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The Land-Rover sped across the plain within the Ngorongoro Crater in Tanzania, one of the largest calderas in the world. Two yards from the fender a black rhinoceros and calf galloped furiously in an attempt to elude the bouncing vehicle, while zoologist John Goddard took careful aim and fired a syringe containing 10cc of anaesthetic.

'It's a hit,' I shouted. 'It injected!'

The rhinos continued to gallop at nearly 30 mph; it would be ten minutes before the drug had a noticeable effect. John quickly loaded another syringe into his rifle and darted the calf, as it followed closely behind its mother.

We now had a few minutes to catch our breath and hastily make notes of the event as we followed slowly and far behind the two rhinos. The ensuing ear-tagging and body measurements promised to be routine. As usual, great care would be taken to prevent any injury to the animals.

Darting and tagging are an important part of John Goddard's ecological and ethological studies of the black rhinoceros (*Diceros bicornis*) in Tanzania. Recently, John spent three years studying the black rhinoceros in Ngorongoro Crater, and at Olduvai Gorge, 30 miles west of the caldera. I had the pleasure of working with him in the study during parts of the second and third years.

Ngorongoro Crater, the world's largest unbroken and unflooded caldera, rises abruptly one-half mile above the eastern edge of Tanzania's Serengeti Plains. Inside, 110 black rhinoceroses, 1,500 carnivores, and more than 24,000 ungulates (mainly zebra, wildebeest, and Thompson's and Grant's gazelles) abound on 102 square miles of cool rolling grasslands. Steep, bush-covered walls reach 2,000 feet above to a cloudy elevation of 7,600 feet. Nearly 20 per cent of the ungulates migrate in and out of the caldera, following winding trails up these steep walls, and many of the black rhinos include parts of the forest-covered outer walls in their home range.

Comparison of rhinoceros data from the forest, and open-grassland/seasonal-marsh habitats of Ngorongoro with the dry-thornbush habitat of Olduvai provides valuable insight into the needs and preferences of the black rhinoceros. But to accomplish a study such as this, it is imperative to be able to recognise every individual rhino.

Hence, binoculars and camera were essential tools. Every rhino was identified by its natural physical features, and catalogued in a 'mugbook' by photograph and written description. The most useful characteristic aiding identification was the

THE BLACK RHINOCEROS

size and shape of the horns, but the ears were also very distinctive because of holes, tears, and tufts of hair. Appearance of the tail and the occurrence of body scars provided additional identifying information. After a while we also learned to recognise and anticipate individual behaviour.

Adult black rhinoceroses normally weigh between 2,000 to 2,800 pounds, and average about 5 feet 2 inches tall at the shoulder. Essentially, they are solitary animals. Males normally remain alone, and the female, too, prefers seclusion with her calf.

However, an immature rhino, which is invariably driven away when its mother has a new calf, seeks the companionship of another rhino. Often it will form a bond of friendship with another immature rhino, or with a lone adult female. Such a relationship developed when Theodore, a three-year-old male, joined with Eloise, a four-year-old female; they remained inseparable companions until Eloise produced a calf several years later. If unsuccessful in finding a companion, a young rhino may eventually return to its mother and her new-born calf. Sometimes, the cow will tolerate the return of the older calf.

The largest group of black rhinos ever seen together in Ngorongoro Crater by John or myself consisted of 13 animals at a mud wallow in a small wooded area of the caldera floor. But after two hours the group disbanded into solitary animals and groups of two and three.

Rhinos have many well-defined behavioural patterns. One of these is the greeting ceremony. When an adult male meets a female, either one or both animals may emit characteristic 'puffing snorts'. Then the male approaches the female with short cautious steps, occasionally thrashing his head from side to side in a sweeping motion or jabbing the air with his front

For two years GEORGE W. FRAME worked with John Goddard in Tanzania, helping him with his ecological and ethological studies of the black rhino. Part of these studies took place in the Ngorongoro Crater and at Olduvai Gorge.

Theodore and Eloise, regular residents of Ngorongoro Crater. Both young rhinos that have been driven away by their mothers, they have typically joined forces, apparently for companionship, possibly for protection against predators. Theodore is licking Eloise's ear (Photo George W. Frame)

horn. When the female charges, the male wheels around and gallops in a tight circle, only to return to her with the cautious short-step approach. Sometimes the male feeds during his approach to the female. This may continue for several hours, or until one of them walks away.

When two females meet there does not seem to be any aggression, but the approach is made with extreme caution. Upon contact they normally nudge one another gently with their horns or with the sides of the head, and thereafter show only indifference to the other's presence.

We found that the black rhino's peak activity periods are the hour beginning at dawn and the hour at dusk. At these times nearly all rhinos actively feed or wander about. As the morning feeding progresses, they seek a comfortable place in the shade of a tree or else in a dust bowl in the hot sun for their midday sleep. Daytime slumbers are sometimes interrupted for a snack or two on the nearest palatable vegetation. In the late afternoon, diminished heat stimulates the rhinos to awaken and begin feeding and wandering. Most of the population is active through the hours of darkness, but apparently some sleeping is done at night, too.

