This needed doing!

CENSUS OF PLAINS ANIMALS IN THE SERENGETI NATIONAL PARK

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IN mid-1957 the director of the National Parks of Tanganyika, British East Africa, Colonel Peter Molloy, approached us with a request to count the number of large animals in the Serengeti National Park and to establish the extent of their seasonal movements. The Serengeti Park, the only national park in Tanganyika, was created to protect the last great plains animal herds and their habitats throughout their life cycles.

In Northwest Tanganyika there are still large concentrations of plains animals, particularly the wildebeeste (gnu), zebra, and Thomson's and Grant's gazelles. Presumably they are the last herds of great magnitude still existing in Africa. Their total numbers were generally considered to be above one million. The government was planning to reduce the size of this national park and change the boundaries on behalf of the Masai natives, chiefly in accordance with the recommendations laid down in the Pearsall report (1957).

With regard to the movements of the large herds, however, Pearsall's otherwise thorough study is based, necessarily, mainly on assumptions of others and short observations of his own. Therefore it appeared essential to establish first the number of animals living there, and whether the animal herds were actually protected by the present boundaries and proposed new boundaries. As far as we know, aerial censuses of the whole visible animal population have not been carried out. Up to now, aerial censuses have apparently been restricted to one or two species. The first prerequisite appeared to be to assess the number of the dominant characteristic animals. This work is reported here.

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Methods

The large size of the area, 4,600 square miles, ruled out the idea of observing and counting the animal herds on the ground. This would not have been feasible for technical and economic reasons. As the plains region and also a major part of the mountainous area are completely devoid of trees, conditions were ideal for counting animals from the air and consequently this was the method used.

The flights were made by a special German Dornier aircraft, DO-27, which permitted a minimum velocity of 30 m.p.h. with a consequent ability to land on very short strips and on rough ground. The plane was painted in conspicuous stripes (Fig. 1) to facilitate detection in case of emergency landing. The cabin allowed excellent visibility in all directions. There were no wing struts to reduce visibility.

At first, the intention was to fly over the whole area in strips and to photograph it entirely with automatic cameras. It turned out, however, that in order to distinguish reliably between different animal species, low altitude photographing (approximately 2,400 feet) would be needed. At this altitude, however, over 50,000 vertical exposures would have been required to cover the entire area. For economic reasons, this procedure had to be abandoned. The lack of landmarks over much of the area also made it impossible readily to put together oblique individual photographs from adjacent areas. It would be very difficult afterwards to establish on the pictures where one parallel strip started and where another one ended.

After excluding these alternatives, we decided to subdivide the area into small districts (Fig.2) and fly through each of these along parallel belts, counting the total number of animals which could be seen under a certain angle of vision on both sides of the aircraft. Areas

*Michael Grzimek died in an air accident at the end of these investigations.

FIG. 1. The Dornier 27, used by the authors for the game census, was capable of extremely slow airspeed and landing on rough ground. The usual flying altitude was higher than shown here. Animals fled only short distances to both sides and remained in the counting strip. The lines on the ground are trails made by the animals.

5 and 28-32 immediately bordered the park limit. Only wildebeeste were counted on Area 31 and in Area 32 only wildebeeste and zebras. Other antelopes appeared here only in small numbers.

In mapping out major areas, natural boundaries such as river valleys and mountain ranges were taken into consideration so that animals could not readily move from counted areas into areas not yet flown.

After several test flights the width of strip was fixed at 550 yards on either side of the aircraft. This required a flying altitude of 150-300 feet. At 1,500 feet an observer could readily distinguish between antelope species and classify them as adults or young. For economic reasons, however, the width of the strips was extended to 2,000 feet on each side in areas which were particularly easy to scan and poor in number of animals. In the eastern mountainous regions, only the crater bottoms and broad valleys with open pastures were well covered by flights (Fig. 2, Areas 1-10). In areas with tropical rain-forests, as at the southern and eastern limits of the Ngorongoro Crater, counting was impossible due to lack of visibility and efforts were abandoned there.

The left-hand observer was aided by a strip of plastic on the window, which indicated the approximate limits of his angle of vision.

