AERIAL SURVEYS IN THE STUDY OF ANIMAL POPULATIONS AND RANGE CONDITIONS

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ABSTRACT

For the past decade, low altitude aerial surveys have been used for counting large mammals, especially wildlife, over extensive areas of land in East Africa. The facilities and methods suitable in East African conditions are not directly applicable to West Africa because of the dense savanna woodland vegetation, which limits the visibility of the animals, and the Harmattan dust, which makes accurate navigation difficult.

The Department of Forest Resources Management, University of Ibadan, has been engaged in a pioneering project of censusing large mammals from the air in Lake Kainji National Park. A high wing, single engine, four seater aircraft was used to overfly the 4,000 sq. km. reserve. The aircraft cruised at 150 kph at a height of 120 meters. Large mammals were counted and the vegetation types and range conditions were also recorded.

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This rapid and relatively low cost technique could suitably be applied to the study of free ranging cattle in the savanna areas of Nigeria. Such a survey would yield information on the total number of animals, their distribution patterns and their habitat utilization.

INTRODUCTION

During the past decase, low altitude aerial surveys have been carried out in many of the East African wildlife reserves (Cobb 1976, Norton-Griffiths 1975, Watson 1969, Western 1975). Some of these surveys (Cobb 1976) have been particularly extensive, covering large areas of both wildlife and pastoral land. To date however, such surveys have not been carried out in West Africa, because of the relatively dense structure of the savanna woodland, the seasonal weather conditions and the lack of suitable aircraft.

In 1976, a low altitude aerial monitoring programme was initiated to study the wildlife populations in Lake Kainji National Park. The survey was designed to answer the following questions: How many animals are there in the reserve? Where are the animals distributed and how does this distribution pattern change between seasons? Why are the animals distributed in particular areas at particular times of the year?

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SURVEY METHODS

The basic plan of the survey was to fly over the reserve in a light aircraft, as low and as slowly as possible, and to count animals and record the range conditions.

One of the first problems in any animal census is to define a suitable sample strategy. Norton-Griffiths (1976) has provided a detailed account of the relative merits and demerits of total and sample counts, of random and non-random counts, of stratified and unstratified counts. For most aerial monitoring programmes, especially in areas where there is little previous information, the best plan for data collection is to overfly the area in strip sample units, using a systematic flight pattern (Cobb 1976). In Kainji, 5 km intervals between the strips were considered suitable in terms of the total area and time available. There are marginal statistical shortcomings in non-random counts, but these are outweighed by the orderly nature in which the data are gathered and the ease that this makes for subsequent spatial analysis.

The survey was designed to cover the entire reserve, an area of about 4000 sq. km. A map of the reserve was divided into 5 x 5 km grids and aerial strip samples were then flown down the centre axis of each grid. In this way, information was collected from each grid.

The surveys were flown by a crew of four, a pilot and three observers, in a single engine, high wing Cessna 206 aircraft. The two rear observers recorded the number, age groups and sex of animals on each side of aircraft; while the forward observer, seated beside the pilot, recorded various range parameters. The range parameters that are recorded in this way will depend on the particular investigation. At Kainji, measurements were taken of permanent features, such as topography, drainage, vegetation type, tree cover and density, as well as seasonal features such as grazing intensity and the presence of water and fire. All information, both animal and range, were collected on pocket tape recorders. The area actually sampled along each flight line was restricted to a fixed strip width on either side of the aircraft, determined from the projection of two streamers trailing from the wing struts. The streamers were placed so that, at a particular height, they subtended a known width on the ground (Pennycuick & Western, 1972).

Following a test flight, a height of 120 meters and a strip width of 200 meters on either side of the aircraft was used. This resulted in a sample fraction of 8% for the reserve. A ground speed of 150 kph was maintained and this resulted in an overall rate of search of 1 sq. km. per minute.

<u>Sources of Error and Bias.</u>

Various sources of error and bias are inherrent in counting animals from the air. However, some of these are quantifiable while others can be kept to a minimum simply by good care.