The Ngorongoro rhinos prefer to feed upon shrubs, herbs, and legumes. However, at Olduvai Gorge the habitat is more arid, and the vegetation different. There the favorite rhino food is *Euphorbia turucalli*, a cactus-like plant. In the two areas combined, rhinos feed on 191 different plant species from 49 botanical families. Several plants considered to be highly toxic are eaten with no apparent ill effect.

Euphorbia plants sometimes grow along the ground, but also occur as trees 15 to 20 feet or more tall. The sap of these plants is

a milky-white latex, and the cylindrical green leaves are smooth and rubbery. We have seen rhinos use their curved front horn to reach up and break off branches up to 7 inches thick, by pulling downward on them. Probably, rhinos with a missing or broken anterior horn most often have broken their horn on branches while feeding, rather than by fighting, as is commonly believed. As they masticate coarse stems and foliage, the slow rhythmic chewing is plainly audible for distances of 50 yards or more—which is an effective method of locating rhinos in thick bush.

An amazing aspect of rhinoceros feeding is their propensity for the thorny *Acacia* at Olduvai Gorge. The inch-long hard, sharp, white thorns easily puncture our tyres, but offer no problem to the rhinoceros, which nonchalantly munches away on the thorny branches as if they were nothing more than lettuce! Sometimes, though, they confine their feeding to the young developing ends of the branches, which offer smaller, less formidable thorns and tender green leaves.

During the dry season in areas of the caldera where legumes are extremely sparse, black rhinos frequently eat dry wildebeest dung. They pick up a mouthful of dung and chew it for several minutes or more. Some of the feces is discarded, but much is swallowed. This may serve to correct a protein or mineral deficiency. I observed another situation seemingly related to this, in which an immature rhino in the same area found a wildebeest skull and licked it quite intently for several minutes. After satisfying himself he walked onward, and continued to feed.

Drinking and wallowing normally occur daily. Rhinos living within Ngorongoro

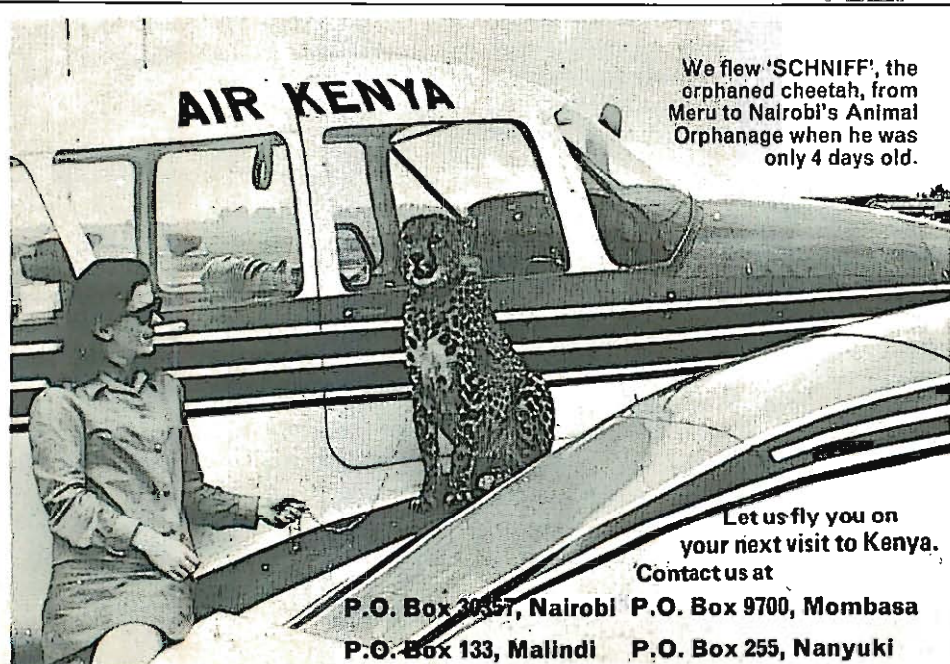
Crater usually have water and mud conveniently near, but those at Olduvai Gorge seldom have wallows available, and often must travel 5 to 10 miles for a drink. Individuals living in arid areas like the plains surrounding Olduvai Gorge may drink less frequently, perhaps at two- or three-day intervals. If a waterhole dries out, the animals sometimes dig with their forefeet like dogs. Former Chief Game Warden Percival, of Kenya, found holes more than 3 feet deep dug by rhinos in a dry river bed.

In Ngorongoro Crater and Olduvai Gorge we found that more than 90 per cent of the observed wallowing occurs during the two hours before sunset, but wallowing may occur throughout the night, too. Usually the wallowing animal rolls over on its sides, coating itself with mud nearly to its spine. Probably this is a method of dissipating excess heat accumulated in the body during the day.

In Tsavo National Park, Kenya, rhinos apparently wallow to seek protection from the numerous biting flies. However, this does not seem to be the explanation in Ngorongoro Crater and Olduvai Gorge, because biting flies are absent. Ticks and mites are abundant though, and may possibly annoy the rhinos, causing them to seek comfort in the mud. Adult rhinoceroses lying in wallows, dust bowls, or elsewhere nearly always lie on their sternum. Resting rhinos must stand for a 10- to 15-minute period every 1½ hours, apparently to relieve their cramped position or to facilitate digestion.