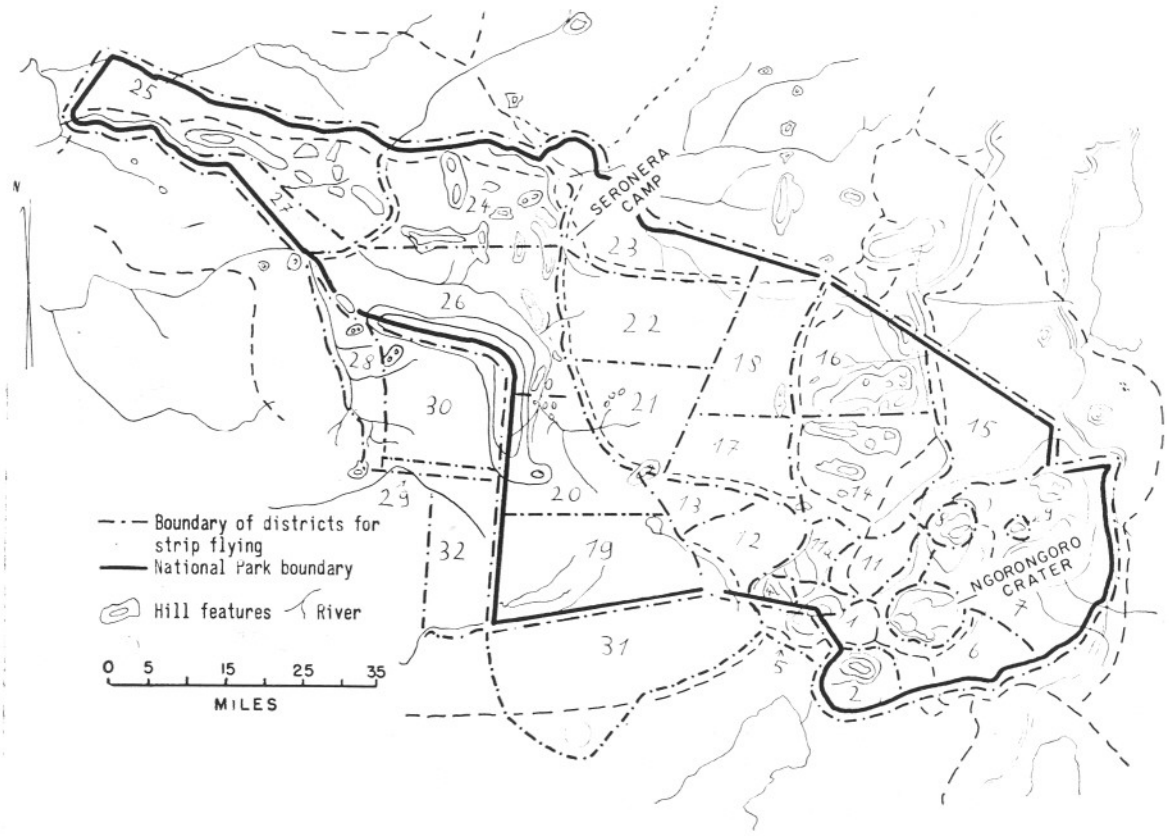

FIG. 2. The Serengeti Area, showing Park boundaries in 1958, and numbered districts for strip flying.

On the right front window this method could not be applied, however, due to curvature of the windowpane. Of the total number of animals counted (see below), 51.3 per cent of the animals were seen on the left-hand side and 48.7 on the right-hand side. This suggests that errors on counting due to the location of the observers in the plane were probably not serious.

Prior to the first counting and whenever introducing new persons to the census operations we made these individuals acquainted with the observation angle and width of strips through flying over test strips delimited by limed stones. As these strips were frequently passed when taking off and landing, the counter always had the opportunity to refresh his memory as to the width of an observation strip.

The task of the pilot was to navigate, and in each case to establish the width of the strips and their mutual order. As no maps were available, the park area had to be flown over on the basis of very incomplete sketches in which only large streams, rivers, parts of the mountains, and some pastures were indicated. The pilot also had to orient himself on the basis of such landmarks as solitary trees, rock outcrops, water holes, and groups of bushes. He flew according to an accurate compass course almost exclusively in an east-west direction or the reverse. As a very strong easterly wind blew constantly during the entire period, the aircraft flying in this way drifted off course least.

When flying above a strip, the pilot observed certain landmarks which constituted its lateral limitation. In turning around and starting to fly the next adjacent strip, these marks constituted the new extreme limitation to one side. The senior author served as pilot during all counting operations in order to maintain continuity.