Errors may occur in the measurement of altitude (and therefore strip width), and in accurate navigation. A radar altimeter provides the most accurate means of height control, but this instrument was not available for the present study. The pilot had to determine height from personal judgement and from a standard air pressure altimeter that was zeroed at ground level. Cobb (1976) has shown that an experienced pilot can maintain an extremely accurate flying height in this way.

Accurate navigation can be a problem, especially over flat, featureless terrain. In Kainji, navigation was possible with reference to two conspicuous hills. However, the Harmattan dust typical of the dry season in West Africa, greatly reduces visibility and can make accurate navigation extremely difficult. These Harmattan effects are not experienced in East Africa, where the early trials of aerial wildlife censusing were carried out. During thick Harmattan, when compass navigation becomes essential, cross winds cause drift across the sample grids. Clearly, the effects depend greatly on daily weather conditions and therefore, flights were planned to avoid days and areas of low visibility. At present, the use of Very Low Frequency (VLF) navigation systems are being examined. The VLF system is global in coverage, so that only the aircraft instrument is needed. This is expensive, but permits transects to be flown very accurately and repeat flights along the same transects are possible.

Bias in counting animals depends on the conspicuousness of the animals and this itself depends on the vegetation structure, light conditions, animal crypsis and individual observer ability.

The vegetation in the reserve is considered typically Northern Guinea Savanna Woodland (Keay 1959) and the canopy cover is, in general, greater than that in most East African reserves. It is clear however, that these levels of canopy, generally about 10%, do not prevent animal observations, especially within relatively narrow strips. The fringing forests that follow the water sources have a virtually closed canopy and this obstructs observations, especially of smaller species such as duikers and buskbucks. During the wet season, only the larger animals can be seen, because of the height (2-3 meters) of the savanna grasses.

Light conditions are poor at dawn and dusk and therefore these periods were avoided. The mid-day period, from 12.00 to 15.00 was also avoided, as this is the time when many large mammal species are resting in the shade and thus relatively inconspicuous.

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Finally, and yet rarely taken into account, are the biases due to observer's ability. Individuals vary widely, both in their ability to remain alert and fully functional over long periods, and in their ability to perceive objects and patterns. Cobb (1976) has shown that the ability to correctly count the number of animals in a herd varies according to the species being counted, with the greatest bias associated with the large herds. Cobb's figures were derived from the photographic correction of the estimates made by eye. In Kainji, the herd size of most species is relatively low, being usually less than ten individuals and this bias was therefore considered to be unimportant. However, for large herd species such as cattle, photographic correction of estimates would be essential, to guage the bias of each observer. Observer bias can be excluded altogether by using video tape recorders, attached to the aircraft wings. Video tapes are reusable and have a frameless format. They can be played back at once and any picture can be held for minute examination.

ANALYSIS OF INFORMATION

It is not the purpose of this paper to report the detailed results of our research at Kainji, but simply to give an indication of the kind of results that can be obtained from such aerial surveys. It is clear that the huge quantity of data that was collected and the relatively complex questions that have been asked from the data, required the development of some sophisticated computer packages.

The first type of analysis that was carried out produced population estimates for each of the large mammal species. Each flight line was taken as a sample unit and, as these were of different lengths, the samples were combined using a ratio estimate (Jolly 1969). This estimate is based on the assumption that a sample flight unit is likely to be nearer to the overall truth, the greater the area sampled. The results of the population estimates must be examined in terms of both accuracy and precision. Methods that return accurate estimates are important because they are close to the truth; while precise estimates are those with a low standard error. Precision is particularly important in the statistical comparison of data, either between different areas, or between repeat counts. Some population estimates from Kainji are given in table 1.

Table 1.

Lake Kainji National Park

Population estimates (± S. E.)
March 1976.

