Game Management and Research by Aeroplane

Applying New Techniques in the Serengeti

By M. I. M. Turner and R. M. Watson

So great are the advantages of a light aeroplane for all aspects of game management, including anti-poacher operations and research, that the effective management of the 5,000-square-mile Serengeti National Park, in Tanzania, now depends on the plane. The running costs are considerably less than those of a Land Rover. The authors, who have been engaged on this work since early 1962, describe some of their observations on wildebeest migration which could only have been made from the air, and their methods of co-operating with ground-based rangers for effective anti-poacher control. Incidental advantages of the plane include its ability to swoop down and " buzz " the meat-carrying poachers, and its speed in discovering the " lost " tourist who has run out of petrol in the park.

SINCE the beginning of 1962 we have flown over 80,000 miles in the Serengeti National Park using a light aircraft for plotting, counting and more general observation of the game. The administrative area of the Park covers 5,000 square miles, but the Seregenti ecological unit covers over 12,000 square miles, with well over a million head of plains game, whose biological cycle takes them over most of the area in a spectacular seasonal migration. We are both qualified pilots, and work as an interchangeable pilot/observer team, the most efficient way to use an aeroplane for this work, as Zaphiro and Talbot noted (25).* This paper outlines our methods, and the wide range of uses for a light aircraft in wildlife management and research.

Although light planes have long been used in game management in the USA, they have only recently been accepted in East Africa. The first aircraft to operate in connection with East African game was the Tiger Moth which the professional hunters, Blixen and Finchatton, used in the late 1920's to spot elephants in the Voi area of Kenya. Not until the 1950's was the important role of the aeroplane in game management realised, and since then its uses have multiplied.† But until 1961, when the Tanganyika National Parks acquired their own aeroplane, aircraft were still only used on the occasions when ground methods were completely out of the question, except by Zaphiro, Lamprey and the Grzimeks. The 8,000 hours which the authors have flown over the last two years represent the

* Figures in brackets refer to the numbered bibliography on pages 21–22.
† See References 18, 4, 5, 11, 7, 8, 9, 25, 26, 19, 10.

https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press

first intensive and continuous use of a light aircraft in research and management in East Africa.

The aircraft we use is a Cessna 150, a high-wing monoplane, seating pilot and observer side by side. Its excellent forward visibility can be improved by flying with flap, and patroller doors give a side visibility that extends down under the aircraft. The cruising speed of 100 m.p.h. is ideal for observation, and we have rarely needed to fly at any slower speed. The only hazards we have consistently faced have been the many birds of prey, who are as keenly interested in following the game concentrations as we are. The low fuel consumption of 4·3 gallons per hour gives a range of 520 miles and makes fuel storage and supply at outlying airstrips manageable. The only drawbacks of the machine are its long take-off when operating between 4,000 and 6,000 feet from strips with an untreated grass surface and its slow rate of climb; these have limited the possible sites for airstrips considerably. The tricycle undercarriage is not ideal for bush landings, and we do not land away from airstrips unless on a road or on ground we know to be smooth. A simple two-crystal RT wireless keeps us in communication with Arusha and Seronera, and with the portable Fisher 800 sets of ground operators. We always carry a small flare pistol, a medical kit, one gallon of water, hard rations for three days and three lengths of nylon rope for tying down.