Once, on the edge of Ngorongoro Crater's tiny Munge Swamp, I saw three rhino calves playing with a 1 inch diameter, 3½ feet long, dry, leafless, unburned stick (probably *Aeschynomene schimperi*). This floral species appears in great abundance in the swamp following burning of the vegetation, and constitutes one of the rhino's favourite foods. While the two adult females fed, their three calves, aged 38, 17, and 14 months spent about 30 minutes playing with the stick. Each took several turns in picking up the stick with his prehensile upper lip, and manipulating it. They gently chewed on it, but did not damage it in any way. This constitutes the only calf play activity that I ever observed.

Predators sometimes attack rhinos, but these occurrences are relatively rare. Within Ngorongoro Crater during the past five years, hyenas have made several attempts at killing rhino calves. Normally, hyenas attack from the rear, biting the hind leg and tail of the calf. The calf responds by trying to pull away, and by making a piercing, squealing sound. Usually, the calf's mother is successful in

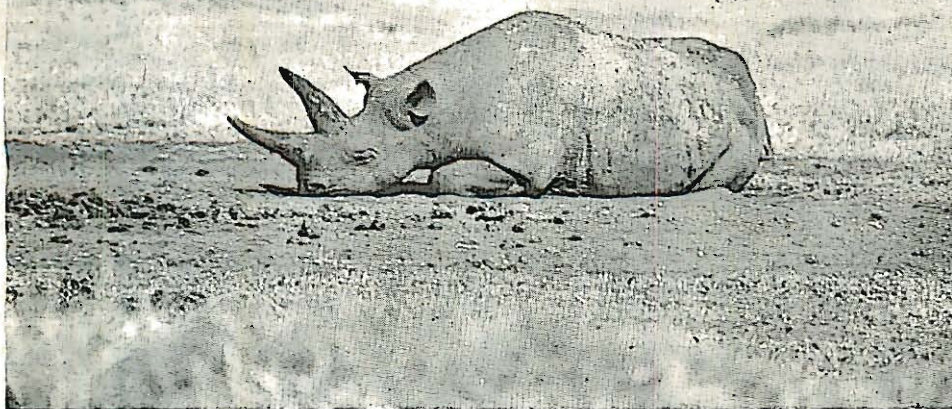


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Pierre, an old male, slumbers away the midday hours in a dustbowl in the centre of Ngorongoro. Below: A female with a broken front horn and her calf running on the plains at Olduvai Gorge. Travelling at moderate speeds a rhino trots, but when going all-out it changes to a gallop (Photos George W. Frame)

charging and driving off the attackers. However, Eleanor, a young rhinoceros at Ngorongoro, recently lost her first calf to hyenas. A hyena bit the month-old calf's hind leg, and before Eleanor could respond with a counter attack the hyena accomplished its mission by breaking the calf's leg.

A party of German tourists and their Ngorongoro guide witnessed a male lion attacking an 11-month-old calf. The calf's mother, whom we call Felicia, is endowed with a beautiful, straight horn that points forward like a saber. Felicia saw the approaching lion and prepared for the imminent attack, while her calf snuggled closely against her. But then the calf panicked, and ran away with the lion in

close pursuit. Felicia trotted after the lion, who promptly diverted his attack from the calf to her. The lion's jaws closed on the cow's hind leg, and he clawed at her thigh. She whirled around with incredible agility, using her horn to stab the attacking lion in the ribs, neck, and jaw, killing him instantly. When I saw her the next day, Felicia's head and horns were still covered with lion's blood and her thigh bore the scratches from the lion's claws, but both she and her calf were well.

In Kenya, A.T.A. Ritchie observed several encounters between cow elephants and black rhinos during his many years as Chief Game Warden. Usually, the cow elephant won the battle by killing the rhino and its calf. Curiously, elephants, after

Centre-spread: Two black rhinos (and wildebeests and zebras) at Ngorongoro; the white-coloured animal is actually covered in caked, dried mud (Photo Nigel Sitwell)