One area, outside the park, where the herds of wildebeeste could be readily counted, we flew at an altitude of 2,000 feet and covered strips 4,500 feet on each side. This, however, was feasible only because the land was completely

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Serengeti plains game census

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flat with no trees whatsoever. Ninety per cent of the animals there consisted of wildebeeste which were orientated in long lines. At this altitude and with this width of strip, zebras and wildebeeste could easily be distinguished from each other. Gazelles could be identified only with difficulty however, and distinguishing between different species of antelopes, e.g., topi and kongoni, was no longer possible.

At the end of a strip the plane was always turned at a higher altitude in order to establish better the exact position of the new strip. The length of the strips was different depending on the size and position of the district which was flown over. The greatest length was about 37 miles. The park warden for each area assisted in the counting. We were also assisted on the eastern part by Mr. Gordon Harvey and for the western part by Mr. Myles Turner, and the Director of National Parks, Col. Peter Molloy. The junior author counted during the entire period.

When the landscape could be readily scanned and the number of animals was sparse, we flew at 140 m.p.h. As the pilot had very good visibility, he could on short notice reduce velocity to 30 m.p.h. Through such adjustments, counting was very much facilitated. Slow airspeeds were also maintained when animals were dense and where acacias and other trees were very sparsely distributed. There it was imperative to fly at low speed in order to identify and count animals under the tree canopies.

Counting flights were made mostly in early mornings and late afternoon when it was cool and pleasant. We were not compelled to take into consideration any special daily rhythms of the animals. Large zebra and antelope herds were never seen to withdraw during the heat of the day. Even quite late in the morning one could see hyenas, jackals, and vultures consuming animal remains from the previous night. In the afternoon, however, most of these disappeared.

In a few areas the pilot assisted the observers by taking over the task of counting one or two rare animal species on both sides of the plane. All counters jotted down the numbers of counted animals as they were censused. For control purposes, two counters often counted the animals on the same side and compared their results later. Counters could communicate with each other and with the pilot during the flight through an intercom system. After landing, the figures were summarized.

Animal Reactions to the Aircraft

Reactions of the animals to the airplane were different, depending on numerous factors. Solitary animals reacted only slightly to the aircraft flying above, even at an altitude of only 30-60 feet. This was true for both gazelle species and also for zebras, kongonis, and topis. Resting Thomson's gazelles did not even stand up when the airplane flew just 60 feet over them. Small herds of 5-15 zebra or antelope ran about 100 yards from the path of the aircraft. In this case, at the last minute the animals often dashed straight across the path of the airplane as they typically do for motor cars in the Serengeti.

Larger herds of 50 animals or more reacted differently. Wildebeeste in particular, were extremely nervous. They started racing away when the airplane flew at an altitude of even 200 yards even though animals standing alone showed no reaction at all. When in herds they also dashed off more persistently, stopping only when several hundred yards away. A few particularly nervous animals seemed to initiate escape reactions within the herd and the others followed suit.

Thomson's and Grant's gazelle in large concentrations showed quite another type of flight reaction. The herd remained calmly at its original place and at the very last minute, when the aircraft was straight above, they ran in all directions in a confused way, but only for a few seconds until the plane had passed.

Zebra noticed the airplane even when it was coming in for a landing with the motor shut off and at an altitude of 150 feet. Ostriches ran only when the aircraft was quite close. Otherwise, they exhibited the typical threat posture with inflated feathers and spread wings. Giraffes were quite difficult to start moving. They fled only rarely and then only approximately 150 feet to the side. When standing under trees, they did not run at all. Baboons immediately ran to nearby trees.

Hyenas with prey (e.g., a young gazelle) always fled while the airplane was still at some distance. Specimens asleep near a water hole could not be chased away. In extreme cases they might wake up, rise and have a good look

at the airplane. Sometimes the hyenas were stimulated by the flight of antelopes and ran with them for a few yards.

Wart-hogs fled promptly in their common attitude, the thin tail held straight upward. In one case a wart-hog was seen to hide in a burrow. A family of about ten foxes also headed for their burrow and disappeared when the plane approached them at a distance of 150 yards.

Lions reacted in different ways. In the Ngorongoro Crater, we flew above and circled around an adult male. At the beginning he did not react much. Finally he started to walk away, gradually walking faster. In most cases lions tried to make themselves invisible in the grass by pressing themselves close to the ground.

In those rare cases when cheetahs were sighted they remained sitting and showed no fright whatsoever. They merely watched the plane. The single leopard which we observed dashed to a tree and climbed it.