Hartebeest	1530 ± 540	Oribi	300 ± 90
Roan antelope	1270 ± 290	Grey Duiker	420 ± 100
Elephant	400 ± 160	Baboon troups	70 ± 20

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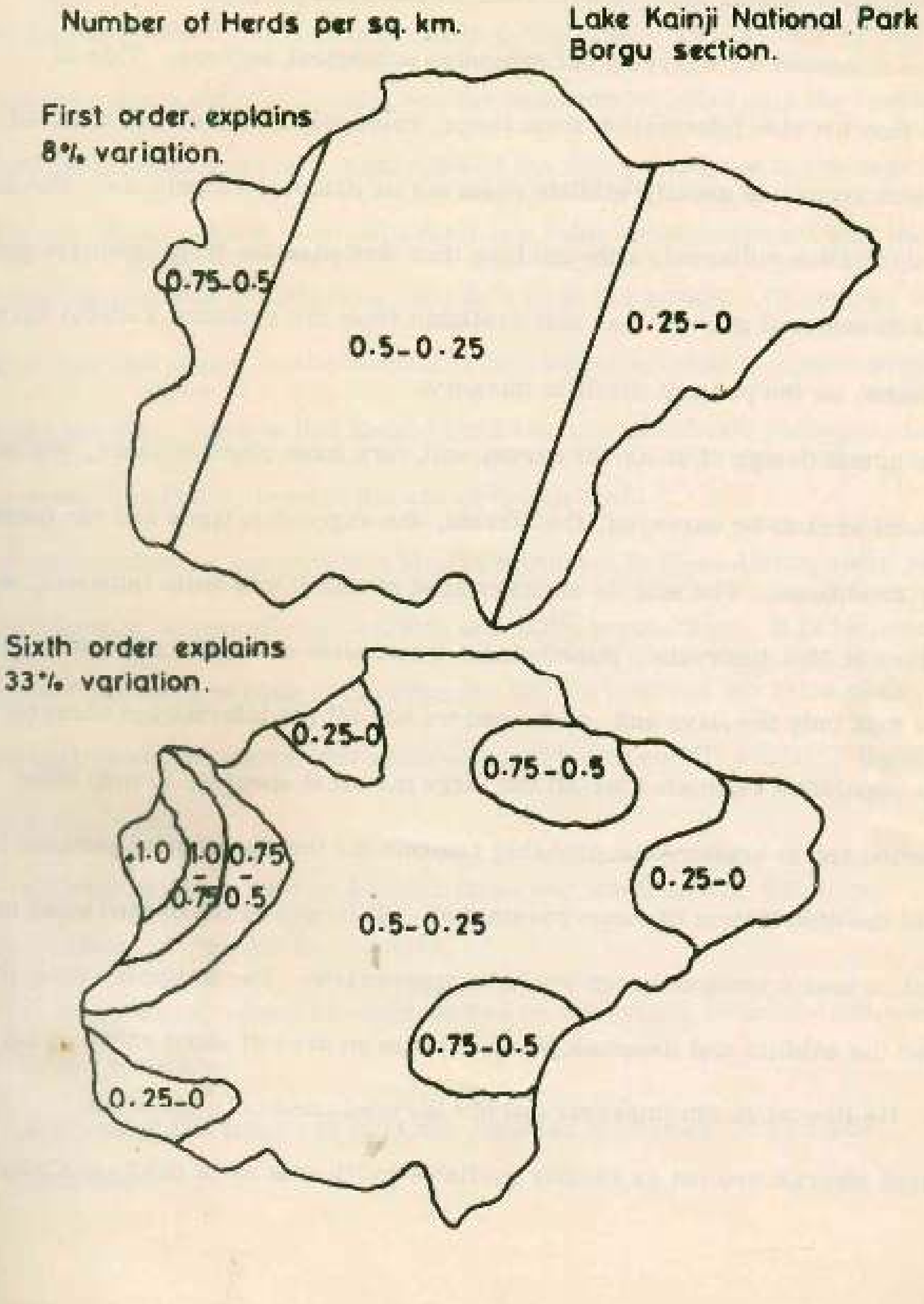
Hartebeest and roan antelope were recorded as the most abundant large mammals in the reserve. However, the precision of the estimates is not very high. This problem is due largely to the low densities of animals in the area, which resulted in a non-normal distribution of sightings between sample flight lines. The problem can be tackled, on the practical side, by either increasing the area of each sample flight line, or by repeat flights.

