Black rhinoceros (*Diceros bicornis* L.) sub-population on the Serengeti Plains, Tanzania*

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Summary

Black rhinoceroses on the Serengeti Plains were surveyed from February 1974 through January 1978. Sex and age composition of the sixty-seven individuals identified was 30% adult males, 36% adult females and 34% immatures and calves. Social groupings were described for 140 sightings (237 rhinos), of which 38% were lone males. The sex ratio was 1:1 for all age classes combined. Of the adult females, 79% had calves. Two observed calving intervals were approximately 3·3 years. The ratio of adult females to young is not significantly different from ratios reported elsewhere in East Africa.

Rhinos did not use the short grasslands of the Serengeti Plains. In the medium grasslands they used mainly the drainage lines where there was food and water, but only minimal cover. Most rhinos on the plains were found along the woodland edge. Near the Seronera River, on the edge of the plains, there was a density of one rhino per 19 km². Home ranges varied from 43 to 133 km², with much overlapping. Some male, female, and male-female dyads shared the same home ranges.

An estimated 700 black rhinos live within the 12 920 km² Serengeti National Park. Management for black rhinos in the park requires primarily that woodlands and abundant watering places be maintained and that poaching be minimized.

Résumé

Les rhinocéros noirs des plaines du Serengeti furent surveillés de février 1974 jusque janvier 1978. La distribution par sexe et par âge des soixante-sept individus identifiés fut de 30% de mâles, 36% de femelles adultes et 34% d'immatnres et de jeunes. Les groupements sociaux furent décrits à partir de 140 observations (237 rhinos), dont 38% étaient des mâles solitaires. Toutes classes d'âge combinées, le sex-ratio était de 1/1. 79% des femelles adultes étaient suitées. Deux observations donnent un intervalle de 3,3 ans entre deux naissances. La proportion femelles adultes/jeunes n'est pas significativement différente de celles décrites ailleurs en Afrique de l'Est.

Les rhinos n'utilisent pas les pâturages ras des plaines du Serengeti. Dans les pâturages moyens, ils fréquentent surtout les sillons d'écoulement où ils trouvent nourriture et eau mais peu d'abri. La plupart des rhinos des plaines se trouvent en lisière forestière. Près de la rivière Seronera, en bordure des plaines, il y a une densité de 1 rhino par 19 km². Les domaines vitaux varient de 43 à 133 km² avec beaucoup de

recouvrement; certaines paires, de mâles, de femelles et de mâle-femelle partagent le même domaine vital. On estime que 700 rhinos vivent à l'intérieur des 12 920 km² du Parc National du Serengeti. Pour les rhinos noirs, une gestion dans le parc requiert en premier lieu le maintien des forêts et d'abondants points d'eau.

Introduction

Studies of the sedentary black rhinoceros (*Diceros bicornis* L.) are important, because widespread poaching and loss of habitat are threatening the rhino's survival throughout its range. This report surveys the black rhinos on the Serengeti Plains in northern Tanzania, describing the sub-population and evaluating the importance, to rhinos, of the several habitat types.

Methods

Incidental to predator research from February 1974 through January 1978, all black rhinos sighted were photographed and data recorded. Other researchers also contributed photographs and information of rhinos sighted. The study area (Fig. 1), in the Serengeti National Park and Ngorongoro Conservation Area, consisted of 2,750 km² of short and medium grasslands and 550 km² of medium-grassland-to-*Acacia*-woodland ecotone. The physiognomic vegetation types follow the terminology of Pratt, Greenway & Gwynne (1966) and floristic details are from Herlocker (1975), Herlocker & Dirschl (1972) and Kreulen (1975). Searching intensity was reasonably evenly distributed throughout the study area; greater distances probably were searched along the roads, but more time was spent searching away from roads.

Individual rhinos were identified by photographs, sketches and written descriptions of their natural physical features, as described by Klingel & Klingel (1966), Goddard (1966) and Mukinya (1973, 1976). I was experienced with identification methods from assisting in previous rhino research (Goddard 1967a,b, 1968).

The following age classes were used:

Adult. Sexually mature, but not necessarily full grown (about 4 years old and older).

Immature. Not sexually mature, but has left its mother and is nearly fully grown (about 2¼–4 years old). The anterior horn is less than ear-length.

Calf. Still with its mother.