Larger birds, such as the European stork, crowned crane, and bustards made short flights 10-20 yards to the side when the aircraft flew above them at an altitude of less than 120 feet. When we flew more to the side of the birds, no movements took place or they were restricted to a short run. Bustards reacted with a horizontally protruding neck being turned around to follow the airplane with one eye upwards. In this angular position they would run away, moving laterally. Only in case of a strong disturbance by the airplane did they actually take to the air.

Vultures and other predatory birds on the ground mostly remained at their prey. Birds in flight (predators as well as storks) moved out of the way of the plane only at the last minute. Predatory birds then turned sharply to the side with their spread wings held vertically. We were aware that even very small birds when hitting an aircraft sometimes cause serious disasters, so we kept away from all birds as much as possible.

When such birds as vultures and buzzard-hawks sailed in the same direction as the plane was flying, it was possible to fly past them at the same altitude if the plane's speed was low and the estimated distance at least 25 yards. The birds only looked closely at the aircraft. In the air, these birds may feel that there is nothing to endanger them, which would explain their lack of escape reaction.

Large swarms of birds the size of starlings frequently flew up when the plane was approaching. These birds kept very close to the ground, however, flying extremely low and frequently changing their direction, presumably a typical flight reaction against small or predatory birds.

Flamingos flew up when we approached them from an altitude of 7,500 feet. This was established through special test flights. In this case it did not seem to matter whether the flocks consisted of 6-10 individuals or 1,000. In any case they flew together and at right angles to the plane's path. Their unpredictable manoeuvres on the wing made it impractical to approach them closer than 300 feet.

The approaching aircraft sometimes caused animals to flee into strips which had already been counted. But in most cases they did not move more than 100-200 yards and remained within the zone being counted. Where conditions permitted, we flew at altitudes sufficiently high to avoid appreciable fleeing or we resorted to the method of counting entire herds. Due to all these flight reactions, we flew to higher altitudes as soon as we spotted larger herds in order not to drive the animals into strips which were already counted. We circled around such a larger herd without disturbing it and, disregarding the strips, counted the whole herd.

Sources of Error

Sources of error were eliminated as far as possible. In counting individual areas, great differences were sometimes encountered between results from the two sides due to the fact that the animals were not uniformly distributed over the plains. They often concentrated in herds and frequently gathered in great numbers around waterholes.

One disturbance that presumably could never be completely obviated was the natural movement of animals from a counted strip into an uncounted one and the reverse. We tried to reduce this error to the utmost by counting in the same day areas that had no natural obstacles between them. As a whole, we constantly strove to count consecutively one area bordering another.

To avoid errors due to disturbance does not seem to be entirely possible even if the entire area were photographed. These errors became particularly large when animals were migrating at the time of the counting. In the course of our observations we could establish no special directions for the movements of animal herds in particular areas. A widespread breakup of the herds and more intense movement of groups began about January 15 when we had almost terminated our studies.

Only about one third of the originally estimated one million large animals now remains.

Directly beneath the airplane was a blind angle which none could observe. Due to the fact that we were flying very low, the area involved was extremely small. In addition, most animals ran in all directions to the side and made this zone free, so that this source of error was probably not important.

Due to long distances into the study areas and back, it frequently became necessary to count for more than two and one-half hours, with obvious exhaustion both of counters and pilot. Several hours of rest were required after each trip.

Another possibility for error arose when the sun was low. We had placed the strips chiefly in the east-west direction, and fewer gazelles were always observed when flying toward the sun as compared to flying the opposite direction. Then the animals were sharply illuminated by the sun. Errors due to this cause were of a different magnitude depending on the animal species.

The conspicuous giraffe and the rhinoceros, for instance, could hardly be overlooked. These animals could be spotted at an extremely distant range, and it was more likely that they would be counted twice rather than that they be missed. For the giraffe, rhinoceros, elephant, oryx, roan antelope, and probably for buffalo, the figures given in the table are considered to be very accurate. Elephants, rhinoceros, and buffalo occurring in rain forests, however, were not included.

Some errors could have occurred in the counts of the larger herds of wildebeeste, zebra, and gazelle. Some herds of 2,000 or more were observed.

It is possible that a margin of error of approximately 20 per cent in the number of counted animals could exist, but the error should not exceed that level.