It is Cheaper by Air

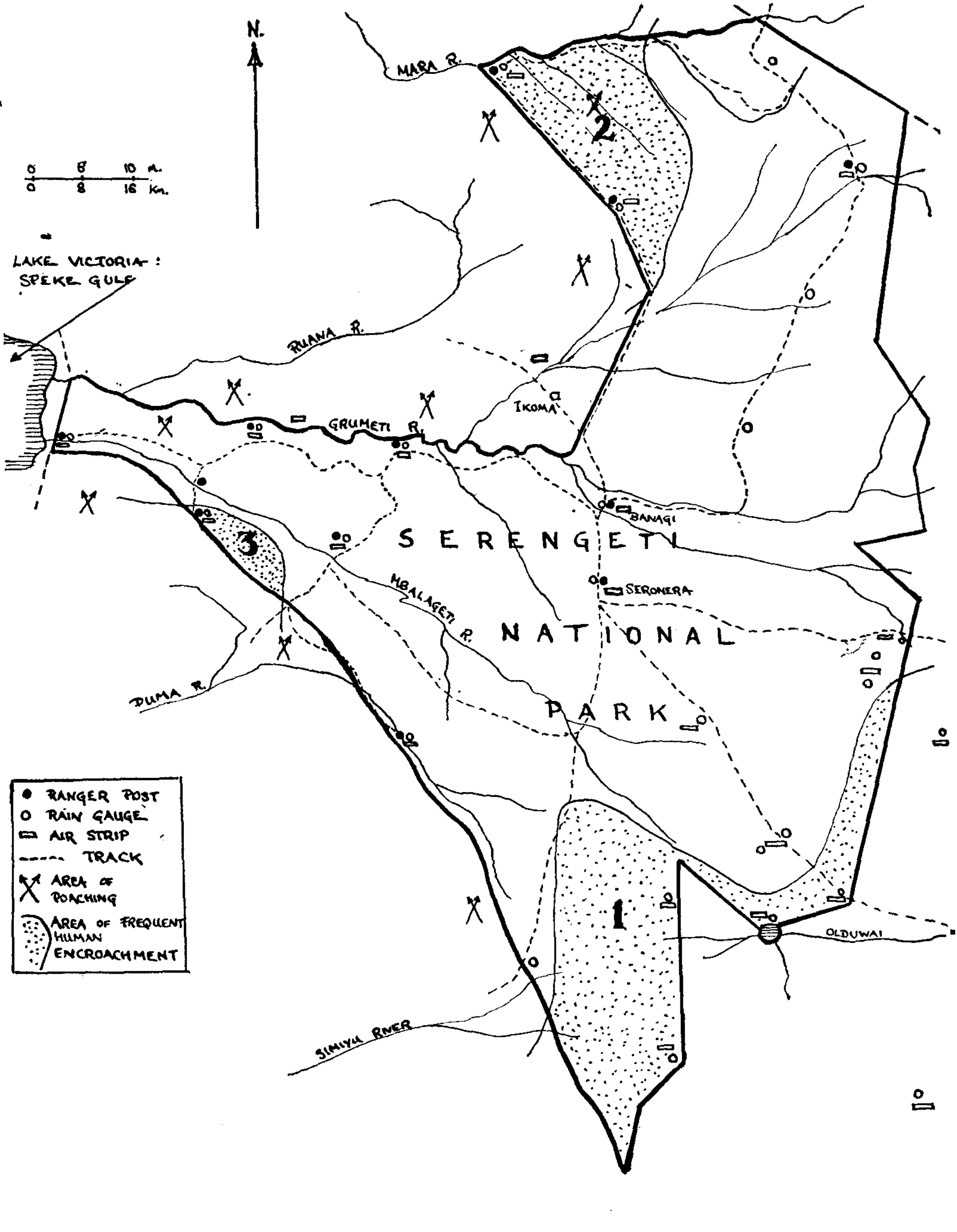
The aircraft is hangared at Seronera, the park headquarters, and flight plans are made for all flights. There are sufficient spares at Seronera for us to carry out 25-hour inspections, but for 100-hour maintenance the plane is flown to Nairobi. A stock of over 200 gallons of 87 Octane fuel is held at the hangar. In 1962 we calculated the cost of flying 490 hours; excluding depreciation, it worked out at 65 East African cents (8*d.* or 9 USA cents) per mile; including depreciation, it was 75 East African cents (about 9½*d.* or 11 USA cents). By comparison a Land Rover costs about 150 East African cents per mile (1*s* 4*d.* or 18 USA cents).

In the management and administration of the park, the plane's main uses are for spotting poachers and illegal grazing and settlement, and to a lesser degree for tourist control.

In 1952, when the Serengeti Game Reserve became the Serengeti National Park, the 5,000 square miles were unknown, unmapped, and, by tradition, very heavily poached. By 1961, when the Cessna 150 arrived, Land Rover tracks had been made to most of the poaching areas, and ten ranger posts had been established from which the Field Force was operating against poaching; but the cost and difficulty of maintaining bases and men in the field over 100 miles from Seronera were enormous. In the wet season, posts might be isolated for three months; rations ran out, prisoners were brought in on foot, and posts were even abandoned.

With the arrival of the aeroplane the anti-poaching system was reorganised. Airstrips were made close to eight of the ten ranger-posts, marked by piles of white-washed stones, and with a home-made windsock, and at each one a strong thorn boma was made in which the aircraft spends any overnight stops. This protects the tyres from being chewed by spotted

https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press



https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press

hyaena *Crocuta crocuta*, and the wings and the tail from stampeding game. The strength of the ranger posts was reduced to two men, one of whose functions is to maintain the narrow (about 8 feet wide) centre strip of the airfield free from grass, and the rest of the landing area free from holes and ant hills. To indicate whether the strip is suitable for landing or not they use red and white flags.

The rangers collect information about the poaching situation in their area, and flights are made to all the posts about twice a month to collect this information and also to supply them with medicines and provisions, and change personnel. The main anti-poaching Field Force is based in Seronera, in a state of readiness, and equipped with a Fisher 800 portable radio with which the members can keep in contact with Seronera when out on operations.

