

# Grzimek's ANIMAL LIFE ENCYCLOPEDIA



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## 2 Rhinoceros

The presently living rhinoceros are a well defined group of animals whose members closely resemble each other, in spite of the fact that two of the species live on the African continent and three in Asia. Similar to the history of the tapirs, the superfamily Rhinocerotidea consisted of many more species during the Tertiary Period and were classified into several rather different families. Among these families were light-footed runners with long, slender limbs, the *Hyrachyidae* and the *Hydracodontidae*, which appeared in North America during the Eocene age, approximately fifty million years ago. Even though they resembled the contemporary members of the horse family, they were originally like hornless rhinoceros. The *Hydracodontidae* became extinct during the Oligocene (about 40–45 million years ago), leaving no descendants; we probably would have to search among the original *Hyrachyidae* in order to find the original ancestors of all the other Rhinocerotidea (Color plate, p. 31). However, during the early Tertiary Period, there were rhinoceros-like animals which looked quite different, for example the *Amynodontidae* of Eurasia and North America whose appearance resembled that of a hippopotamus, and was rather plump.

The true rhinoceros of the *Rhinocerotidae* family during the Tertiary were also a widely distributed group of many species. During the Eocene, a hornless, small form with slender feet, probably not too different from the other odd-toed ungulates of this era, first appeared. The skull was low and flat, without any indications of horns. The molar teeth consisted of premolars and molars with low crowns and ridges across and on the sides. This basic structure, in spite of some variations, is the same as found in the later rhinoceros. Fossils of members of the subfamily *Caenopodinae* (*Eotrionias*, *Caenopus*, etc.), which belong to the most primitive, oldest rhinoceros, and fossils of several such forms have been found in the Early Tertiary stratum of North America and Europe. These slender-footed, hornless, primitive rhinoceros still had a complete set of front teeth and molars.

Phylogeny  
by Erich Thenius

Rhinoceros once in  
Europe

Of the contemporary rhinoceros, the ASIATIC TWO-HORNED RHINOCEROS (*Dicerorhinidae*) may be traced back approximately forty million years into the Oligocene. At first they occurred as small animals, *Dicerorhinus turgicus*, which were less than the size of a tapir and soon split up into different lines. One line led to the well known, early glacial WOOLLY RHINOCEROS (*Coelodonta antiquitatis*). He was a cold-resistant species with a long-haired, thick coat. Knowledge about him is gained not only from bones, but also from complete bodies with skin and fur which were discovered in the Siberian permafrost soil. In addition, the people of the Early Stone Age have portrayed him on their cave drawings. He was extinct by the end of the glacial period. The woolly rhinoceros had a long drawn out skull and high crowned molars which were especially adapted for the crushing of the hard grass of the steppe. His front teeth had completely disappeared, as in the contemporary SQUARE-LIPPED RHINOCEROS (see p. 64), which also is a grass-eating animal of the steppe. But this similarity in adaptation does not indicate any closer relationship. We find a similar evolution in the somewhat older relative of the woolly rhinoceros, the STEPPE-RHINOCEROS of the earlier and middle glacial period of Europe (*Dicerorhinus hemitoechus*). The larger MERCK RHINOCEROS (*Dicerorhinus kirchbergensis*) from the same glacial periods, however, was rather a forest type. The only contemporary species of this group, the SUMATRAN RHINOCEROS (*Dicerorhinus sumatrensis*) is much closer to the phylogenetically older forms than his glacial relatives, a fact which is frequently found in the inhabitants of the tropical prime forests. Since he still has front teeth and molars with low crowns, which are not suitable for the crushing of hard steppe grass, we have to consider him as a slightly modified survivor from the Tertiary Period.

The GREAT INDIAN RHINOCEROS, which live in South Asia today, can also be traced back to the Tertiary (Miocene, approximately twenty-five to ten million years ago). *Gaundatherium browni* from the lower and middle Siwalik strata of India can easily be traced from the Early Tertiary genus *Caenopus*, and thus represents the original form of the glacial species of *Rhinoceros sivalensis* and *Rhinoceros sinensis* as well as of the present-day Great Indian and JAVAN RHINOCEROS (*Rhinoceros unicornis* and *Rhinoceros sondaicus*). The Javan rhinoceros is the older of the two species, remaining almost unchanged since the late Pliocene of more than a million years ago.

The African rhinoceros form a separate branch (subfamily *Dicerotinae*) which includes the present-day BLACK RHINOCEROS (*Diceros bicornis*), which originally fed on foliage, and the SQUARE-LIPPED RHINOCEROS (*Ceratotherium simum*), which is a more highly evolved grass-eater.

From the Eocene until the Miocene (approximately sixty to ten million years ago), the Paraceratheria or Baluchitheria (subfamily Paraceratheriinae) lived in Eurasia. They were hornless, long-necked

rhinoceros with huge, column-shaped legs. The largest terrestrial mammals of all times belonged to this group, the genera *Paraceratherium*, *Indricotherium*, and *Benaratherium*. The *Indricotherium asiaticum* was five meters in height and seven meters long. The bones of this giant animal, which were approximately thirty-five million years old, were found in Kazakhstan on the banks of the Tschulka River. Those giant rhinoceros became extinct during the Miocene without leaving any descendants.