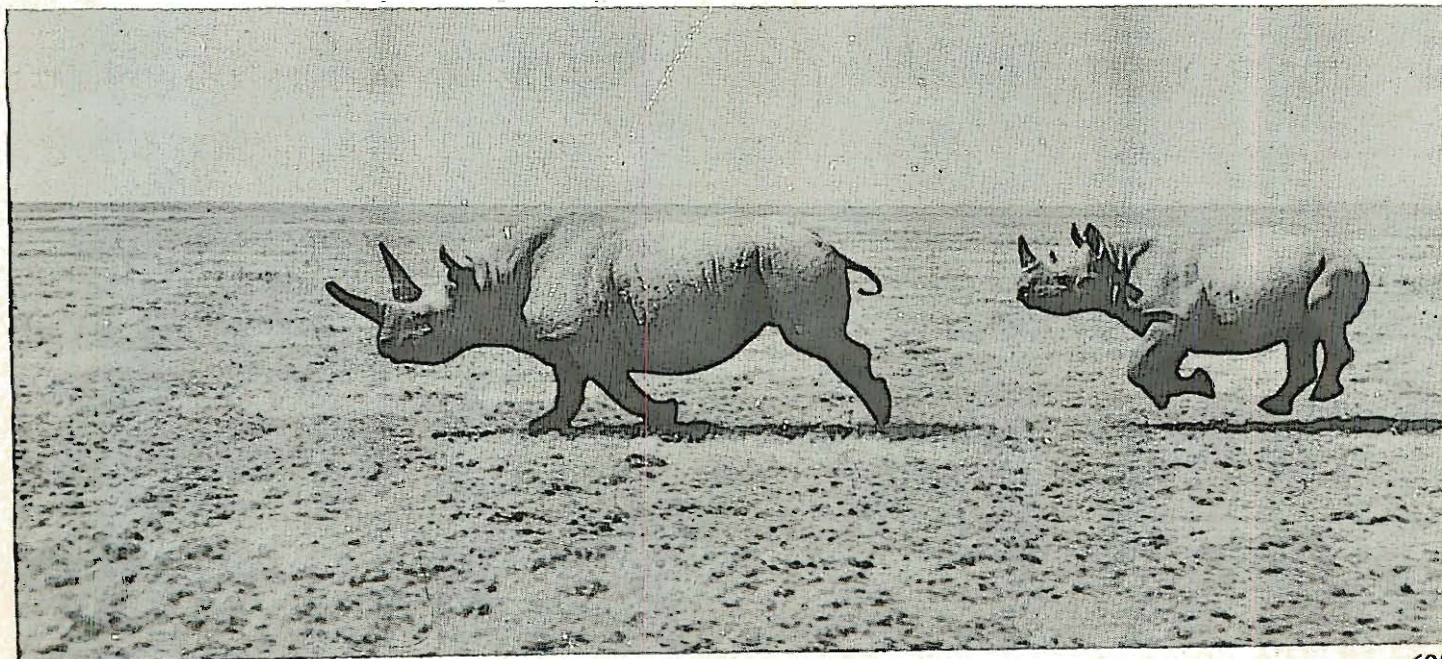
killing a rhino, almost always covered it with branches and bushes.

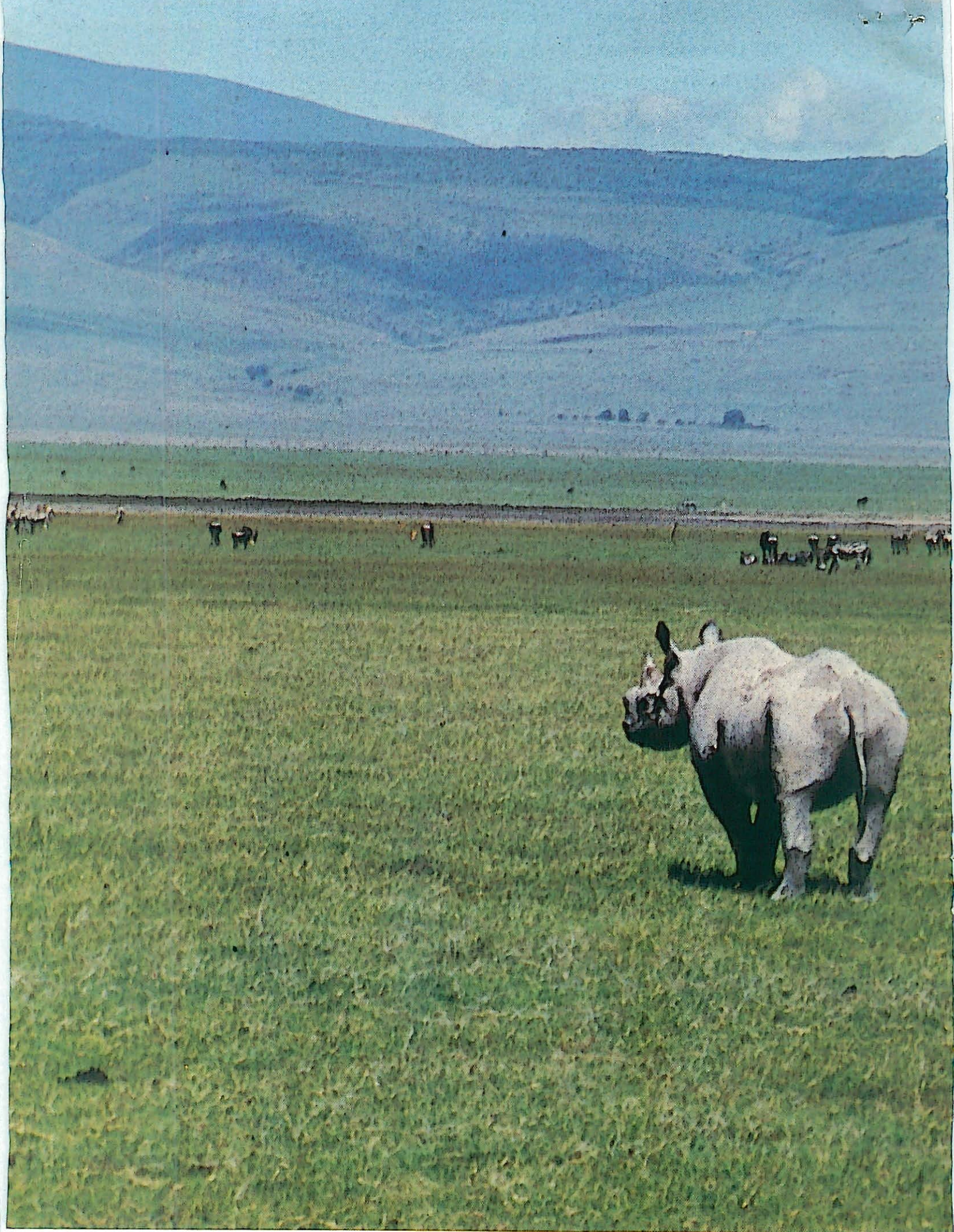
The home range of black rhinos within Ngorongoro Crater and Olduvai Gorge is dependent upon three main factors—age, habitat, and time of year. The black rhinoceros is a very sedentary species, but the size of the home range varies considerably according to the availability of food and water.