Results and Discussion

The total number of each species found in all areas is given in Table 1. The distribution of all animals at the beginning of January is shown on Figure 3. In Figures 4-13 the distribution of animals is presented graphically by species. Figure 14 covers several uncommon species, as indicated by distinctive symbols.

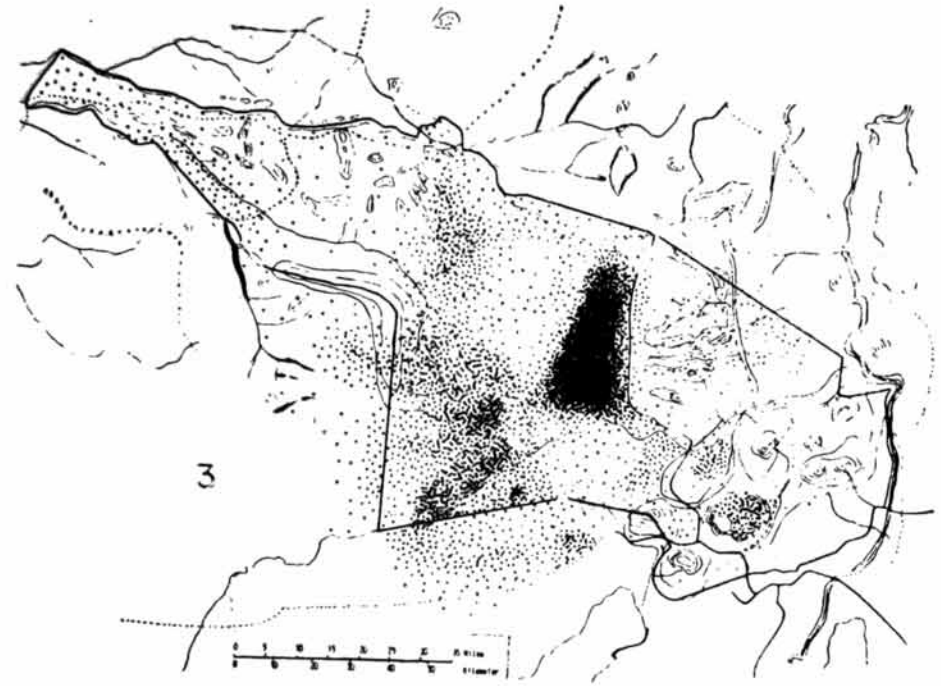
It was evident from preliminary counts that movements of several species were not limited by park boundaries. During some seasons, a great number of animals leave the park area. Figures 5,6,9, and 12 make this clear for wildebeeste, zebra, topi, and buffalo, respectively.

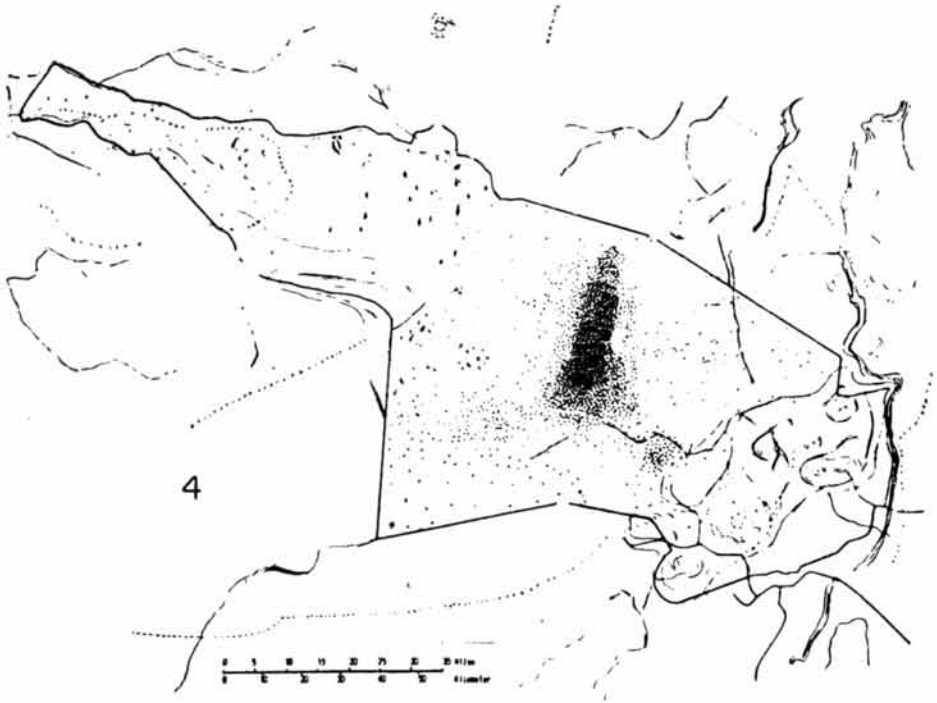
In the Plains of Salei, a grass plain extending north from Area 5, the density of wild animals declined very rapidly from the boundary of the park to the north.