However, this list nowhere near exhausts the multitude of prehistoric forms of rhinoceros. There were slender-footed, long-legged rhinoceros, for example, the predominantly hornless *Aceratherium* which had long tusks in the lower jaw; furthermore, there were short-footed savannah types like the genus *Teleocerus* from North America and the genus *Brachypotherium* from Europe; and finally, there was the North American-Eurasian genus *Diceratherium*, which had two horns side by side on the nose. Another extinct line of the rhinoceros are the Elasmotheria from the glacial period of Eurasia. *Elasmotherium* was a giant form with a skull almost one meter long. This skull bore on its forehead a huge bony pad on which a correspondingly large horn must have sat. The dental enamel of the molars was ruffled, which is unknown in any other rhinoceros.

Compared to this multitude of forms in the tertiary and glacial rhinoceros, the surviving four genera appear rather stunted in spite of their size. They all live in remote habitats, seemingly because they have not been able to compete any longer with the other ungulates, especially the ruminants. Above all, however, human influence has basically changed wide areas of Africa and Asia, thus making them uninhabitable for rhinoceros. Since man first pursued animals, the rhinoceros have been hunted. The pictures in the Early Stone Age caves of Pech-Merle, Rouffignac, Colombière, and Les Trois Frères tell an obvious story. But they also show that these animals already had mystical significance in earlier times.

The present-day rhinoceros (family Rhinocerotidae) are either hairless or barely villous. HRL 200-400 cm. TL 60-76 cm. BH (shoulder) 100-200 cm. weight 1000-3600 kg. The surface of skin is distinctly sectioned, especially in the Asiatic species. On the nasal bone are one to two horns. There are 24-34 teeth arranged as follows:  $\begin{smallmatrix} 0 & 1 & 0 & 3 & 3 \\ 0 & 1 & 0 & 1 & 3 \end{smallmatrix}$ . The gestation period is 419-550 days. One young is born.

It is commonly held that rhinoceros horns consist of matted hair. This is not quite correct. The horns consist throughout of ceratin, and they do not have a bony pith like the horns of cattle. Under a microscope, however, one can see that the individual rods are not coated with an individual protective layer as is real hair. They adhere densely together in layers, thus they resemble neither the hair nor the horn of a ruminant, but rather the material of the hoof. This construction

## ▷ Rhinoceros

1. Great Indian Rhinoceros (*Rhinoceros unicornis*)
2. Javan Rhinoceros (*Rhinoceros sondaicus*)
3. Sumatran Rhinoceros (*Dicerorhinus sumatrensis*)
4. Square-lipped Rhinoceros (*Ceratotherium simum*)
5. Black Rhinoceros (*Diceros bicornis*)

▷▷

A black rhinoceros mother with her sub-adult young. The African black rhinoceros (*Diceros bicornis*) is the only species of rhinoceros which still occurs rather frequently in many areas of its distribution.

Present-day rhinoceros  
by E. M. Lang

Distinguishing characteristics

Of what does the horn consist?







Extinction because of  
superstition

Black rhinoceros (*Diceros bicornis*) like to take dust baths. These gray giants are often accompanied by cattle egrets (*Bubulcus ibis*) which do not, as formerly presumed, collect the parasites from the rhinos, but rather eat the insects the rhinos stir up.

gives the nose horn a stiffness and quality similar to a ruminant's horn with a pith. The nose horn sits on a bony dome formed by the nasal bone; it may unravel in places, causing it to look like a growth of hair. If it is torn off by accident, only a lightly bleeding area remains on the nose. Soon a new horn begins to grow. In young animals a horn may be replaced completely.

Except for the elephants, we find the largest terrestrial mammals among the rhinoceros. However, these handsome mammals provide a classical example of the extent to which man is responsible for the decrease and extinction of large mammals. Superstition played a dominant and especially destructive part in the disappearance of many rhinoceros species. The Chinese, as well as other Asiatic peoples, believe that powdered rhinoceros horns make an aphrodisiac. Many centuries ago the powder made from these horns was sold in East Asiatic pharmacies at a high price. Since the rhinoceros are easy to kill, they have been poached ever since; now, after the almost total extinction of the Asiatic species, those in Africa are poached. Years ago, on the black market, people in Africa paid approximately fifteen dollars for a kilogram of nose horn. The medium sized horn of a great Indian rhinoceros literally is worth its weight in gold, as well-informed people have confirmed. In 1965 the price for an Asiatic horn was no less than \$1125 for one kilogram. The strong faith in the healing powers of these "remedies" increases the prices constantly and stimulates natives and agents to kill even the very last rhinoceros without regard for the laws protecting the animals.