Tackling the Poachers

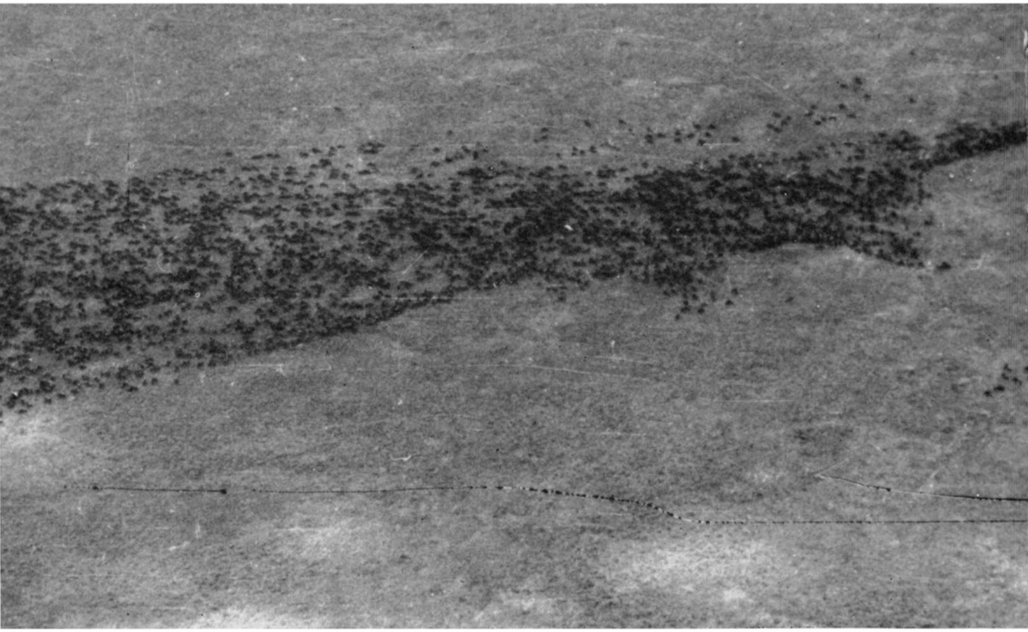
A great deal of the information about poaching on a large scale comes from our aerial reconnaissance as well as from the rangers and other informers. The gangs poaching in the Serengeti use bows with poisoned arrows and steel wire snares set in slight thorn fences. From the air it is very easy to spot large groups of people on foot and the snare line fences (see Plate 5); fires, excessive numbers of vultures, disturbed game and car tracks are all evidence of a poached area. We have recently been able from the air to distinguish between game tracks and the tracks of human beings, for example from a camp to a snare line. Moreover the constant plotting of the position of the migratory wildebeest *Connochaetes taurinus albojubatus* and zebra *Equus burchelli* groups, although done primarily for research purposes, is a vital intelligence service for the Field Force, because a large, dry-season concentration of wildebeest and zebra outside the park boundaries in any of the areas marked on the map as poaching areas invariably attracts the maximum number of poachers; this has been met by concentrated anti-poaching measures. Finally the all-seeing aeroplane, which may swoop and buzz a meat-carrying band as they cross open spaces, is a useful deterrent.

The regions marked 1–3 on the map are specially liable to illegal grazing by Masai, or illegal settlement and cultivation. Such activities are easily spotted from the air, and appropriate action can be taken before the offenders have become firmly entrenched. Very occasionally visitors break down, get lost or stuck, or run out of petrol in the park. From the air such people are easily located and a relief party directed to the spot. This, of course, is not the prime use for the plane, and air searches are instituted only when it is known that a vehicle is overdue.

The use of the aeroplane for research involves rather special methods to collect information. The first workers to give a realistic picture of the plains game migrations were the Grzimeks (9), for previous work had been ground based and therefore showed little understanding of the phenomenon. Talbot's work substantially confirmed and extended the Grzimeks' findings (17). In our work on migration we have concentrated on wildebeest, as the most significant species and having the greatest biomass of all the migratory animals. Each week over the past two years we have

Plate I : COUNTING WILDEBEEST IN THE SERENGETI.