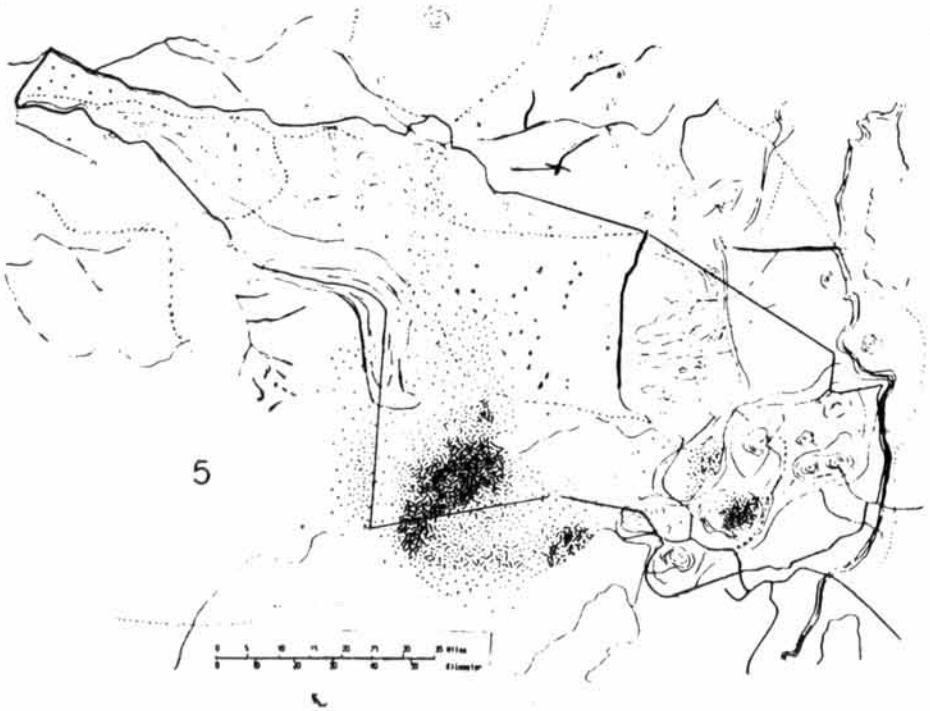
On the basis of our findings as regards distribution, a whole series of new questions arise. The animals of one species are not regularly distributed over the entire area but form concentrations in certain places, while in other areas they are entirely missing. As

TABLE 1.—RESULTS OF AERIAL GAME CENSUS OF THE SERENGETI AREA—JANUARY 3-16, 1958

Common Name	Scientific Name	Number
Thomson's Gazelle	*Gazella thomsonii thomsonii.* Gunther, 1884.	194,654
Grant's Gazelle	*Gazella granti robertsi.* Thomas, 1903.	
Wildebeest (Gnu)	*Connochaetus taurinus albojubatus.* Thomas, 1892.	99,481
Zebra	*Equus burchellii Boehmi.* Matschie, 1892.	57,199
Topi	*Damaliscus korigum eurus.* Blain, 1914.	5,172
Eland	*Taurotragus oryx pattersoniamus.* Lydekker, 1906.	2,452
Impala	*Aepyceros melampus melampus.* Blyth, 1866.	1,717
Black Buffalo	*Syncerus caffer aequinoctialis.* Blyth, 1866.	1,813
Kongoni (Coke's Hartebeest)	*Alcelaphus buselaphus cokii.* Gunther, 1884.	1,285
Giraffe	*Giraffa cameloparadalis tippelskirchii.* Matschie, 1898	837
Waterbuck	*Kobus defassa raineyi.* Heller, 1913.	284
Stork	*Ciconia ciconia ciconia.* Linne.	178
Oryx Antelope	*Oryx beisa callotis.* Thomas, 1892.	115
Elephant	*Loxodonta africana africana.* Blumenbach, 1797.	60
Roan Antelope	*Hippotragus equinus langheldii.* Matschie, 1898.	57
Rhinoceros	*Diceros bicornis bicornis.* Linne.	55
Ostrich	*Struthio camelus massaicus.*	1,621
Total		366,980