John A. Hunter, who may claim the sad record for having killed the highest number of rhinoceros, shredded rhinoceros horn and made it into a dark brown tea. "Even though I drank several portions of the brew," he writes, "I am sorry to say that I did not feel any reaction whatsoever, perhaps because I did not believe in it, or maybe because I was not in the right company." The possible medicinal effect of the horn has recently been carefully tested, thanks to the initiative of A. Schaurte. There, too, not the slightest effect could be demonstrated. Perhaps the Asiatic superstition is based on the fact that the great Indian rhinoceros do copulate for about one hour during which the bull ejaculates approximately every three minutes. To become capable of such sexual prowess seems to be desirable to many Asiatic people.

Skillfully carved cups of rhinoceros horn used by Indian and Far Eastern potentates to test beverages for the possibility of containing poison, may indicate a similar belief. Today these rhinoceros horn cups are rare collector's items. An example from the Calcutta Zoo shows how far superstition can go: All great Indian rhinoceros who die there are immediately removed by the keepers, cut up, and sold at an immense price to fanciers. In Assam, when one of the few surviving great Indian rhinoceros was shot with official approval, as hap-

pened a few years ago when the English Queen visited the country, not only the nose horn but also the skin, the skeleton, the muscles, and even each hair went to the black market trade. As was confirmed not only by Professor Ullrich, the director of the Dresden Zoo, but also by other visitors of the Kaziranga Game Reserve in Assam, poachers even in the nineteen sixties still dug many traps there for the rhino.

Therefore, all species of rhinoceros are threatened by extinction and urgently need all possible protection. In Africa, only in the National Parks and in the protected areas will one find a good rhinoceros population. The situation in Asia is much more critical. Of the once abundant great Indian rhinoceros, there are presently only a few hundred animals left, whose further existence is not at all assured. The closely related Javan rhinoceros' extinction is imminent; it is only in a tiny area, the Ujung-Kulon Reserve in Java, that 25 to 40 animals are found. The number of surviving Sumatran rhinoceros on the Malayan continent is unknown; according to official statements, there are 170 to 600 animals left. If the World's Nature Conservation efforts do not succeed in establishing effective measures for protection, our descendants will not see a living Javan or Sumatran rhinoceros. Unfortunately, not even the most general data of the life and behavior of these animals are known. The few surviving ones have to lead such a secretive life that any close survey or research is technically impossible.

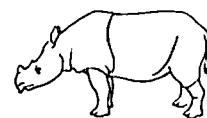
The original, yet also the smallest, living species of rhinoceros is the SUMATRAN RHINOCEROS (*Dicerorhinus sumatrensis*, Color plate, p. 37). HRL 250-280 cm, BH (shoulder) 110-150 cm. It is the sole villous rhinoceros. There are two nose horns; the maximal length of the anterior one is 25 cm; the second one is, in most cases, only a blunt protuberance (or hump). The skin is only slightly sectioned (semi-plated); the ears are fringed with hair; and the coat, while dense, thins out in older animals. Formerly the distribution was over all of East India and Indonesia; presently there are only infrequent sightings. These animals are very rare.

The great Marco Polo (1254-1324), on his travels through East Asia, had seen the Sumatran rhinoceros in the Malayan Archipelago and described it. However, there is hardly anything known about the life in the wild of this animal which will soon become extinct. Earlier zoologists distinguished between the original form on the island of Sumatra (*Dicerorhinus sumatrensis*) and a continental form (*Dicerorhinus sumatrensis lasiotis*), which was also called the rough-eared rhinoceros. But in comparison with specimens in museums and pictures from the wild, this opinion is open to question. According to cautious present-day estimates, there are only a few hundred of these animals on the island of Sumatra, some others on the island of Borneo, in Burma, in Siam, and in the Malaysian preserve of Sungei Dusun (Selangor). But the timber industry, the establishment of rubber plan-

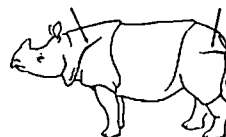
#### Asiatic rhinoceros



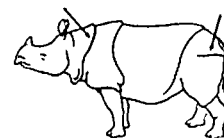
Fig. 2-1.  
Former and present distribution of the Sumatran rhinoceros (*Dicerorhinus sumatrensis*). This species now exists only in those few places which are marked by triangles on the map.



Sumatran Rhinoceros



Great Indian Rhinoceros



Javan Rhinoceros

Fig. 2-2.  
The skin folds at the shoulder and base of the tail are differently arranged in the various species of Asiatic rhinoceros.

tations, and other similar interferences with the natural landscape destroy the original habitat of this animal to such an extent that it is uncertain whether the species may be preserved.

Lately only a very few Europeans have encountered Sumatran rhinoceros. On March 14, 1957, a rhinoceros was seen on a coconut plantation at the Slim River near Perak in Malaysia. A farmer was able to take a photograph of it. At first sight it seemed to be a Javan rhinoceros (see p. 44). Some people, therefore, presumed that there might be some surviving specimen of the Javan rhinoceros on the South East Asian continent. Therefore, the photographs were widely distributed. But the lack of a horizontal skin fold on the buttocks indicated clearly that it was actually a Sumatran rhinoceros. It had a fairly dense coat and no ear tufts. From behind such a small, hairy rhinoceros almost looks like a cape buffalo.