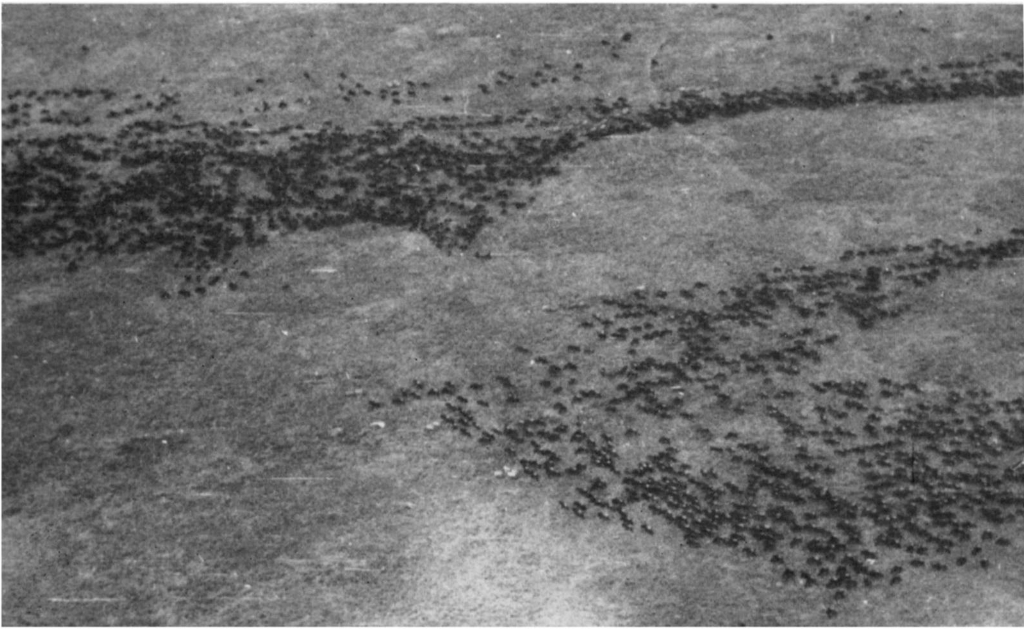
https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press



Plates 2 and 3 : Two photographs from a series, taken from 1,000 feet, of an elongated
The two " points " at the right-hand end of the herd in Plate 2 overlap the similar
front of Plate 2 are those in

Plate 4 : A 14-month-old male wildebeest, one of a small herd
of free-ranging semi-tame animals used in the research work.

https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press



concentration of wildebeest, showing the method of counting overlapping obliques.
" points " on the left-hand of Plate 3, and the few animals on the right edge at the
the lower centre of Plate 3.

Plate 5 : A poachers' snare-line fence (across the centre of the picture) is clearly seen from the air among acacia trees in the Serengeti.

https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press

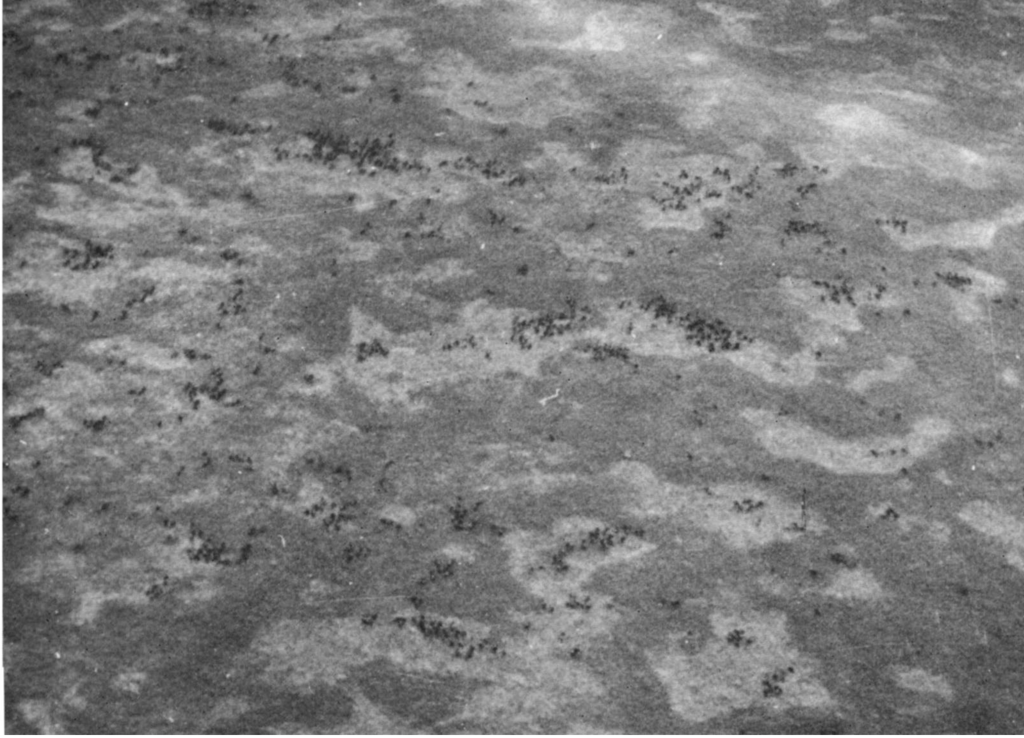
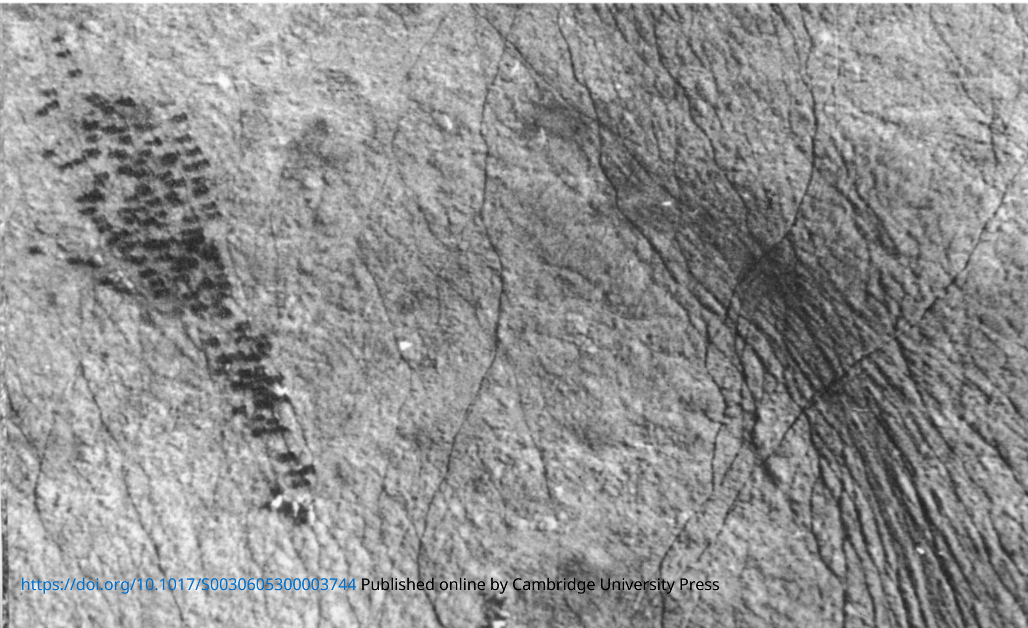