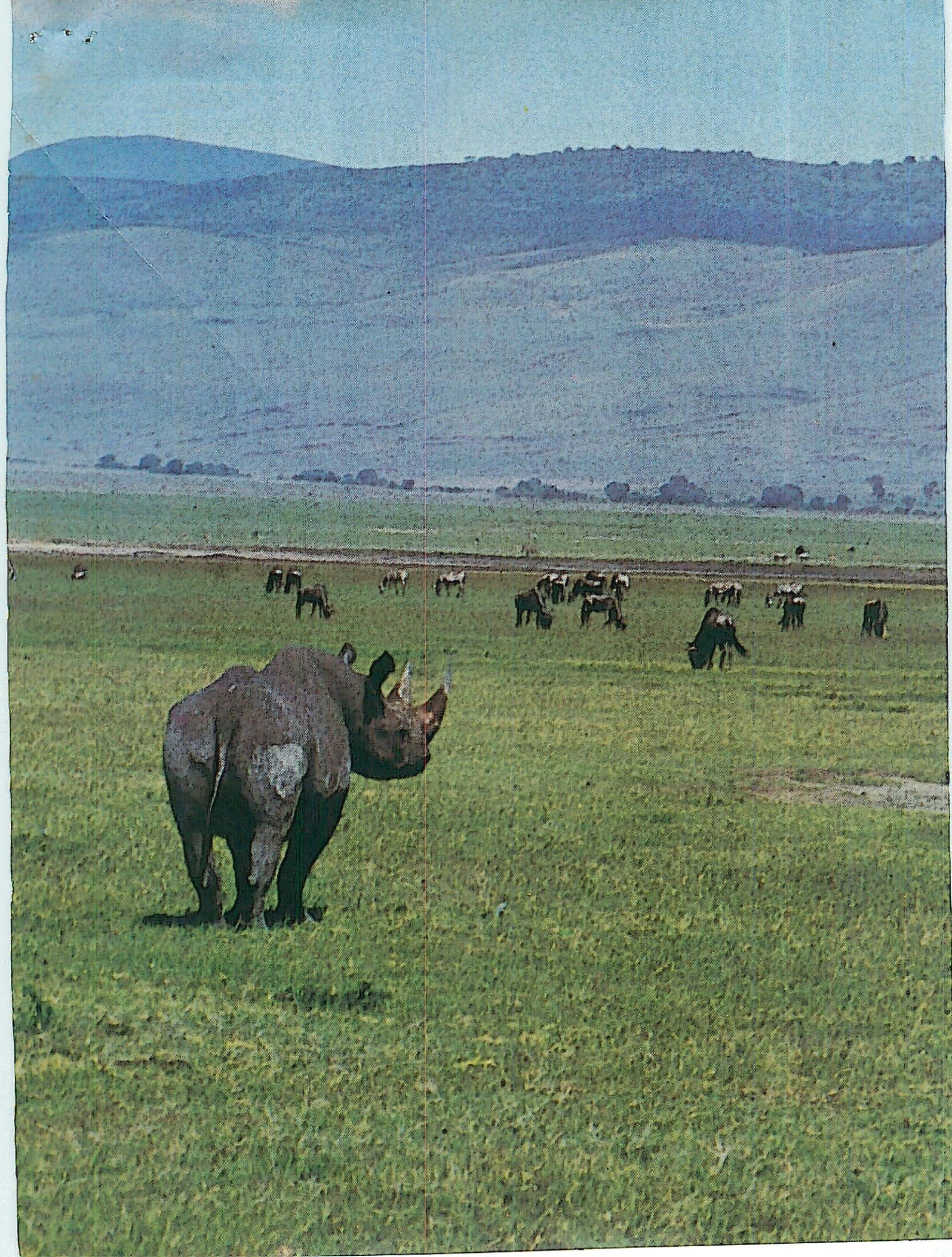
Lerai Forest covers one square mile of the floor within Ngorongoro Crater. Tall, majestic, yellow-barked fever trees (*Acacia xanthophloea*) with dense bushy undergrowth delimit the area that provides cover and palatable food throughout the year. The result is an extremely high density of 23 rhinos per square mile. Seventeen of these were never seen outside of the forest during the three-year study. There are few waterholes in the 170 square miles in and around Olduvai Gorge, and palatable vegetation is less abundant than at Ngorongoro. Consequently, the average home range covers about 12 square miles.

The grasslands within the caldera of Ngorongoro are somewhat intermediate in that they have less available food and water than the forest, but not nearly so little as exists at the Gorge. The average home range in the grasslands is 6 square miles. This is only half as large as at Olduvai, but considerably larger than the forest habitat.