In 1959 two female Sumatran rhinoceros were captured in the area of the Siak River on the island of Sumatra and brought to Europe. One of them arrived at the Basel Zoo in very poor health; her body height at the shoulder was 112 cm and she weighed 386 kg. After almost uninterrupted medical treatment for two years, she died of total deterioration of the kidneys. The other animal remained in good health and was to this date (1967) in the Copenhagen Zoo. Presently, it is the only Sumatran rhinoceros on earth in man's care. Unfortunately, all efforts to find a mate for this animal have been unsuccessful.

After the success achieved in keeping the great Indian rhinoceros in the Basel Zoo, it should be as easy to keep and breed the Sumatran rhinoceros. The first rhinoceros ever to be born in captivity was a Sumatran rhinoceros, born on January 30, 1889, in the Calcutta Zoo in India. Then, these small rhinoceros were not nearly as rare as they are now. However, it would be possible to preserve the species only if there were enough pairs available for the zoological gardens. But by now they have become too rare. It would be absolutely necessary to place the few remaining specimens in their original habitat under rigorous protection. However, the situation in Malaya is rather discouraging. Because many Chinese live in the already limited remaining habitat of the Sumatran rhinoceros, effective protection there seems impossible. Wherever Chinese poachers are at work or buy rhinoceros' horns from the hunting natives, the rhinoceros disappear.

The earliest species of rhinoceros to become known in Europe was the GREAT INDIAN RHINOCEROS (genus *Rhinoceros*). HRL 210-420 cm, TL 60-75 cm, BH (shoulder) 110-200 cm. The weight is 1500-2000 kg; the ♀♀ are somewhat smaller and lighter; footprints of adult ♂♂ measure 28-29 cm in diameter in the front, those of adult ♀♀ measure 26-27 cm in the front, in the rear 23.5-24.5 cm. There is only one horn. The bare skin is not very thick, is well supplied with blood vessels, and is divided into sections by large folds. On individual sections there

are flat bumps which look like rivets on a hull of a ship. Hair occurs only in a few places: the tail tassel, tufts on the tips of the ears, and, in neonates, also a light hair brush at the base of the ear's outer rim. The three toes on each foot are covered by rather large nail plates, and are buffered by massive tissue pads which bulge out when the foot is lifted. The upper lip ends in a strong "finger." The two incisors in the lower jaw grind against the tooth plates in the upper jaw, and since they are razor sharp they are effectively used as weapons.

There are two species: 1. GREAT INDIAN RHINOCEROS ( $\sigma$  *Rhinoceros unicornis*; Color plate, p. 37), whose shoulder skin fold arches over the shoulder blade. 2. JAVAN RHINOCEROS ( $\sigma$  *Rhinoceros sondaicus*; Color plate, p. 37), is rather similar, but smaller and lighter;  $\sigma$  have only a weak horn,  $\text{♀♀}$  are often hornless. Their shoulder fold comes up from both sides and meets above the shoulder.

The great Indian rhinoceros (*Rhinoceros unicornis*) is an impressive sight. It does not really have a hunchback as does the African square-lipped rhinoceros but the bull has a bulky, wide neck. The withers and pelvis in most cases are of the same height, but once in a while one may see "overendowed" females. Within the same population, there are both long-legged, slender animals and shorter, heavier types. The pace of the great Indian rhinoceros is a deliberate walk but may also be faster. The trot appears surprisingly elegant, and the gallop is extremely fast. When galloping on a good surface, a great Indian rhinoceros may well reach speeds of up to 35–40 km/hr.

As is true of all the rhinos, the great Indian rhinoceros is a vegetarian. It feeds on grasses and twigs, pushing them into its mouth with the finger-like extension of the upper lip. In the Basel Zoo, the great Indian rhinoceros are fed, besides the basic diet of good quality hay, which at times may be mixed with alfalfa, a special compound of highly concentrated food containing oil cake and several cereals, the necessary vitamins and minerals, and about 18 percent pure protein. An adult great Indian rhinoceros eats about 15 kg of hay per day and 4–6 kg of the Basel special compound; it drinks 80–100 liters of water.

Great Indian rhinoceros like to rest in the water or in a clay wallow which helps to keep their skin in good condition. In the Basel Zoo, which is perhaps the most experienced in the keeping and breeding of the great Indian rhinoceros, the animals have a pool, heated in the winter, which they use the whole year round. Great Indian rhinoceros are well adapted to life in the water. They are skillful swimmers and divers; even as wide a river as the Brahmaputra is frequently crossed by great Indian rhinos.

E. P. Gee, the protector and warden of the Kazirange Reserve in Assam, has found that the rhinos there defecate on certain "rhino-dung heaps." Gee is of the opinion that each great Indian rhinoceros that passes such a dung heap is attracted by the scent—whether its own

#### Social life of the great Indian rhinoceros

or that of another rhino—and thus is almost stimulated to defecate as if by some compulsion. The director of the Dresden Zoo, Wolfgang Ullrich, saw dung heaps forming mounds up to 70 cm high. He writes: "How strong a stimulus for defecation such a mound represents is demonstrated by the fact that even rhinos in flight will stop there for a few seconds in order to deposit a dropping. These dung heaps are found especially often near wallows, bathing places, and grazing grounds, which are on the edge of open spaces. With their odor they mark the entrances to the tunnel-like paths in the dense elephant grass, thus enabling the rhinos to find the path by olfaction."