Plate 6: Wildebeest displaying a grazing preference. The light patches of vegetation which they are grazing are an association of *Andropogon greenwayii* with a few annual species.

Plate 7: Tracks made by wildebeest are used again by a small herd. The zebra at the head of the column are a typical sight.



https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press

made two or three flights with the object, first, of determining exactly the grosser aspects of migration. The position and estimated number of wildebeest are recorded on a 1 : 500,000 map; other information is recorded in proforma style and attached to the map. With over 250 aerial maps, representing 500 hours flying over the migration, we now have a substantial body of data from which the gross features can be described, and hypotheses about cause, regularity, etc., made.

Our migration flying is non-systematic; once we have established the whereabouts of the greatest numbers of wildebeest, subsequent flights are made in that direction. Usually flights are continued until we are satisfied that we have seen 200,000 head, i.e. over 66 per cent of the total. At most times of the year the wildebeest are concentrated in one, two or three fairly small areas. Only at the height of the dry-season dispersion does this wide distribution make complete coverage difficult, and then we make more flights over the major groups and only locate the smaller groups every one or two weeks. The validity of non-random flying to locate the migratory wildebeest is confirmed by the very small numbers sighted on other management flights.

Finding Wildebeest by their Tracks

One of the interesting features of our observation methods on these flights is the use of tracks. Usually at 1,000 feet large groups of wildebeest are visible up to 8 miles away. But the wildebeest are able to travel much further than 8 miles in two or three days, and only by following tracks from the known position on a previous flight can a rapidly moving group be easily relocated. Old tracks, sometimes revealed as a characteristic reticular pattern in the vegetation, give valuable information on the migrations in previous seasons, and in particular show how much hills and valleys are used as topographical guides by wildebeest on the move.

One thing the migration flying has demonstrated is the complete inadequacy of the Serengeti National Park for the year-round ecological requirements of over half of its game animals, which confirms the Grzimeks' findings (9, 15, 16, 22).

The methods used for counting animals have varied widely in the last ten years (1, 5, 21, 2, 3, 13). Factors such as seasonal movements of the animals, the size of the groups, the visibility and spacing of individual animals, all affect the choice of method. The plains game of the Serengeti were first counted at the beginning of 1958 by the Grzimeks, and again in May, 1961, by the Royal Air Force, and by Stewart and Talbot independently (7, 14). We make our counts at the end of May when the wildebeest and zebra are mainly concentrated in a few dense groups, immediately before they start their westward migration away from the plains. The animals must either be packed in rather small groups of 5,000 to 6,000, or the groups must have a very pronounced long axis, as they have when the westward movement has just started. These groups are then photographed with a 35 mm. camera, using a 50 mm. lens obliquely, from 800 feet; where the group requires more than one frame, overlapping obliques are taken (see Plates 2 and 3). From glossy prints 16·5 × 21·6 cm., the individual wildebeest or zebra are counted with the aid of a

https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press

mounted needle and lens. In 1963, 150,000 zebra and 303,000 wildebeest were counted in this way, with an error judged not to exceed 10 per cent. The method is dealt with in detail in a paper under preparation.