We found that adult males and females have home ranges of similar size, but the ranges of immature rhinos are nearly twice as large. This is because the calf, when







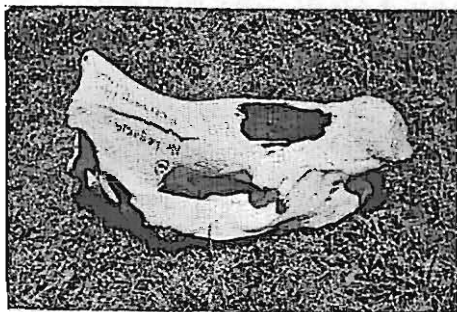
driven away by its mother, not only retains its former home range, but adopts as well the home range of the rhino with which it becomes associated for companionship.

Size of the home range varies with the season. The proportion of utilised range is considerably greater during the wet season, because the variety of palatable plants is greater. In the dry season when the plains are dry and sterile, the rhinoceros confines his activities to areas close to marshes and water. This is why visitors can sometimes see as many as 30 to 35 rhinos at Ngorongoro in one day during the wet season, but only five or six during the dry season.

Both sexes mark their range with short puffs or sprays of urine as they walk along feeding. Individual home ranges are well-defined, but overlap considerably even among adult males. In Ngorongoro Crater one old bull rhino named Pierre shares 40 per cent of his home range with a younger adult male rhino called Michael. In five adjacent home ranges on the Crater floor there was an average overlap of 35 per cent with one or more other home ranges.

Rhinos sharing common parts of their home range frequently come into contact with each other during their daily activities, and are usually not aggressive to one another. While feeding in the late afternoon, Pierre and Michael usually wander toward the tiny Munge River, where they drink and wallow. Frequently, they feed or wallow near each other, completely tolerant of each other's presence, and showing no territorial behaviour. Adult females residing in overlapping home ranges display a similar tolerance toward each other.

Some rhinoceroses living in the caldera occasionally leave their usual range on the walls to descend to the crater floor, possibly for salt. When one of these intruders is noticed by a resident rhino, he is usually confronted with territorial defence. In one such instance Horace, an exceptionally docile old male, charged the



Skull of rhino poached at Olduvai. Circle indicates bullet hole. Note that horn has been cut off (Photo George W. Frame)

intruder. Horace snorted vigorously and emitted hideous groans, but the intruder would not be intimidated. Both faced each other, heads lowered, ears flattened, and tails raised. The intruder did not respond to Horace's vocalisations, but silently stood his ground. Anterior horns were mere inches from each other; both jabbed and clubbed at the sides of each other's head. Nevertheless, actual physical contact seldom occurred. As usually happens, the aggressor made a sudden retreat, closely pursued by the successful resident bull, namely docile old Horace!

In one unusual conflict, the intruding bull rhino drove out the resident male, and the latter assumed residence in an adjacent home range. On another occasion an adult male defended his territory against a strange female, but aggression was neither as prolonged nor as violent as that between two bulls.

Black rhinos are noted for their regular use of well-worn trails. These 20-inch-wide paths lace the terrain, running along ridges and over hilltops, inevitably ending at a distant waterhole. Less-worn secondary trails, which are used for feeding, branch off and sometimes parallel the main trails. Elephants, antelopes, and other wildlife also use these trails.

Dung piles are apparently randomly located over a rhino's home range. The same dung piles are used by neighbours of

either sex, and often measure several yards in diameter. Rhinos encountering dung piles show stereotyped behaviour. The deposit is first sniffed extensively. Then, frequently, the front horn and prehensile upper lip are swept through the pile from side to side in a long sweeping motion. The sweeping motion is more commonly done by the males, and they sometimes uproot the pile with their horn. Males may shuffle through the dung pile with front and hind legs held rigid. After defecation, both sexes scatter the dung with sharp kicks of the hind legs.

The black rhinoceros has keen olfactory abilities, and orientation within his home range is very probably by means of fecal scent trails. Unlike Asian rhinos the black rhino does not have pedal scent glands, so scent trails are created by kicking and shuffling through dung piles with its feet. Besides orientation within the home range, scent trails are probably useful in maintaining contact with neighbouring rhinos and recognising intrusions by strange rhinos.

We tried to learn more about the significance of scent trails by dragging bags of rhino dung behind our Land-Rover. As the vehicle zig-zagged back and forth across the plain, we laid out complicated patterns on the ground for distances as great as 2 miles. Sure enough, we found that most rhinos were able to follow the scent trail exactly, constantly sniffing the ground while walking. This proved that they have the ability to orient by means of scent. They showed the greatest tendency to follow scent trails of dung from animals with which they shared a home range. But most frequently they chose their own feces piles for defecation.

Like their olfactory abilities, rhinoceros hearing is quite good. However, their eyesight is exceptionally poor—for instance, they seem to be unable to distinguish a standing man from a tree at 20 yards. Once I stood on a tree branch not more than 6 feet above a rhino trail, as a young cow rhino approached. The tree was leafless and offered no cover, but the walking rhino failed to notice me. Arriving directly beneath me, she caught my scent, and responded with several loud snorts as she quickly fled in alarm. In both Ngorongoro Crater and Olduvai Gorge, rhinos encountering human scent trails snorted with great alarm and fled for half a mile or more.