According to Gee, the great Indian rhinoceros are not strictly bound to a specific home range; usually a weaker bull will leave the territory after he has lost a fight with a stronger rival. Gee sometimes followed single rhinos when they were roaming through wide areas; he also found gatherings of four to six animals using the same wallow. As Gee reports, the mating season in Assam extends from the end of February to the end of April. Wolfgang Ullrich spent several weeks in the Kazirange Reserve. There he observed the great Indian rhinoceros feeding on the young sprouts of high grass and bamboo shoots, on several herbs in the swamp, and on the water hyacinths which cover the lakes like a carpet. All other animals generally avoid the rhinos, according to Ullrich's observations. The great Indian rhinoceros flee only, at least in most of the cases, from mounted elephants, and then, in contrast to the African black rhinoceros, they do not carry their tails erect but closely pressed to the body. Occasionally, they may attack a riding elephant or at least threaten him; but in most cases, the rhino will veer off just before reaching the elephant. Many of the great Indian rhinoceroses have serious injuries and large scars, which in Ullrich's opinion are the result of fights over a territory. There are also some cases known where female rhinos have been injured by a bull.

In the journal "Der Zoologische Garten" Ullrich wrote on the home ranges and paths of the great Indian rhinoceros: "The grassy jungle is crossed by many paths, which are separated into 'public' and 'private' pathways. The 'public' paths are used by several rhinoceros. They connect wallows, bathing places, and grazing grounds. Wallows and bathing places belong to all rhinos and are not defended. We frequently observed several rhinos resting peacefully beside each other in wallows and ponds. In a small lake covered with water hyacinths, we found nine rhinoceros; several of them, including a calf about four months old and a subadult, were laying close together. Two of them had even put their heads on another's back. At most, only the noses, the eyes, and the ears were visible above the water. Two other rhinos were also resting closely together, about 20 meters away from the group. When three of these rhinos began to feed on the water hyacinths, there was no conflict.



Fig. 2-3. Former and present distribution of the great Indian rhinoceros (*Rhinoceros unicornis*). Presently it is found only in a few protected areas (marked on the map with triangles).



Fig. 2-4. Former and present distribution of the Javan rhinoceros (*Rhinoceros sondaicus*). Today only a few animals live in the Ujung-Kulon Preserve in Java (see arrow).

#### Public and private rhino paths

"When a rhinoceros came to the edge of a lake where two others were already resting, those two arose uttering threatening sounds. Then the rhino on the shore would make a snorting sound. It sounded as if someone was blowing air through a hose into water. The two rhinos immediately answered with the same sound, then went back to rest and allowed the newcomer to rest with them.

"Branching off from the 'public' paths near the resting places and the grazing ground are the 'private' paths. Daily we visited a large swamp meadow which was divided into seven grazing territories which belonged to three females with three calves, another adult female, and three adult males. Except for the territory of one of the bulls, all the grazing areas, which were situated at the edge of the pasture, were about 4000 square meters in size. A short 'private' path connected each grazing area with the 'public' paths which led through the grassy jungle around the pasture. The rhinos approached the area on the 'public' paths and then entered to their 'private' paths in order to reach their part of the pasture which they defended against conspecifics. When they were disturbed while grazing, they always fled to their 'private' paths. In the same manner, 'private' paths branched off from the 'public' paths near their sleeping places which are defended in the same way as the grazing territories. The sleeping places are situated in the tall elephant grass, where the rhinos rest from midnight until sunrise and during the hot part of the day at noon."

Except for the observations of Gee, Ripley, and Ullrich about the reproductive behavior of the great Indian rhinoceros, the only other information comes from zoological gardens. Even though this species had already come to Europe during the Middle Ages, they were first bred in a zoo in 1956. A female in heat sprays urine, while the vagina opens up and "flashes." At the same time, she utters rhythmical whistling sounds that are produced by forcing the air in and out during breathing. She comes into heat every 46-48 days and remains so for approximately 24 hours; however, the intervals between heats may vary from 38 to 58 days. The bull reacts immediately to her condition. Shortly after heat begins, the animals will drive one another intensely; we often saw them galloping around the large rhinoceros pen in the Basel Zoo two dozen times. Usually a rest period of several hours follows this driving. Then the animals will stand beside each other; the bull may lie down, and sometimes the female holds her head between his hind legs. After many hours, the first attempt to mount will take place, but only after several such attempts is the bull's penis erect enough to achieve intromission. Both animals remain in the copulation posture for an average of sixty minutes. During one such copulation, we counted up to fifty-six ejaculations. The longest copulation we recorded was eighty-three minutes. After the bull dismounts, the animals pay no further attention to each other.