Talbot and Zaphiro (19) noted the possibility of using the aircraft to analyse wildlife population structures; to do this for large migratory populations, aerial photography is essential. In the Serengeti we use aerial photographs for both sampling and analysis of the wildebeest population. The advantage of an aircraft in sampling a population that may be spread over several hundred square miles is obvious, especially as different age and sex groups are often segregated. Moreover the aircraft eliminates the possibility of the sampling being biased because of behavioural differences common to some age or sex classes. For instance, on the ground it was clearly seen that cows with young calves had a flight distance up to five times greater than other adults, and in ground based analyses of population this was reflected in an apparent loss of calves. Photographs are taken from 150 feet, obliquely, at fixed time intervals while flying a predetermined course. At present it is not always possible to distinguish cows and bulls on the photographs, but classification as adults, yearlings and calves is simple. Every month a sample of 15,000–20,000 is analysed in the way described.

So far it has been impossible to establish comprehensive meteorological stations all over the Park. Rainfall is thought to be the most important single climatic factor in the ecosystem. The Serengeti Research Project, continuing and extending a system already operated by the park wardens, established a system of storage rainfall gauges, to be read on the first of each month (and at any convenient intervening period). The problems of reading all twenty-six gauges on the same day has been overcome by the use of the aeroplane, and with the co-operation of the park wardens, and we now have our first strictly comparable rainfall records for a year.

A standardised record is kept of range conditions observed on every flight. The two criteria demonstrated to be empirically the most significant are the colour and height of grasses. Six grades of colour are used, and we have no difficulty in classifying any grass colour into an appropriate grade. We find that only vertical observation gives a valid comparative colour. The height of the grasses of a particular section of range can be judged from texture, but such judgment needs ground control before the observer can give a reliable estimate. The presence of animals and tracks and the movement of grasses in the wind are valuable aids in assessing grass heights. Four height classifications are considered adequate.

The presence of rain water, or overflow and oxbow pools is recorded on every flight map, and the status of the river flow (flooding, flowing or standing pools) and spring flow noted. As observed in the Serengeti Research Project Report, 1963, rain water pools represent the major source of drinking water for the plains game for eight months of the year. The distribution of these small pools is unrelated to any general topographical feature, and it is possible on the ground to pronounce an area devoid of surface water, which from the air shows ten to twenty rainwater pools to the square mile.

As in most grassland areas of Africa, fire plays an important, possibly

https://doi.org/10.1017/S0030605300003744 Published online by Cambridge University Press

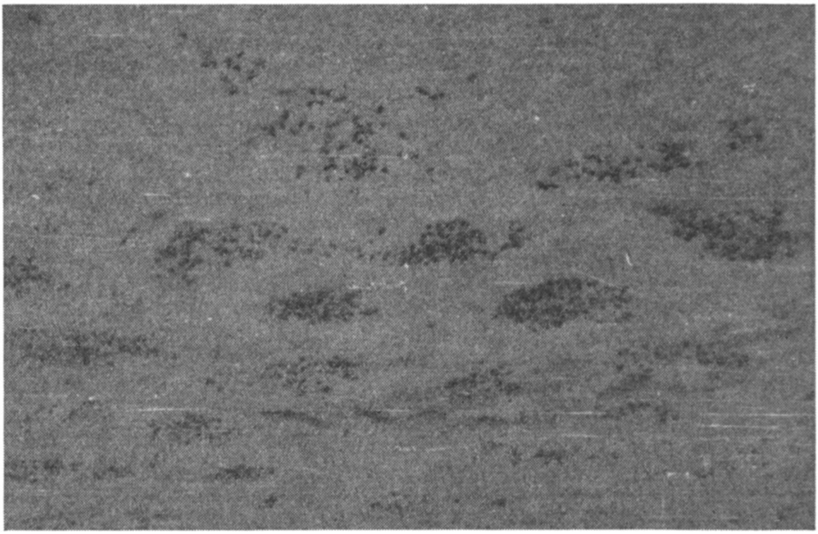


Fig. 1 : Typical rutting groups of wildebeest, photographed from 800 feet. Each group consists of between 20 and 100 cows with their calves and one or two bulls. The more widely spaced animals are bulls.

dominant, role. Over the last two years, the exact regions burnt, and the dates of burning, have been recorded for all fires in the Serengeti. This information will show what the typical burning patterns were in primitive Africa. Areas with different burning régimes may be expected to show vegetational differences.

On our migration flights we have recorded and photographed the patterns of wildebeest (see Fig. 1), and to a lesser extent zebra and gazelle *Gazella thomsoni*, *Gazella granti*. The patterns have purely physical characteristics of group number, group area, distribution within the group, orientation of animals within the group, shape of the group and movements of the group (or of individuals in the group). As information about the characteristics of these patterns was built up, it became obvious that groups had a collective activity character, and we could recognise grazing groups, rutting groups, and so on. Moreover, the density of any activity pattern indicates its stability. For instance, a group of animals showing regular distribution at high density shows an unstable grazing pattern, and will in the near future begin moving. From these clear patterns, and their accurate analysis, we have been able to infer details of wildebeest activity normally requiring many hours of ground observation. The full details of pattern analysis in wildebeest are still being worked out.