Recognition occurs more readily when the man is walking, but I believe this is partially a response to the inevitable noise. Red-billed oxpeckers (*Buphagus erythorhynchus*) and yellow-billed oxpeckers (*B. africanus*) often congregate on the rhinos,

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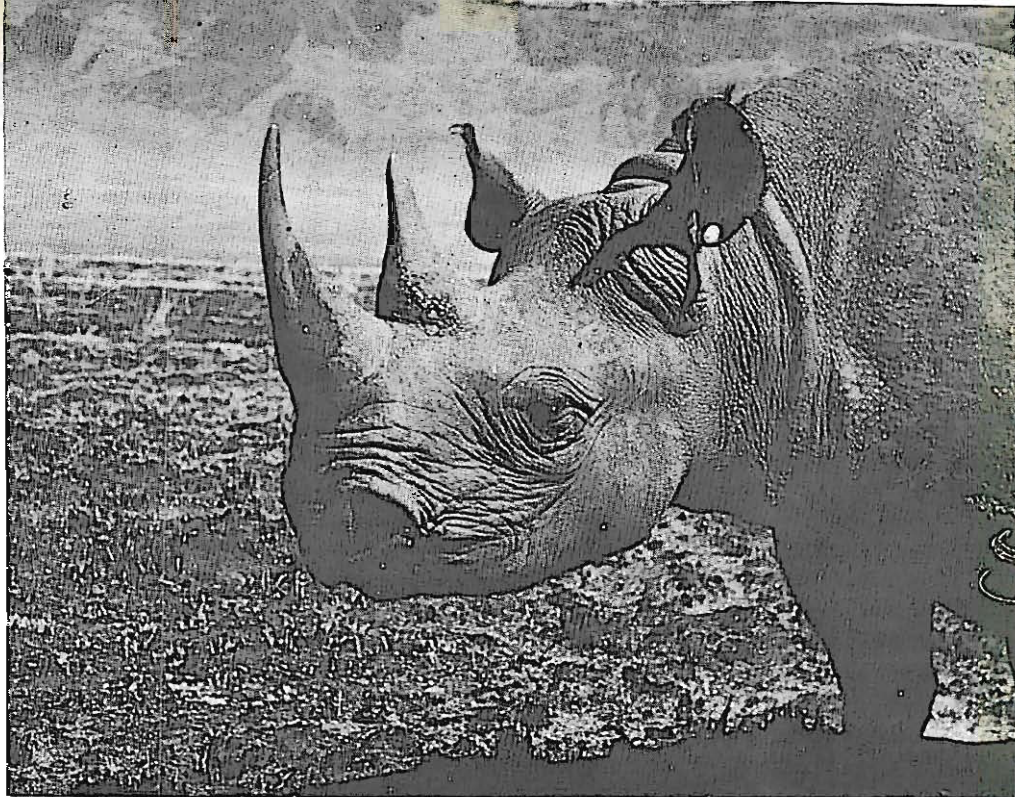
apparently for ticks. The rhinos seem to understand the meaning of the birds' alarm call, because they immediately become attentive and defensive in response to it. Thus, the oxpeckers serve to compensate for their hosts' deficient vision.

Rhinos make various noises which range from 'squeaks' and 'grunts' to 'roars' and 'puffing snorts'. There is also a deep 'breathing' call, likened to a man gasping for breath. If a mother and calf become separated while browsing, the adult emits a very high-pitched, scarcely-audible 'mew'; the calf immediately responds by walking in the direction of the call. Once, a calf we were tagging 'squealed' in distress, and Horace, about a mile away, heard it and came running to its aid.

The black rhinoceros is polygynous and polyandrous—each individual may have many wives, or many husbands, as the case may be. Mating occurs at any time throughout the year, and the gestation period is 15 to 16 months. The average interval between calves should be about 27 to 28 months, because successful conception apparently does not occur until about a year after parturition. Sexual activity may begin close to the fifth or sixth year, but maturity may not be reached until about the seventh year. Zoo records indicate black rhinos probably live for 30 to 40 years.

We found that pre-copulatory behaviour of the male rhinoceros is not aggressive, and the main sequence of events appears to be controlled by the female. Sometimes the female walks considerable distances, with the male following closely behind. When she stops to feed or rest, the male begins to show an active interest. As the male approaches, the female stands facing him. Either the female, or both, frequently make short, fast jabs at the air with their horns. As the courtship progresses they may gently nudge one another on the side of the head. Sometimes the male thrashes his head from side to side, and scrapes the front horn and prehensile lip against the ground in wide sideways sweeping motions. He then advances in a stiff-legged walk, with his hind legs rigid and shuffling on the ground. The same stiff-legged gait can sometimes be seen at other times, such as when a male encounters a female, or prior to defecation in a well-used dung pile. The male frequently jabs the female under the chest or abdomen in a rough but playful manner.

Prior to mating, the male rests his chin on the female's rump and pushes his head along her spine. As many as 20 mounting attempts may be made over a several-hour period before mating is successfully achieved. Copulation is a prolonged affair,



Xenopus displays an ear tag. She and other rhinos were tagged so as to be permanently identifiable; as with humans, natural features change with age (Photo George W. Frame)

ranging from 29 to 36 minutes. Some black rhinos vocalise loudly during mating and courtship. Other species in the vicinity, such as the wildebeest or spotted hyena, show an intense interest in the courtship activities. The female rhino's calf may initially charge the strange male, causing him to retreat momentarily. After the bull has apparently been accepted by the female, the calf shows little further interest and appears completely indifferent to the entire proceedings.