#### Reproductive behavior

#### Birth and the raising of young in the zoo

Can the Javan rhinoceros still be saved?

While the females reach sexual maturity at three years, the bulls do not become sexually mature until they are seven to nine years old. The average gestation period for twelve females in captivity was between 462 and 489 days. The birth started with episodes of labor lasting about one hour; the actual birth, however, took only 15-30 minutes. A neonate great Indian rhinoceros has an average weight of 65 kg; it has folded skin like an adult with all the "rivets" and protuberances. On both sides of the head is a light spot which the English zoologist Cave interprets as a relic of tactile hair. The plum-shaped head is especially conspicuous in the newborn great Indian rhinoceros. There is a flat, smooth, oval plate where the nose horn will grow later. At the age of five weeks, this plate begins to rise. During the development of the sub-adult, the forehead becomes depressed while the area around the ears and the horn arch upward.

The young great Indian rhinoceros grow much faster than has been thought earlier. At the Basel Zoo, we found weight gains of 2-3 kg per day; thus, the weight at birth is multiplied tenfold within one year. Shortly after birth, the BH at the shoulder is 62-64 cm. After one year, it is approximately 120 cm; at the age of two years, about 145 cm. At the age of three and a half to four and a half years, the female is fully grown, while the bulls may keep growing for up to five years. The rhino mother has to produce twenty to twenty-five liters of milk in order to increase the weight of her young to such an extent.

It is most regrettable that we know so much less about the exact appearance or even the behavior of the closely related Javan rhinoceros (*Rhinoceros sondaicus*). There are only a few specimens in museums and only a few photographs of this moribund species. In former times, the Javan rhinoceros were widely distributed all over East India, Sumatra, and Java. Reliable observers, like Eugen Schuhmacher, a photographer and student of animals, doubt whether the last survivors in the Ujung-Kulon Reserve in Java will be able to sustain the species. Only in 1967 did the World Wildlife Fund manage to send an ethologist, Professor Rudolf Schenkel from Basel, to Java to study the habitat and the behavior of this species, which is literally at the point of extinction. In his letters to me from the Ujung-Kulon Reserve, he reported that the Javan rhinoceros lives in the dense jungle. Its feeding grounds are at the edge of the forests of the coastal area and in the sparse mountain forest, where there are many young trees and openings caused by fallen trees. There it feeds predominantly on young trees whose trunks are no thicker than 10 cm, on the foliage of low-hanging branches, and on bushes. The rhinoceros bends these trees with the upper part of its trunk until they break; then it feeds on some of the leaves from the crown—the rest it does not touch.

Compared with other rhinoceros, the population density is rather low, which can probably be linked with the scarcity of suitable food



plants. The animals are solitary; the young become independent at a relatively early age. In order to study the behavior of individual animals, which are hardly ever seen in the dense jungle, Schenkel measured their footprints. In adult animals, these are 27–39 cm wide in the front, and 25–27 cm in the rear. In the young who were on their own, Schenkel measured 21.5–22 cm for the front feet and 20–20.5 cm for the hind feet. Presumably, the females, with or without young, remain in a rather fixed home range but they take long trips from there daily. This roaming is even more pronounced in the males. The paths of the Javan rhinoceros are found predominantly on passes which cross mountain ranges and parallel to them, but the paths are most distinct near wallows. These wallows and bathing places, as well as the resting places, are different depending on the season. During the rainy season, the rhinos wallow in creeks, and less frequently in wet places in the brush. However, during the dry season most of these wallows dry out. The Javan rhinoceros also bathes where larger creeks flow into the ocean and occasionally even in the ocean itself.

The bulls spray their urine backwards and upwards at bushes. The fresh urine, which is orange to red in color, smells like horse urine. Until now these red splashes were thought to be nasal secretions. The Javan rhinoceros defecate either in creeks or on regularly visited "manure fields" of five to ten meters in diameter. Often they may leave droppings on their way. Rudolf Schenkel thinks that defecation in Javan rhinoceros is of no special significance in intraspecific communication.

The only species of rhinoceros of which there still is a good population in the wild is the AFRICAN BLACK RHINOCEROS (*Diceros bicornis*; Color plate, p. 37 and pp. 38–40). HRL 300–375 cm, TL approximately 70 cm, BH (shoulder) 150–160 cm. The weight is up to two tons. There are two horns, of which the anterior one is longer (usually about 50 cm, sometimes up to 138 cm). Occasionally there is even a disposition for a third horn. The body is hairless, except for the tips of the tail and ears. Rib like folds are on the sides of the rump. The upper-lip is extended and the tip is suitable for grasping. There are no incisors or canine teeth; there are seven premolars and molars on each side of the jaw. The gestation period is fifteen to sixteen months.