In describing the broad vegetation types and identifying the most important grass species we have been fortunate to be under the tutelage of Dr. P. J. Greenway, who has frequently accompanied us on flights. As a result we have been able to map and describe the broad vegetation types of the unit. Particular patterns in the various grassland types are very striking from the air, resembling in many ways the patterns described by other workers in semi-arid areas (24, 12). Examination on the ground shows that the components of the pattern are made up of different grass species, and very often of one species only. Having identified these components, we have been able in special cases, to say from the air that a particular grass species was being grazed, and confirmed it by control-observation on the ground.

Over two years we have accumulated information on the grazing preferences of the different plains game for the major vegetation types, in different conditions and at different times of the year (23). By overlapping the total records of wildebeest, zebra or gazelle positions on a vegetation map it has been possible to show the broad habitat preferences (generally equivalent to a grazing preference) of the species at different times of the year, and, as already mentioned, in special cases it has been possible to infer from aerial observation the actual species of grass being grazed (see Plate 6). This photograph also shows how at one time all animals will prefer to graze species A, whereas at another time they will all be grazing species B.

It is difficult to approach animals on the ground when they are drinking, because their flight distance is far greater when they are drinking or waiting to drink. But from an altitude of 800 feet we have observed drinking so often that we can generalise on the time and type of water preferred. The preference for rain-water pools has been mentioned, and the depth of the tracks radiating from these pools suggests that these temporary water supplies have been important for several wet seasons.

SUMMARY

Since the beginning of 1962 the authors have flown more than 800 hours in light aircraft, performing management and research work in the Serengeti National Park. The general management of this 5,000-square-mile park now depends on the use of a light plane for the maintenance of effective ground patrols, the prevention of poaching, location of illegal grazers and cultivators, and the control of visitors and white hunters. Full aerial coverage of the plains game migrations has been carried out. Non-random flying is favoured for plotting the position of migratory ungulates, and for counting plains game. A detailed picture of rainfall distribution is becoming available from a system of rain-gauges at airstrips. Range condition is described at regular intervals for the whole ecological unit, and related to ungulate movements. Pattern analyses, from direct observation and from photographs, are reliable indicators of the activity, and probable future activity of wildebeest. Information about grazing and drinking preferences has been gained through aerial observation. The vegetation types of the ecological unit have been described from the air, and more detailed examination of the grasslands has shown regular distribution of certain grass species. The grazing of a broad grassland type is more influenced by this local position of certain grass species within the type, than any other factor.

ACKNOWLEDGMENTS

Turner acknowledges the permission of the Director of Tanzania National Parks to present this paper. Watson acknowledges the permission of the Food and Agriculture Organisation of the United Nations (who have provided three biologists to investigate the basic ecology of the Serengeti area, with a special view to determining the productivity in terms of animal protein). Our aeroplane was bought with the help of contributions from Mrs. M. Spalding and Air Commodore Benson, O.B.E. We were both taught to fly by Army Air Corps Staff Sergeant Tom Driver, and to him and his C.O., Major Whitehead, we offer sincere thanks. Dr. Jacques Verschuren and Dr. Hans Klingel have acted as observers, and Mr. J. S. Owen, Director of Tanganyika National Parks, has given constant encouragement and acted as pilot in the first wildebeest census. Finally we acknowledge the pioneer of aerial work in the Serengeti, Michael Grzimek, who was killed in 1960 when his aircraft crashed over the Serengeti. His dedication, and the enthusiasm of Professor B. Grzimek showed the great potential of light planes in the Serengeti. Through the Michael Grzimek Memorial Fund (and now also the Fritz Thyssen Foundation) the costs of running the Serengeti Project have been met.

Postscript: Since this article was written a Piper Super Cub aircraft has been obtained, through the considerable assistance of the New York Zoological Society and Mr. Royal Little. Its performance is superior to that of the Cessna 150. An aerial camera system, using an F.24 camera has been installed in it, and aerial photography both oblique and vertical is now done with this equipment.