These classifications conform to those used by Goddard (1967b, 1970a,b). However, rather than assume females had attained sexual maturity because of their body size, known age or behaviour, I also used the criterion of visible signs of oestrus. A female in oestrus dribbles urine every few minutes resulting in a large dry white stain on the hind legs and vulva. The 'immature' category is approximately equivalent to 'Group III' of Mukinya (1973).

Rhino sightings were plotted on the latest government 1:250 000 scale map (Finnmap 1972 photography). Home-range size then was estimated by drawing a polygon around all of the plotted sightings of each individual. Rhino densities in each habitat type were considered in making estimates of the size of the sub-population on the Serengeti Plains.

The number of rhinos in the entire Serengeti National Park, which covers about one-third of the ecosystem, was also estimated. To approximate the area of each
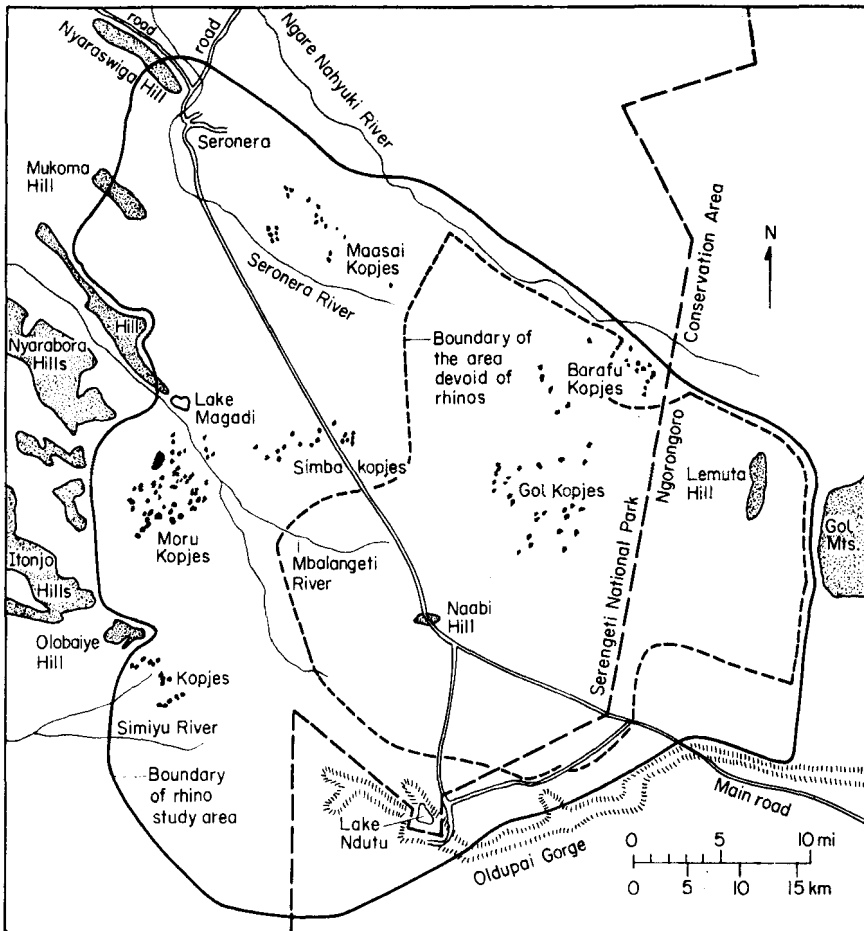
Fig. 1. Study area for black rhinos on the Serengeti Plains in the Serengeti National Park and Ngorongoro Conservation Area, Tanzania. Of the study area 83% is short and medium grasslands; the remainder is primarily grassland/woodland ecotone. *Acacia* woodlands border the study area on the north, west and south-east.

habitat, a map of the woody vegetation (Herlocker, 1975), the government map and the author's knowledge of the extent and physiognomy of the vegetation types was used. The author's rhino density figures for the habitats studied, plus the density estimates of others for different habitat types were also used. The value used for the area of the Serengeti National Park was 12 920 km²; this was measured by planimeter from the latest government 1:250 000 scale map (H. Epp, personal communication).

Results and Discussion

A total of 140 sightings of lone individuals or groups were recorded. Because some of the 140 sightings consisted of groups, the actual number of rhinos seen was 237. Nearly 38% of the sightings consisted of solitary adult males and 25% of adult

females with calves (Table 1). A total of sixty-seven different rhinos were identified (forty-eight adult or immature individuals plus nineteen calves). These sixty-seven known individuals accounted for all of the 237 rhinos seen. The three most frequently sighted adult males were seen on twenty-five, sixteen and thirteen occasions and three adult females (each with a calf) were seen on thirteen, twelve and six occasions, respectively. The remaining fifty-eight individuals were sighted from one to seven times each.