A person on foot who encounters a black rhinoceros really feels rather small and insignificant. One immediately recalls the angry attacks and even fatal accidents one has read about in books on Africa. After all, the black rhinoceros is one of the largest terrestrial mammals, next to the elephant and the square-lipped rhinoceros. The most impressive attributes are the two nose horns. A visitor to a zoo, seeing the animal for the first time, may already imagine them between his ribs. But then zoo rhinos almost never have the remarkable length of horns as do rhinos in the wild. The world record probably is held by

The African black rhinoceros by Bernhard Grzimek



Fig. 2-5. Former and present distribution of the black rhinoceros (*Diceros bicornis*). This is the only species of rhinoceros which still occurs quite frequently (black triangles) in some areas.

Gertie, one of the two adult female rhinoceros of the Amboseli Game Reserve; her front horn is bent in an unusual way forward horizontally and upward to a length of 138 cm. For many years she was the most photographed wild game animal on earth. The adult female Gladys, who lives in the same area, had a similarly monstrous horn formation. In 1965 she broke 45 cm off of it. With photos, one was able to show that the frontal horns of these animals had grown 45 cm in six to seven years.

In some areas of Africa, where the rhinoceros are now extinct, there have allegedly been groups in which the two nose horns were of the same length. The three-horned rhinoceros were found frequently in Northern Rhodesia (in the vicinity of Lake Young). There are reports even about a five-horned rhinoceros and of others with horns growing out of their bodies. The great Indian rhinoceros on the famous drawing by Albrecht Dürer, which has a small horn on the shoulder, may well have had a living model. Occasionally, rhinos without ears are born. Gertie of the Amboseli Game Reserve of Kenya, who has perfectly shaped ears herself, in 1953 gave birth to Prixie, who did not have ears. I received the impression that Prixie, whom I have observed and filmed from a very close distance, may, in spite of this defect, decrease or even close the openings of the auditory canal.

In contrast to the square-lipped rhinoceros—the "white rhinoceros" of the literature on Africa—the "black rhinoceros" is not really black, just as the white rhino is not white. Depending on the soil of the habitat where the rhino likes to roll in the mud and the dust, the originally slate-colored skin may be covered with substances that may make it look white or reddish, or, in areas with lava, black. Since it is hairless and without sweat glands, it has a special liking for mud baths. Hence, in rare cases it may happen that a rhino becomes trapped in the mud without being able to get out; then it may be attacked by hyenas.

Black rhinoceros are remarkably nearsighted. Apparently they cannot distinguish between a man and a tree at a distance of only 40 or even 20 meters. This nearsightedness explains some of their behavior, for example, their alleged "aggressiveness." Their sense of hearing is much better; their cone-shaped ears react quickly to unusual noises. The best developed of their senses is the sense of smell, which is probably comparable to the quality of a dog's. They follow conspecifics by the scent of their tracks. When mother and young have lost one another, they may be within range of clear sight. However, they do not move towards each other but rather they sniff at the ground until they encounter the other's track, which they then follow.

Animals with poor eyesight may well approach people or other objects slowly and curiously until they catch their scent. Once a rhino approached Cherry Kearton, an explorer of Africa and animal photographer, who was filming it. The animal circled closer and closer

until, at a distance of 10 meters, it finally ran off. The black rhinoceros have another habit which can become fatal for them; they will attack an object which they cannot identify, approach it snorting furiously, and then veer off or just pass within a few meters. A camera man, Martin Johnson, together with his wife, jumped down a deep cliff from attacking rhinos, but then they saw that the animals had stopped five meters from the place where the two of them had just stood. In two other instances, when the Johnsons could not flee, the rhinos also turned off shortly before reaching them.

However, in most cases, travellers in Africa do not have the nerve to wait and see whether it is the exploring approach of the nearsighted animals or actually an attack. Therefore, in most cases, the hunters will shoot the rhinoceros before they know for sure. Rhinoceros sometimes attack tree trunks or termite heaps in the same manner and then simply walk on. John Owen, the director of the Tanzania National Parks, had an especially exciting experience. One day when he was climbing up hill in the Ngurdoto Crater with a woman who was a famous horsewoman, the two suddenly saw a rhino coming towards them. Owen quickly escaped into the bushes; the lady pulled herself up on a branch. The branch broke and the woman landed on the rhino's back. Both mount and rider were terrified; the lady fell off and the rhino hastily ran away.

Of course, one cannot always rely on the harmlessness of rhinoceros. This the Swiss zoologist Rudolf Schenkel learned when he observed rhinoceros and lions in the Tsavo National Park in Kenya while on foot. Many of his encounters with black rhinos indeed were harmless—but one evening a bull attacked him when he moved along at a distance of about 50 meters, silhouetted against the horizon. Schenkel ran towards the bull, roaring in order to drive him away. Since the bull was approaching at full speed, Schenkel had to dash aside in order to avoid him. He ran towards a small tree whose top half was broken off and was hanging down. There was no time left to climb into the intact part of the tree top. So he just ran around the trunk and over its broken part, while the rhino had to run around the part with the dead top. But soon the bull changed his method. While Schenkel remained on the side of the tree with the broken part of the trunk, the bull waited on the other side in order to suddenly dash forward. Schenkel tried to get into the remaining part of the tree top, but the bull caught him and threw him into the air. He came down at first on the animal's shoulder and then to the ground where he immediately crawled under the broken tree top. The bull pushed aside the broken trunk and top part of the tree. Schenkel decided to remain motionless, lifting one foot to the level of the rhino's mouth so he could push himself off in case the worst happened. At first the bull was puzzled; then he came closer until his nose touched the naked foot—the

Is the African black rhinoceros dangerous?