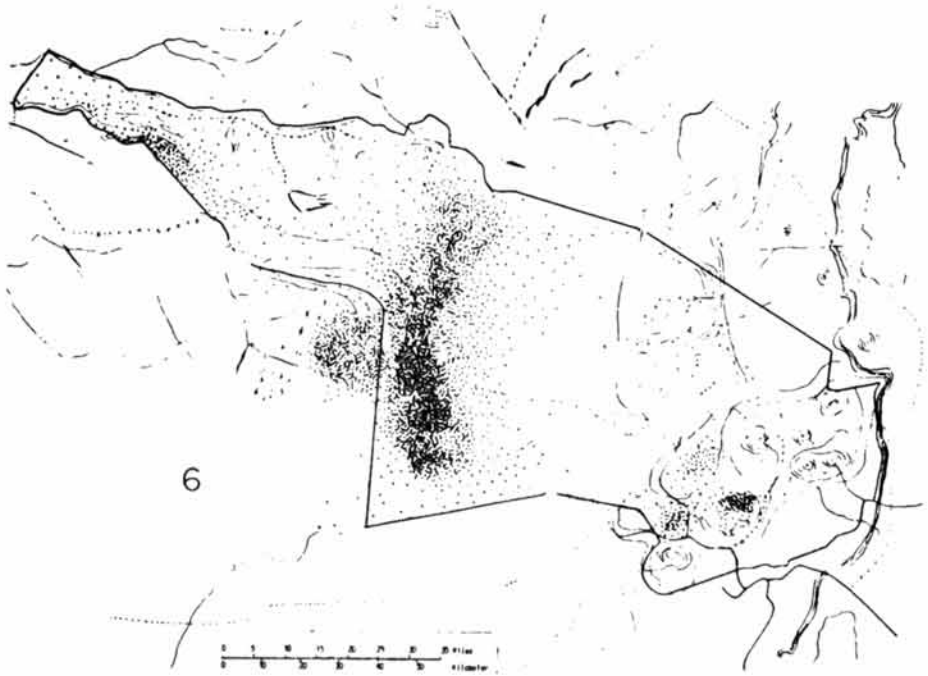


FIG. 3. Distribution of game in general. 1 point 100 animals. FIG. 4. Distribution of Thomson's and Grant's gazelles. 1 point 100 animals.
FIG. 5. Distribution of wildebeeste. 1 point 50 animals. FIG. 6. Distribution of zebra. 1 point 20 animals.

regards the giraffe, the reasons for this are clearly indicated. The animals stay among trees or in their vicinity. Waterbuck only occurred along the river sides or in parts of the Ngorongoro Crater. Impala occurred only in dense bush and tree plains areas and did not occur on the open plains. This also was true for the topi, although less strictly so. The interpretation as regards the gazelles is more complicated. We have not been able to find, so far, any explanation for the fact that they do concentrate in certain definite regions within the steppe. The same is true for the wildebeest. Possibly soil types and indirectly the composition of the vegetative cover play a role. Gazelles also could be pushed out of an area into regions with a poor vegetation through population pressure by the closely associated wildebeest.

At any rate it was conspicuous how one species fits into the openings left by another one. Similar conditions prevailed for zebras, although they overlapped with wildebeeste in large areas. Movements of the game populations were studied by marking individual animals and by following them by plane, and will be reported in a separate publication. We also initiated studies of soil types and vegetative cover.

Summary

The number of plains animals was studied in the Serengeti National Park in Tanganyika, British East Africa. This area of 4,600 square miles was subdivided into 32 smaller areas and the animals were counted from the air. Each area was flown in parallel strips at low altitude with a specially-built airplane. The total count of large animals was 366,980, only one-third of the number which had earlier been estimated for this region.

These animals are presumably the last large concentrations of plains animals in Africa. A considerable number of animals were found at the time of our census in the area outside of the park. A far greater number will be outside of the park on the basis of contemplated future boundaries. Studies of the seasonal movements, and their causes, of these animal herds are in progress. The reaction of different species to the aircraft are described.

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FIG. 7. Distribution of eland. 1 point = 1 animal. FIG. 8. Distribution of kongoni. FIG. 9. Distribution of topi. 1 point = 2 animals. FIG. 10. Distribution of impala. 1 point = 1 animal.