None of the individuals identified in the present study could be matched with those studied a decade ago at Oldupai Gorge (Goddard 1966, 1967a,b, 1968). Sufficient time had elapsed for about a third of the original rhinos to die. Among the survivors the natural physical features of most individuals probably changed significantly.

Sub-population structure

The sex ratio of Serengeti Plains rhinos is 1 male:1 female, for all age classes combined (Table 2). For adults only, the ratio is 1 male:1·2 females. These sex ratios are compared in Table 3 to those reported from other areas in Tanzania and Kenya. The χ^2 test for k independent samples (Siegel, 1956) was applied to the ten

Table 1. Social groupings during 140 sightings of sixty-seven known individual black rhinos on the Serengeti Plains, Tanzania

Group composition	Number of sightings	Group size	Number of rhinos seen (including calves)
Lone male (adult or immature*)	53	1	53
Adult female with calf	35	2	70
Two males (adult or immature)	13	2	26
Lone female (adult or immature)	11	1	11
Adult male + adult female	10	2	20
Adult male + adult female with calf	4	3	12
Adult female with calf + adult female with calf	2	4	8
Adult female with calf + adult female with calf + adult male	2	5	10
Adult female with calf + adult female with calf + adult male + immature female	1	6	6
Adult female with calf + two males (adult or immature)	1	4	4
Three males (adult or immature)	1	3	3
Adult female + immature male + adult male + adult male (mating)	1	4	4
Lone adult, unsexed	4	1	4
Two adults or immatures, unsexed	1	2	2
Four adults or immatures, unsexed	1	4	4
Total	140		237

*'Immature' is nearly adult size, old enough that it has left its mother, but still not sexually mature.

sets of sex-ratio data that were complete for all age classes (i.e., adults, immatures and calves). These data appear to be free of observer bias, because in each case the rhinos were identified as catalogued individuals with sexes known for nearly all of the individuals through prolonged or repeated observations. One additional set of sex-ratio data was complete for all age classes, but was excluded from this analysis

because the authors (Schenkel & Schenkel-Hulliger, 1969) concluded that sex bias resulted from the easier recognition by telescope of adult females with calves. The null hypothesis that there was no difference in the proportion of each sex in each of the study areas could not be rejected (df=9, $\chi^2=3.95$, $P=0.91$). Consequently, nothing can be concluded from the diversity of reported sex ratios.

Table 2. Sex and age structure of sixty-seven known individual black rhinos on the Serengeti Plains, Tanzania

	Males	Females	Sex undetermined	Sexes combined
Age class:				
Adult	20 (29·8%)	24 (35·8%)	0	44 (65·6%)
Immature	3* (4·5%)	1 (1·5%)	0	4 (6·0%)
Calf	8 (11·9%)	7 (10·5%)	4 (6·0%)	19 (28·4%)
Total rhinos	31 (46·2%)	32 (47·8%)	4 (6·0%)	67 (100·0%)

*Includes one male calf who left his mother early in the study.

Table 3. Sex ratios of black rhinos in Tanzania and Kenya

Sex ratio male:female	Location	Sample size and composition*	Source of information
1:1	Serengeti Plains	63, a+i+c	This study: Table 2
1:1·1	Serengeti Plains	48, a+i	This study: Table 2
1:1·2	Serengeti Plains	44, a	This study: Table 2
1·2:1	Oldupai Gorge	74, a+i+c	Goddard, 1967b: Table 5
1·1:1	Ngorongoro Crater†	105, a+i+c	Goddard, 1967b: Table 5
1·2:1	Maasai Mara	97, a+i+c	Mukinya, 1973
1·1:1	Maasai Mara	80, a	Mukinya, 1973
1·3:1	Amboseli	29, a	Western & Sindiyo, 1972: Table 4 and text p. 51
1:1·1	Tsavo	358, a+i+c	Schenkel & Schenkel-Hulliger, 1969: Table 5
1:1·3	Tsavo	285, a	Schenkel & Schenkel-Hulliger, 1969: Table 5
1:1·1	Tsavo, low density	65, a+i+c	Goddard, 1970: Table 10 ('ground cataloguing')
1:1·2	Tsavo, medium den.	52, a+i+c	Goddard, 1970: Table 10 ('ground cataloguing')
1:1	Tsavo, high den.	124, a+i+c	Goddard, 1970: Table 10 ('ground cataloguing')
1·2:1	Tsavo, high den.	89, a+i+c	Goddard, 1970: Table 10 ('ground cataloguing')
1:1·1	Tsavo, high den.	119, a+i+c	Goddard, 1970: Table 10 ('ground cataloguing')
1:1	Tsavo, high den.	77, a+i+c	Goddard, 1970: Table 10 ('ground cataloguing')

*a=Adults, i=immatures, c=calves.
†Klingel & Klingel's (1966) sample is not considered separately here, because Goddard's (1967) larger sample included most or all of their known individuals.