The second type of analysis examines distribution patterns and works on both the animal and habitat data. The animal observations per grid square are converted to density values and these can simply be presented in the form of a map. Similarly, all the range data can be mapped with reference to the grid squares. These maps are simple to produce and provide a rapid assessment of geographic distribution.

The third analysis, also of distribution, involves producing contour maps from the density values in each grid square. This may simply be done by hand, but, the contour intervals have more meaning if their significance is tested statistically. Trend surface analysis was used to identify and map the population density contours over the reserve. This analysis is essentially a three dimensional multiple regression, that fits polynomials of increasing order to the grid density data. Each polynomial order is examined in terms of its goodness of fit and contour intervals are examined using a 't' test. This analysis is particularly useful because it separates the broad, overall pattern of variation, from the local fluctuations. The purpose of the analysis, in fact, is to isolate and reveal these separate aspects of a distribution pattern.

A trend surface analysis of the large mammal community at Kainji is given in figure 1. Only the first and sixth order regressions were significant, indicating that there are two distribution patterns superimposed over the reserve. There is a general west - east decrease in animal density, with relatively high densities near the Benin boarder and relatively low densities near the Kainji lake shore. In addition, there are highly localized areas of high and low animal density.

The fourth kind of analysis examines habitat utilization and attempts to explain the distribution of the animals in terms of the variation in certain range parameters. Basically, the analysis examines the similarity between the animal density maps and the maps of range parameters, using multivariate multiple regression techniques. As an example, in the analysis of elephant distribution, water availability may explain 40% of the distribution, grass greeness, 20% and soil type, 10%. This analysis therefore gives the research not only descriptive value, but also predictive value. Analysis of this type would seem the most appropriate for solving many management problems.


Number of Herds per sq. km.
Lake Kainji National Park
Borgu section.
First order. explains
8% variation.
0.75-0.5
0.5-0.25
0.25-0
Sixth order explains
33% variation.
0.25-0
0.75-0.5
1.0
1.0
0.75
0.75
0.5
0.25-0
0.5-0.25
0.75-0.5
0.25-0

PRACTICAL CONSIDERATIONS

Low altitude aerial surveys have become increasingly popular in recent years, as a method for carrying out extensive ecological surveys. This is because they provide information from large, relatively inaccessible areas of land. Such areas are usually wildlife reserves or pastoral rangelands. The detail of the information collected, although less than that possible from intensive ground work, is considered greater than that available from the standard Federal Survey photographs, or the present satellite imagery.

The actual design of an aerial survey will vary from place to place, depending on the total area to be surveyed, the terrain, the vegetation types and the seasonal weather conditions. The sample strategy used at Kainji was quite intensive, with flight lines at 5km intervals. Nonetheless, a complete census of the 4000 sq km reserve took only two days and, at the end we had all the information necessary to make population estimates for all the large mammal species, to map their distribution and to examine the probable reasons for the distribution patterns in terms of the distribution of range parameters. If larger areas of land were to be sampled, a less intensive design would be appropriate. For example, Cobb (1976) analysed the wildlife and livestock populations in an area of about 45000 sq km in Kenya. He flew at 10 km intervals and his survey lasted only one week.

Light aircraft are not as readily available in Nigeria as in the East African countries, and official costs of rent can be prohibitive. The present survey was carried out using a private aircraft and the expenses included only the operational costs of the aircraft and fuel. Estimates of the flying costs are in the region of 25 kobo per sq km, which is an extremely low value when compared with the costs that could be involved in collecting such data from the ground. Of course, considerable time and money has been spent in developing suitable computer programmes to handle the data, but now that these have been assembled into packages, the future costs should only involve the use of the aircraft.

Opportunities for applying this kind of technique in West Africa would seem to be considerable, especially for wildlife and cattle populations. It is believed that, because of the relative ease of carrying out the surveys and the value of the associated analytical techniques, the methods could be especially useful in the following general situations:

1. As a preliminary survey for both large and small areas, where no previous information is available.
2. In large areas, where detailed studies on the ground cannot be extended to the whole area.
3. In areas where access is difficult, because of physical or climatic conditions.