Once in Ngorongoro Crater we watched as Michael, a male rhino, approached Ophelia, a female who appeared to be in oestrus. At first Michael was unaware of Ophelia's medium-size calf, but when he saw it nearby, he charged viciously. His horn jabbed between the calf's hind legs, lifting them off the ground and causing the calf to fall and roll over. As he continued his attack by jabbing the fallen calf, Ophelia realised her calf's plight and came running and snorting to its aid. Michael ceased his attack, and ran away as the threatening Ophelia pursued him. The calf limped from its bruises, but survived.

At Ngorongoro and Olduvai an average of four years is required for each adult female to add one calf to the population. The interval for recruitment of one calf is so long because some cows are barren and some lose calves at birth or to predators. The resulting effect is therefore an average yearly gain of one calf for every four adult females. This small annual population increment must not be exceeded by

natural adult mortality and losses to poachers if the population is to remain stable.

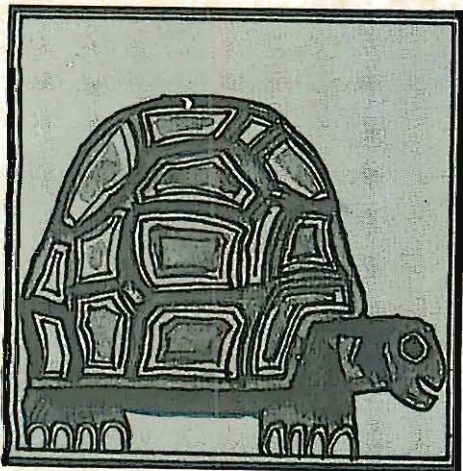
At least 110 black rhinos inhabit the 102 square miles of Ngorongoro Crater, and in the 170 square miles of Olduvai Gorge and adjacent plains the population numbers 74. In the caldera, about seven calves are born per year, and at Olduvai five calves appear yearly.

Rhino populations can be exterminated rather easily by merely removing a relatively small percentage each year. This is largely a result of their sedentary nature; often they fail to move into and repopulate areas from which they have been exterminated.

Within the Ngorongoro Conservation Area during the past several years the rhinoceros populations have apparently remained stable, and may possibly have been increasing. This is due to the protection afforded under the able direction of Solomon ole Saibull, Conservator of NCA. The future of the black rhinoceros within NCA seems favourable, providing its habitats are not destroyed through encroaching cultivation and excessive human habitation. ●

GEORGE W. FRAME studied at the University of Alaska, and while there worked as an Arctic oceanographer. He spent two years in Tanzania where he assisted John Goddard in a study of the black rhino of Ngorongoro Crater and Olduvai Gorge.





Readers' Letters

Jon Tinker replies

I suspect that not all your readers will share the opinion given in your signed February editorial that I was wrong to write, and the *Observer* wrong to publish, my criticisms of the World Wildlife Fund last year. I do not wish to repeat those charges now: they were discussed at length in the correspondence columns of the *Observer*. But I am sorry you felt my article was 'strangely vindictive' and sprinkled with 'personal allegations and insinuations'—and that these were directed against Peter Scott. For the record, I repeat my view (which was included in my *Observer* article) that his sustained contribution to conservation has been (and still is) immense, dedicated, and unequalled. I have a great personal admiration and respect for him.

Your editorial agreed that WWF is not perfect, but did not feel that the way to make improvements was 'to try to sabotage the whole organisation'. With respect, might I suggest that it is this slightly hysterical reaction to criticism (sabotage?) which made my article necessary. For years, those who have known what is wrong with the World Wildlife Fund have not made their views public. I do not believe it is healthy for any organisation to be kept immune from public criticism. Such a situation rapidly grows until an expression of the slightest doubt is regarded as the darkest blasphemy; when no criticism at all is voiced, there is a danger that an organisation may come to believe that none exists.

If my doubts about the wisdom of some of WWF's practices and policies had been mine alone I should have kept them to myself; instead they were shared by many responsible and senior conservationists in

Britain. I had been urged by many conservationist friends to write such an article for some months. Others were perhaps restrained from speaking out because they lacked the necessary knowledge, because they did not have access to the national press, or because they held office in a major national conservation society. I came to feel that my knowledge, and my freedom to make matters public, imposed a certain obligation on me in particular. I knew it would not make me popular in the short run, and I expected this. I am confident, however, that the long-term result will be a stronger WWF, raising more money for conservation at home and overseas.

JON TINKER,
BAMPTON, OXFORD.

Third airport

With reference to the letter and Comment in the March edition of *ANIMALS*, and to the growing belief that a third airport is unnecessary, would it be possible to organise a petition to that effect on a nationwide basis?

It seems to me that it would be much more sensible to encourage the production of vertical take-off aeroplanes, for which we have the requisite knowledge, and which would provide work in an ailing aircraft industry, than to ruin inland areas, or destroy a unique estuarine habitat.

It would be a tragedy if any of the sites considered by the Roskill Commission were ultimately converted to an unwanted airfield.

GARETH PATERNOSTER,
CLACKMANNANSHIRE, SCOTLAND.

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