Nineteen (79%) of the twenty-four adult females observed on the Serengeti Plains had calves. This is similar to the 'over 70%' reported in the Maasai Mara Game Reserve, Kenya, by Mukinya (1973). One female had two calves during the study. The first left his mother when he was still immature, while his mother was being courted by an adult male. About 14 months later, the female gave birth to a second calf. The Serengeti Plains' cow:calf ratio was 100:79, compared to 100:79 reported for Oldupai Gorge on the eastern edge of the Serengeti Plains and 100:72 for Ngorongoro Crater, Tanzania (Goddard, 1967b).

The months of birth for three calves born on the Serengeti Plains, for which I observed the approximate birth dates, were March, August and October. One of the rhino mothers had an estimated calving interval of 3·3 years and another slightly more than 3·2 years. Rhinos in Ngorongoro Crater were reported to have a calving interval of 2·3 years (Goddard, 1967b). My resightings were not sufficiently frequent to estimate a mean annual natality.

Sub-population structures of black rhinos in six different study areas in East Africa are summarized in Table 4. Testing the two age classes (adult females v. immatures and calves) against the six different study areas failed to result in rejection of the null hypothesis that the proportion in each age class is independent of the study areas (df=5, χ^2=4·65, P=0·47; χ^2 test for k independent samples; Siegel, 1956). In four of the study areas, the number of calves was recorded separately from immatures. Testing the two age classes (adult females v. calves) against the four different study areas also failed to reject the null hypothesis that the proportion in each age class is independent of the study areas (df=3, χ^2=0·12, P=0·99). The data, therefore, show no population trends.

Distribution and home range

Rhino sightings were not evenly distributed throughout the Serengeti Plains study area (Fig. 1). Rhinos seemed to avoid the portions of the short and medium grasslands that were more than 3 km from wooded or bushed grasslands or from drainages (with or without cover, but containing waterholes and dominated by the

Table 4. Sub-population structures of black rhinos in Tanzania and Kenya, determined from random ground cataloguing (identification of individuals)

Location*	Number of known individuals	Adult males	Adult females	Immatures	Calves	Combined immatures and calves	Cow : calf ratio	Cow : immature + calf ratio
Serengeti Plains	67	20	24	4	19	23	100 : 79	100 : 96
Oldupai Gorge	74	22	19	18	15	33	100 : 79	100 : 174
Ngorongoro Crater	108	37	29	21	21	42	100 : 72	100 : 145
Maasai Mara	97	38	31	—	—	28	—	100 : 90
Amboseli	48†	16	13	—	—	19	—	100 : 146
Tsavo	531‡	167	171	69	124	193	100 : 73	100 : 113

*References are the same as in Table 3.

†Apparently extrapolated from a smaller sample.

‡All of Goddard's ground cataloguing data combined; Schenkel & Schenkel-Hulliger's data (1969) not included.

thorny herb *Indigofera basiflora* Gillett, a favourite food of black rhinos). Open grass-lands were searched more intensively than areas of denser cover. Thus, the absence of rhinos from much of the open grasslands was significant. No rhinos were seen in the vicinity of the wooded Naabi Hill, Gol Kopjes, and Lemuta Hill (Fig. 1), all of which are surrounded by short grasslands that are devoid of water during the dry season. This, and the occurrence of rhinos in drainages devoid of cover, suggest that rhino distribution is more closely related to the availability of food and water than to the availability of cover. Schenkel & Schenkel-Hulliger (1969) also noted the importance of water in restricting the distribution of black rhinos, but Mukinya (1973) stressed that the availability of cover may be most important.