Specifically, the techniques could be used to study the Fulani cattle in the savanna areas of Nigeria. The results of such a survey would indicate the abundance, seasonal distribution patterns and habitat utilization of the free ranging cattle. At present, these parameters of the populations represent some of the biggest gaps in our knowledge. As an example of the inputs required for such a cattle survey, an outline programme has been drawn up and is attached as an appendix.

These techniques can be used, in the first instance, to simply examine the present status of an area. A suitable design could then be set up as a baseline for an ongoing monitoring programme, which would indicate the major trends in the area, both seasonally and from year to year. The survey would be most valuable as part of a co-ordinated, multidisciplinary ecosystem study.

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REFERENCES

COBB, S. (1976). The distribution and abundance of the large herbivore community of Tsavo National Park, Kenya. Ph. D. thesis, Oxford University.

JOLLY, G. M. (1969). Sampling methods for aerial censuses of wildlife populations. E. Afr. Agric. For. J. 34 (special issue) pp. 46 - 49.

KEAY, R. W. J. (1959). An outline of Nigerian vegetation. 3rd edn. Federal Ministry of Information, Lagos.

NORTON-GRIFFITHS, M. (1975). The numbers and distribution of large mammals in Ruaha National Park, Tanzania. E. Afr. Wildl. J. 13(2) pp 121-141.

NORTON-GRIFITHS, M. (1976). Counting animals. Handbook of African Wildlife Ecology, A. W. L. F., Nairobi.

PENNYCUICK, C. J. and WESTERN, D. (1972). An investigation into some sources of bias in aerial transect sampling of large mammal populations. E. Afr. Wildl. J. 10(3), pp 175-192.

WATSON, R. M. (1969). A survey of the large mammal populations of south Turkana. Geogr. J. 135 (4), pp 529-546.

WESTERN, D. (1975). The structure, dynamics and changes of the Amboseli ecosystem. Ph. D. thesis, Nairobi, University.

APPENDIX

TITLE:

The cattle and Range of the Savanna Zone of Nigeria.

OBJECTIVES:

1. To carry out an aerial census of Fulani cattle in some selected ecological zones in the savanna areas of Nigeria, in order to describe and quantify the number of cattle in each zone.

2. To determine the distribution patterns of the cattle within each zone, in relation to season and other ecological factors that may be found to affect cattle distribution and habitat utilization.

3. To study the range conditions of each zone, in relation to burning, grazing intensity and the trend of the entire habitat.

BACKGROUND:

The Fulani cattle are easily the most important source of animal protein in Nigeria today. Because of the prevalence of tsetse flies in the southern areas, the larger part of the cattle population exists in the savanna areas of the north. Up till now, management has been mostly that of extensive nomadic pastoralism. While the ecological advantages of pastoralism are obvious, especially on marginal and sub-marginal grazinglands, this system, together with some complex social factors have made it difficult in the past to carry out a comprehensive census of this stock.

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It is difficult for the Government to plan for the management and development of any livestock, unless information is available on the total number, distribution and reproductive performance of the population. This information allows development planners to know how much investments will go into the cattle industry and what returns, in terms of productivity they can expect from the herds under specific systems of management.

Experience so far gained in the study of wild animal populations, which graze and browse within similar habitats to that of cattle, has shown that aerial survey methods in censusing wildlife can be adopted for cattle. The methods will not only give results within a short time, when compared to conventional ground census techniques, but would also avoid most of the sociological problems involved in a ground census. For example, no public relations work need be carried out prior to an aerial cattle census.

FACILITIES REQUIRED:

1 single engine, four seater, high wind aircraft.

1 colour video tape recorder

1 radar altimeter

1 very low frequency receiver and 3 tape recorders.

PERSONNEL:

The services of the following specialists would be required for the project:

(a) Population ecologist - to monitor the total numbers, distribution patterns and dynamics of animal populations.

(b) Range ecologist - to investigate the range conditions in relation to physical and biological factors and under different systems of management.

(c) Aerial photogrametric expert and biometrician - to interpret aerial photographs and process large quantities of multivariate data.