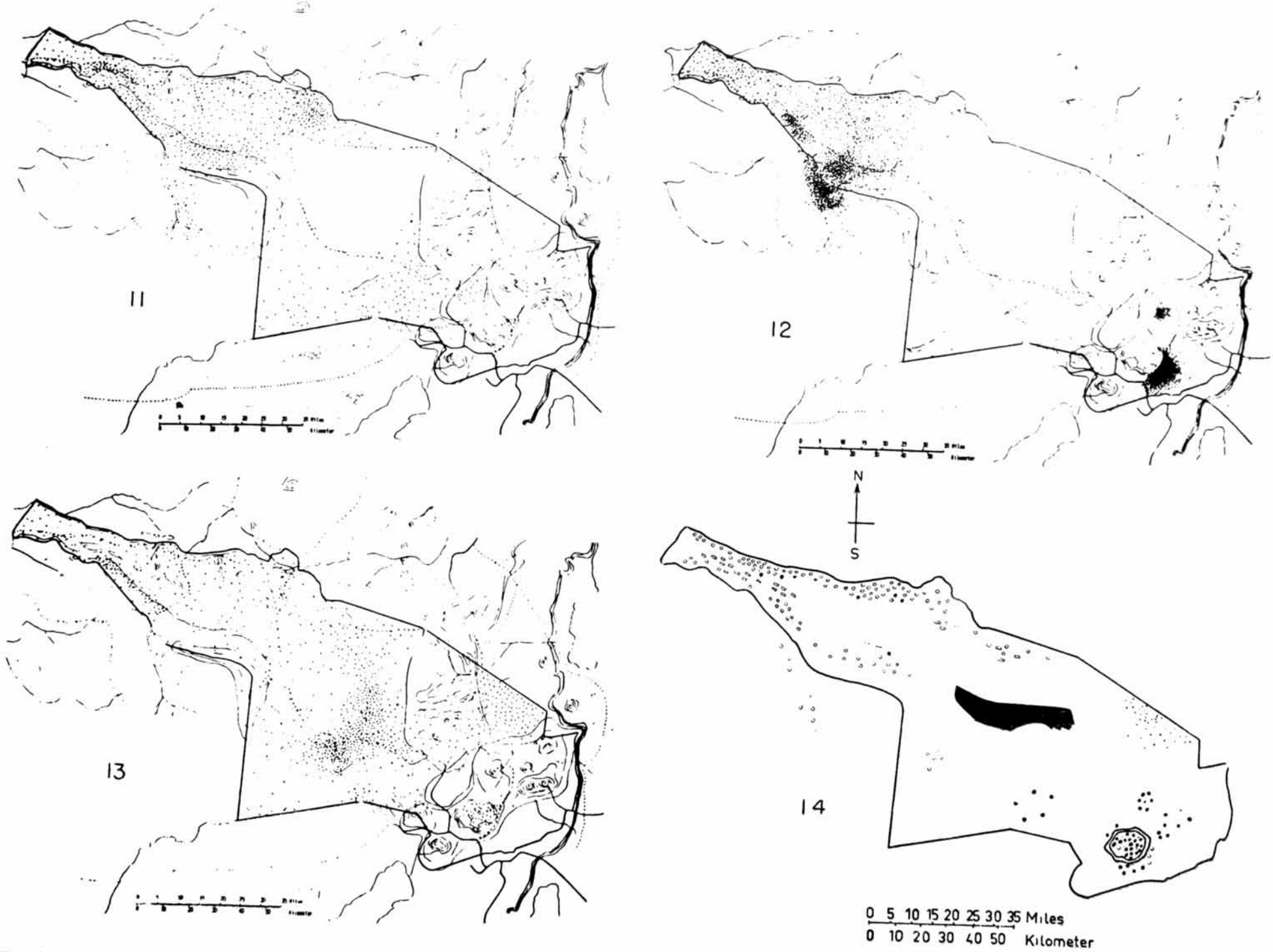

FIG. 11. Distribution of giraffe. 1 point=1 animal. FIG. 12. Distribution of buffalo. 1 point=1 animal. FIG. 13. Distribution of ostriches. 1 point=1 animal.
FIG. 14. Distribution of miscellaneous game. Small dot=2 oryx ; large dot=1 black rhino; open circle=2 waterbucks; rectangle=2 roan antelope.