REFERENCES

1. BANFIELD, A. W. F., D. R. FLOOK, J. P. KELSALL, and A. G. LOUGHREY, 1955. An aerial survey technique for northern big game. *Trans. N. Am. Wildl. Conf.*, 20, 519–532.
2. BERGERUD, A. T., 1963. Aerial winter census of caribou. *J. Wildl. Mgmt.*, 27 (3), 438–499.
3. BUECHNER, H. K., I. L. BUSS, W. M. LONGHURST, A. C. BROOKS, 1963. Numbers and migrations of elephants in Murchison Falls National Park, Uganda. *J. Wildl. Mgmt.*, 27 (1), 36–53.
4. BUECHNER, H. K., 1957. Aerial count of elephant in Tsavo National Park. Kenya Game Department, file GA/3/1/1.
5. BUECHNER, H. K., 1958. Elephant Census II. *Uganda Wildlife & Sport*, 1 (4), 17–25.
6. GREENWAY, P. J. The vegetation of the Serengeti National Park, Tanganyika. Tang. Nat. Parks, Arusha. 43 pp. typed.
7. GRZIMEK, M., and B. GRZIMEK, 1960. A Census of plains animals in the Serengeti National Park, Tanganyika. *J. Wildl. Mgmt.*, 24 (1), 27–37.
8. GRZIMEK, M., and B. GRZIMEK, 1960. B. Serengeti darf nicht sterben. Ullstein, A.G., Berlin. 337 pp.
9. GRZIMEK, M., and B. GRZIMEK, 1960. C. A study of the game of the Serengeti Plains. *Z. für Säugetierkunde.* Berlin 25, 1–61.
10. LAMPREY, H. F., 1962. A study of the ecology of the mammal population of a game reserve in the acacia savanna of Tanganyika, with

particular reference to animal numbers and biomass. Thesis for D.Phil., Oxford University. 209 pp.
11. LONGHURST, W., 1957. Elephant Census 1. *Uganda Wildlife & Sport*, 1.
12. MACFADYAN, W. A., 1950. Vegetation patterns in the semi-desert plains of British Somaliland. *Geogr. J.*, 116, 199–211.
13. ROBEL, R. J., 1960. Determining elk movements through periodic aerial counts. *J. Wildl. Mgmt.*, 24, 103–104.
14. STEWART, D. R. M., and L. M. TALBOT, 1962. Census of wildlife on the Serengeti, Mara, and Loita Plains. *Af. Agr. and For. J.*, 28 (1), 58–60.
15. SERENGETI RESEARCH PROJECT, 1962. Interim Report. Tang. Nat. Parks. Arusha. 10 pp. (mimeographed).
16. SERENGETI RESEARCH PROJECT, 1963. Report for year 1962. Tang. Nat. Parks. Arusha. 14 pp. (mimeographed).
17. TALBOT, L. M., and M. H. TALBOT, 1963. The Wildebeest in Western Masailand, East Africa. *Wildl. Monogr.*, 12, 88 pp.
18. TALBOT, L. M., 1956. Serengeti National Park Report. Internatl. Union for the Prt. of Nature, Brussels.
19. TALBOT, L. M., and D. R. O. ZAPHIRO, 1960. Aerial analysis of wildlife population structure. Paper for Conf. on Land Management Problems in Areas Containing Game, Lake Manyara, Kenya Game Department, Nairobi. 4 pp. (mimeographed).
20. TURNER, M. I. M., and R. M. WATSON, 1964. A census of game in Ngorongoro crater. *E. A. Wild. J.*, 2, 165–168.
21. WATSON, G. W., and R. F. SCOTT, 1956. Aerial censusing of the Nelchina Caribou herd. *Trans N. Am. Wildl. Conf.* 21, 499–510.
22. WATSON, R. M., 1963. A land use plan for the Grumeti and Ikorongo Controlled Areas. Report submitted to a special committee considering settlement planning in the Ikorongo/Mugumu/Grumeti areas of the Mara Region. Musoma Regional Office, Musoma, Tanganyika. 4 pp. typed.
23. WATSON, R. M., and O. KERFOOT, 1964. A short note on the intensity of grazing of the Serengeti plains by plains-game. *Z. für Säugetierkunde*, 29, 5, 317–320.
24. WORRAL, G. A., 1959. The Butana grasslands patterns. *J. Soil Sc.*, 10, 34–53.
25. ZAPHIRO, D. R. P., and L. M. TALBOT, 1961. The use of light aircraft in East African wildlife research and game management. ORYX, London. 6 (3), 190–199.
26. ZAPHIRO, D. R. P., 1959. The use of a light aircraft to count game. *Wild Life*, Nairobi, 1 (4), 31–36.

Film Strip on African Wildlife

A FILM strip in colour *Our African Heritage*, with a commentary to be read in English or French by Jean Vidal and Alain Gille, is published by UNESCO. In thirty-nine frames it gives a simple introduction to the wildlife of Africa and some conservation problems, together with some account of what is being done. Particularly telling are the neat coloured diagrams to illustrate important points such as the grazing differences between wild animals and domestic cattle, and how man has upset the natural balance—one good diagram may be worth *more* than any number of words. The distributor is Norman E. Willis, Educational Foundation for Visual Aids, 33 Queen Anne Street, London, W.1.