Home ranges were large. In the ecotone around the Seronera River, the three most frequently seen adult males had home ranges of 88, 89, and 133 km². Adult females (with calves) in the same area had known home ranges of 70, 90 and 99 km². Overlap between these six individuals was from 25 % to 100 % for male–male, female–female and male–female dyads and the extent of overlap appeared to be independent of their sex. Further on the plains, in the medium grasslands and in the drainages of the upper Mbalangeti River (Fig. 1), the two most frequently seen adults had ranges of 59 km² (a male) and 43 km² (a female with calf). Their known range overlap was only about 10 %. Because of the small number of observations, all estimated home ranges should be considered minimum areas. The maximum distance between two sightings of the same individual was 28 km. The overlap in home ranges of males, and the occasional aggression between some adult males and tolerance between others (unpublished data), suggest that the black rhino may have a territorial system similar to that described for the white rhino (*Ceratotherium simum*) by Owen-Smith (1971).

Rhino home ranges elsewhere were considerably smaller. Goddard (1967b) reported that mean home ranges in Ngorongoro Crater were less than 2·6 km² to 15·4 km², and in Oldupai Gorge 30·0 km².* In the Maasai Mara, home ranges varied from 5·6 to 22·7 km² (Mukinya, 1973).

The rhinos that I observed had a continuous distribution from Oldupai Gorge to Seronera, via the drainages of the Simiyu River, Mbalangeti River and Seronera River. This suggests that the Serengeti Plains are at most only a diversion and not a barrier to rhino gene flow. There appears to be one continuous population from Ngorongoro Crater westward to the Serengeti National Park and northward to the Maasai Mara Game Reserve. This population is probably continuous in distribution to Amboseli and Tsavo National Parks, but recent intensive poaching undoubtedly is isolating these sub-populations.

Sub-population density

The rhino density on the Serengeti Plains is 'very low', using the terminology of Goddard's (1970a) five categories for Tsavo National Park. Density was calculated in the following three ways:

(1) The entire 3,300 km² study area, which includes short, medium, bushed and

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*Typographical errors occurred with the inequality signs in Goddard (1967b), page 135, erroneously showing for the Lerai Forest in Ngorongoro Crater a mean home range of greater than 1·0 mile², a wet season home range of greater than 1·0 mile² and a dry season home range of greater than 1·0 mile². All three figures should read 'less than' (J. Goddard, personal communication).

wooded grasslands, was divided by sixty-seven (the total of all known adults, immatures and calves). This yielded a density of one rhino per 49 km².

(2) The 1,700 km² area where rhinos were seen, which was defined by drawing a polygon around all rhino sightings in the 3,300 km² study area, was divided by sixty-seven. The area occupied by rhinos consisted of the 550 km² medium-grassland-to-*Acacia*-woodland ecotone and part of the medium grassland. This yielded a density of one rhino per 25 km².

(3) The 470 km² portion of the study area around the Seronera River, which consists of medium-grassland-to-*Acacia*-woodland ecotone, was divided by twenty-five (the total of adults, immatures and calves known to use this area). The habitat is the transition from the Serengeti Plains to the Serengeti Woodlands and contains a mosaic of medium grasslands, bushed grasslands and wooded grasslands. This yielded a density of one rhino per 19 km².

Goddard (1967b) reported densities of one rhino per 6·4 km² in the bushed woodlands at Oldupai Gorge, and one rhino per 3·1 km² in the woodlands, swamps, medium grasslands and short grasslands in Ngorongoro Crater. In Maasai Mara Game Reserve, Mukinya (1973) found densities of one rhino per 7·1 km² for the 749 km² rhino-occupied area and one rhino per 14·3 km² for the entire 1,530 km² study area, which consisted of medium grasslands, bushlands and riverine vegetation. The lower rhino densities which I found in the Serengeti Plains study area (an area free of poaching) demonstrate the marginal suitability of this habitat.
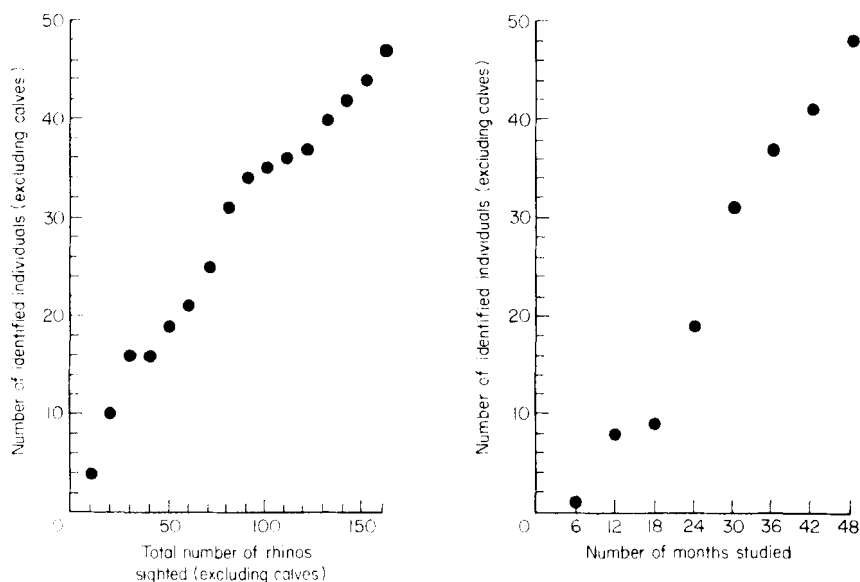

