much larger areas, and also rough and inaccessible country, can be covered in a short time. There was however a wide discrepancy between the estimates obtained from the ground counts and those from the air counts. This confronts us with the problem as to which of the two estimates is most likely to be closer to the true totals.

Recent analyses of air counts for a variety of species have shown that these are likely to give misleading results (Lovaas *et al.* 1966, Goddard 1967, Watson *et al.* 1969). Jolly (1969) has argued for random sampling rather than total area counts, as greater accuracy may then be achieved by spending more effort on less area. But this view is at variance with Cole's (1946) for species which herd together, and in fact the difference between the air and the ground counts in this study tended to increase with the increase in the index of dispersion (Table 4).

CONCLUSION

In view of the errors of estimation which contagion may introduce, replicated total area counts would seem to eliminate all errors other than operational ones. The latter could then be recognised as such although Jolly (personal communication) considers that bias may then become larger relative to random errors. In this study there were insufficient air counts to assess errors, and we can only postulate that the true animal totals lie somewhere between the air and ground count estimates.

SUMMARY

Two methods were used to estimate large mammal numbers in the 250,000 ha Akagera National Park, and the 61,200 ha Mutara Hunting Reserve, Rwanda. Six monthly ground counts were made by Landrover, of twelve randomly chosen quadrats covering 3.8 % of the total area ; and two total air counts. The methods gave differing results, the ground estimates being up to about six times greater. This may have been attributable to contagious distribution of some of the species counted, and the small sampling fraction.

RESUME

Deux méthodes ont été employées pour estimer les effectifs des grands mammifères du Parc National de l'Akagera et du domaine

de chasse du Mutara, qui couvrent respectivement 250 000 et 61 000 ha.

D'une part, six comptages terrestres par Landrover de douze quadrats pris au hasard et couvrant 3,8 % de la superficie totale, et d'autre part, deux comptages par avion.

Les deux méthodes donnent des résultats différents, les estimations terrestres étant jusqu'à six fois supérieures. Cela peut être attribuable à la petitesse de l'échantillon, et au fait que certaines espèces ont une distribution aggrégative.

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