Fig. 2. Identification rate for new black rhinos on the Serengeti Plains, Tanzania, study area. Forty-eight known individual adults and immatures were identified by the end of the 4-year study. Calves were excluded from this analysis because they do not occur independently. The number of rhino sightings was 140, but some of these were of temporary groups, giving a total of 164 adults and immatures seen.

Sub-population size

The black rhino sub-population actually using the Serengeti Plains apparently is much larger than the sixty-seven individuals identified thus far. The incidence of new adult and immature individuals compared to the resighting of previously identified ones is shown in Fig. 2. The slope of the curve, which shows the rate of new sightings, did not decrease, so it is reasonable to expect that many more individuals are still to be found.

I tried a simple mark-recapture estimate of the rhino sub-population on the plains. A resighting of a previously identified individual was defined as a 'recapture'. Using the last 6 months of the study as the recapture period and excluding calves (because calves are not distributed randomly), the number of adults and immatures was estimated to be fifty-three, which is only five more than I had already identified on the plains. Adding the nineteen known calves plus two additional calves for the extra adults, gives an estimate of seventy-four rhinos on the Serengeti Plains.

Two censuses of Serengeti Plains animals were carried out in 1977 (Serengeti Research Institute, 1977a,b). The census area, from Seronera to Oldupai Gorge, was divided into three strata. Eight vehicles were driven along parallel, evenly-spaced (2·5 km apart) transects. All animals within 100 m on either side of the vehicles were counted. Although nine rhinos (eight adults and immatures plus one calf) were seen on the plains during the May census, and fourteen rhinos (eleven adults and immatures plus three calves) in the October census, only one adult was counted within the transects in each census. This gave an estimate of 16±28 rhinos (excluding calves), i.e., 11–44 (excluding calves). Adding the appropriate proportion of calves (0·28 calf per adult or immature of either sex), because rhinos in the census transect must occur randomly, gives three–twelve calves. The number of rhinos on the Serengeti Plains estimated by these censuses, therefore, is 14–56.

Repeated road counts by S. J. McNaughton (personal communication) in the combined areas of the Serengeti National Park and Maasai Mara Game Reserve resulted in an estimate of only 60–108 rhinos, with a mean of 84. This obviously is an underestimate, for Mukinya (1973) found 108 rhinos in Maasai Mara alone and sixty-seven were found on the Serengeti Plains (this study).

The Serengeti Ecological Monitoring Programme collected data on rhinos in the woodland portion of the park during several years of aerial censusing, but rhino sub-population estimates and distribution mapping are not yet available. However, the following estimate is from the January 1977 census. During a 4% sample count of the woodlands in the Serengeti ecosystem, twenty-eight rhinos were seen from the air. This gave an estimate of 672 rhinos in the 22,400 km² woodland census area (J. J. R. Grimsdell, personal communication). Counts of rhinos by air are notoriously conservative (Goddard, 1967a) so it would be expected that the true number would be double or triple this estimate.

My computations of the size of the rhino sub-population in the entire 12,920 km² Serengeti National Park give the following five estimates:

(1) During the January 1977 aerial census, twenty-eight rhinos were sighted in a 896 km² sample area. This represents a density of one rhino per 32 km² of woodland. Goddard (1967a) showed that only 5–50% of the rhino sub-population in the nearby Oldupai Gorge was seen from the air during repeated aerial censusing. It therefore seems reasonable and conservative to double the density of the sighted rhinos to give

a corrected value of one rhino per 16 km² of woodland. The park contains approximately 9,720 km² of woodlands,so from this rhino density an estimated 608 rhinos inhabit all of the park's woodlands. The remaining 3,200 km² of plains habitat contain about 2,200 km² of medium grasslands. Here a density of about one rhino per 25 km², or a total population estimate of eighty-eight on the medium grass plains, was found. No rhinos were resident on the remaining 1,000 km² of short grass plains. The estimate for the entire park is, therefore, 608+88+0, or 696 rhinos.

(2) The woodlands in the park contain a mosaic of medium grasslands, bushlands and riverine vegetation similar to that of the adjacent Maasai Mara Game Reserve where Mukinya (1973) found a density of approximately one rhino per 14 km² for his entire study area. This density, applied to the 9,720 km² of woodlands lying within the Serengeti National Park gives an estimate of 694 rhinos. The estimates for the plains are the same as in estimate (1). So, the estimate for the entire park is 694+88+0 or 782 rhinos.

(3) The density estimate for the 1,700 km² portion of my Serengeti Plains study area where rhinos were seen was one rhino per 25 km². For the entire 12,920 km² of park (less 1,000 km² of short grass plains where there were no resident rhinos) the estimate is, therefore, 477 rhinos.

(4) The density estimate for the 470 km² portion of my study area along the woodland edge around Seronera was one rhino per 19 km². For the entire 12,920 km² of park (less 1,000 km² of short grass plains) the estimate is, therefore, 627 rhinos.

(5) Using Mukinya's (1973) density of one rhino per 14 km² for his entire study area in the Maasai Mara Game Reserve, and applying it to the 4,860 km² half of the Serengeti National Park's woodlands lying adjacent to that area, gives an estimate of 347 rhinos. The 4,860 km² southern and western half of the park's woodlands, if assumed to have the same density (one rhino per 19 km²) that I found at the woodland edge around Seronera, should contain an estimated 256 rhinos. The values for the 2,200 km² of medium grasslands and 1,000 km² of short grasslands are the same as in estimate (1). Thus, the estimate for the entire park is 347+256+88+0 or 691 rhinos.

Based on these five estimates (ranging from 477 to 782), it is concluded that there are presently about 700 black rhinos within the Serengeti National Park.

Conclusions

The described black rhino 'populations' in the Ngorongoro Crater and at Oldupai Gorge (Goddard, 1967a,b, 1968) the Maasai Mara Game Reserve (Mukinya, 1973), and on the Serengeti Plains all represent sub-populations or segments of a continuum of the same large rhino population within the Serengeti ecosystem. They are not geographically isolated populations.

Rhino densities vary greatly throughout the Serengeti ecosystem, depending upon habitat type and possibly the intensity of poaching. The Serengeti Plains contain the poorest rhino habitats of the ecosystem. The short grasslands, under the present grazing intensity and lack of water in the dry season, are unsuitable for rhinos. The medium grasslands, which contain a network of drainages with herbs and bushes and permanent waterholes, are of marginal importance to rhinos. The ecotone from the Serengeti Plains to the Serengeti Woodlands, a mosaic of medium, bushed and wooded grasslands with permanent waterholes, is important rhino habitat. But even

the best areas of the grassland–woodland ecotone do not support the rhino densities found by other authors elsewhere in woodland, bushland, riverine, and swamp habitats.

The status of the black rhino in the Serengeti National Park appears to be good. More than half of the Serengeti Plains and nearly one-third of the Serengeti Woodlands lie within the park boundary. Poaching of rhinos within the park probably is not serious, because the poaching laws are strict and law enforcement efforts have been good. The worst known rhino poaching in the park in recent years was in January 1977, when ten rhino carcasses without horns were found. Yearly totals of poached rhinos were one in 1975, two in 1976, twenty-four in 1977 and eighteen in 1978. Most poached rhino carcasses were found around the Lobo and Bologonja areas in the north, but a few were discovered in the western corridor (J. Hando, personal communication).

Rhino spearings and poaching are more serious within the Ngorongoro Conservation Area. During 1972 through 1974, reports were received averaging one rhino killing per month in the area around Oldupai Gorge and on the portion of the Serengeti Plains that lies within the Conservation Area and probably many more killings must have gone undiscovered. Many rhinos at the east end of Oldupai Gorge have been killed during the past decade (Mary Leakey, personal communication). However, it is doubtful that the rhino population around the western half of Oldupai Gorge is much different from what it was in the late 1960s. The rate at which rhinos were sighted along the edge of the gorge during the present study was similar to that experienced there in 1965 and 1966, when at least seventy-four rhinos were known to be resident (Goddard, 1967b). If there were now fewer rhinos, a lower sighting rate would be expected, i.e., more searching would be required to find rhinos. Most sightings were made beyond the rhinos' distance of perception, so greater tameness to vehicles in later years would make no substantial difference.

Management for black rhinos in the Serengeti National Park requires the maintenance of woodlands. This involves the conscientious and skilful implementation of the early burning programme recommended by the Serengeti Ecological Monitoring Programme (Bunning, 1976) and possibly reductions of animal species found to be causing a significant decrease in the woodland vegetation. An even distribution of watering places also is essential. The park should continue to be maintained entirely free of domestic livestock and excessive human disturbance, if rhinos and other wildlife species are to be conserved. These are similar to recommendations made by Mukinya (1973) for the contiguous Maasai Mara Game Reserve. In addition, anti-poaching efforts should be intensified because of the threat of increased poaching but this will be possible only if additional financial assistance is provided by international conservation organizations.

References

BUNNING, J.O.H. (1976) *A fire management plan for the Serengeti National Park.* African Wildlife Leadership Foundation, Nairobi, Kenya. (Unpublished report.)

GODDARD, J. (1966) Mating and courtship of the black rhinoceros (*Diceros bicornis* L.). *E. Afr. Wildl. J.,* 4, 69–75.

GODDARD, J. (1967a) The validity of censusing black rhinoceros populations from the air. *E. Afr. Wildl. J.,* 5, 18–23.

GODDARD, J. (1967b) Home range, behaviour and recruitment rates of two black rhinoceros populations. *E. Afr. Wildl. J.,* 5, 133–150.

GODDARD, J. (1968) Food preferences of two black rhinoceros populations. *E. Afr. Wildl. J.,* 6, 1–18.

GODDARD, J. (1970a) Age criteria and vital statistics of black rhinoceros population. *E. Afr. Wildl. J.,* 8, 105–121.

GODDARD, J. (1970b) A note on age at sexual maturity in wild black rhinoceros. *E. Afr. Wildl. J.,* 8, 205.

HERLOCKER, D. (1975) *Woody Vegetation of the Serengeti National Park.* The Caesar Kleberg Research Program in Wildlife Ecology, Texas A & M University, College Station, Texas.

HERLOCKER, D.J. & DIRSCHL, H.J. (1972) *Vegetation of the Ngorongoro Conservation Area, Tanzania.* Canadian Wildlife Service Report Series No. 19. Information Canada, Ottawa.

KLINGEL, H. & KLINGEL, U. (1966) The rhinoceroses of Ngorongoro Crater. *Oryx,* 8, 302–306.

KREULEN, D. (1975) Wildebeest habitat selection on the Serengeti Plains, Tanzania, in relation to calcium and lactation: a preliminary report. *E. Afr. Wildl. J.,* 13, 297–304.

MUKINYA, J.G. (1973) Density, distribution, population structure and social organization of the black rhinoceros in Maasai Mara Game Reserve. *E. Afr. Wildl. J.,* 11, 385–400.

MUKINYA, J.G. (1976) An identification method for black rhinoceros (*Diceros bicornis* Linn. 1758). *E. Afr. Wildl. J.,* 14, 335–338.

OWEN-SMITH, N. (1971) Territoriality in the white rhinoceros (*Ceratotherium simum* Burchell). *Nature (Lond.),* 231, 294–296.

PRATT, D.J., GREENWAY, P.J. & GWYNNE, M.D. (1966) A classification of East African rangeland with an appendix on terminology. *J. Appl. Ecol.,* 3, 369–382.

SCHENKEL, R. & SCHENKEL-HULLIGER, L. (1969) *Ecology and Behaviour of the Black Rhinoceros (Diceros bicornis L.).* Verlag Paul Parely, Hamburg.

SERENGETI RESEARCH INSTITUTE (1977a) *Census of predators and other animals on the Serengeti Plains, May 1977.* Serengeti National Park Report No. 52.

SERENGETI RESEARCH INSTITUTE (1977b) *Census of predators and other animals on the Serengeti Plains, October 1977.* Serengeti National Park Report No. 73.

SIEGEL, S. (1956) *Nonparametric Statistics for the Behavioral Sciences.* McGraw-Hill, New York.

WESTERN, D. & SINDIYO, D.M. (1972) The status of the Amboseli rhino population. *E. Afr. Wildl. J.,* 10, 43–57.