Rhino attacks on cars

shoe had fallen off. When the bull no longer saw the moving object, he responded to the human scent. He suddenly turned around and trotted away with his tail erect.

So we can see that the behavior of black rhinoceros may differ substantially; it depends on the behavior of the people who share their habitat. The Wakamba in Kenya pursue these animals with poisoned arrows or sling traps for the legs. The poor rhinos may drag around such a sling of wire with a heavy piece of wood attached to it for days and weeks, while all the time the wire cuts deeper into muscles and bone. Therefore, the rhinoceros in the Wakamba territory are said to be aggressive and mean. However, in the territory of the Masai who do not hunt and leave the rhinos in peace, they are known to be rather peaceful.

Sometimes it turns out that rhinoceros who suddenly attack have been wounded before. Once in Tanzania, Oscar Koenig had shot the hindquarters of a rhino which was blocking his way. During the following nights this animal turned over three limousines and two trucks and finally had to be shot. Kearton reported that a woman hunter, who had shot at a rhino which was generally known to be peaceful with too small a caliber bullet, was killed by the animal. The following day a farmer and his wife from the area came along the road with their car. The rhino immediately attacked when he saw the car. The man quickly pulled his wife out of the car and helped her to climb a tree; he could not reach it himself in time and was killed. In 1964, a game warden in the Hluhluwe Game Reserve in Natal was thrown into the air twice by a black rhinoceros; he was seriously injured in the thighs and buttocks. When the rhino started the third attack, the game warden grasped the frontal horn and desperately clung to it. The rhino shook his head vigorously from one side to the other, trying to dislodge the man. He finally succeeded with an extremely vehement jerk. When the man flew into the bush, the rhino departed.

I have experienced several attacks on cars, all of which I had provoked myself. In most cases the animals stopped just short of the car without touching it; only in one case did I get a dent in the metal. One day when I wanted to take a closer look at the ear openings of the earless Prieze, the game warden's son drove me close to the sleeping animal. Prieze suddenly jumped up on all four legs and attacked immediately, making a dent in the side of the open car right next to my buttocks. In Amboseli, too, in 1965 a rhinoceros pierced his horn through the open window of a fully occupied limousine into the metal of the roof, and then made dents all over the car. It injured the passengers with the shaft of a spear which was still stuck in his throat—so again this aggressive rhino actually was a wounded animal. Often rhinoceros work over a passing car just out of mere curiosity, sticking their heads under the fender and shaking the vehicle. A game

warden of the Hluhluwe Reserve, on one such occasion, bravely got out of his car and hit the animal over the head with his belt. On the railroad from Moshi to Same a rhino once chased off all the workers and damaged their lorries.

I do not know of anyone who has even seen a black rhinoceros cross a lake or a river by swimming, although these animals love to wallow or go into shallow water to graze on the reeds. However, they are able to swim. During the damming up of the artificial Lake Kariba in Zambia, attempts were made to save the game animals from the slowly disappearing islands. It happened that a rhinoceros, while attacking the boat, went into surprisingly deep waters where it could no longer stand. However, it did not disappear completely in the floods—just the nose, ears, and eyes were slightly above the water. A few waves would have been sufficient to eventually drown the animal.

In spite of their apparent awkwardness, black rhinoceros climb rather high up into the mountains. In East Africa, they were found at elevations from 900 to 2700 meters. They live in dense bush, in scattered forest, on open grass plains, and even in semi-desert. They do not like hot and humid areas; therefore, they have never penetrated the rain forest of the Congo Basin or the woodlands of West Africa. Thus, even in earlier times, they were never found throughout Africa. From the time the Europeans first entered Africa, the rhinos have become exterminated in wide areas of their habitat. In South Africa, south of the Zambesi River, only a few are left in protected areas. In Rhodesia and Malawi, too, they have become rare; they are somewhat more numerous in Zambia, especially in the area of the Luangwa River. The estimate for the Portuguese area of Mozambique is approximately five hundred head; for Angola it is one hundred and fifty; and for Southwest Africa, two hundred and eighty. In the French colonies of Africa, they were nearly extinct by 1930. Only then were strict laws for their protection introduced, saving some. The few rhinoceros in the Southern Sudan may have disappeared in the last years due to the civil wars going on there and the ready availability of firearms. If it had not been for the National Parks, especially in East Africa, and other protected areas, the black rhinoceros would probably be extinct by now. The total number now (as of 1967) of black rhinoceros left are only 11,000 to 13,500, three to four thousand of them in Tanzania.

The white hunters especially have wreaked havoc among the black rhinoceros. No less than 800 rhinoceros horns were exported from the sultanate of Fort Archambault in the area of Lake Chad in 1927. The professional big game hunter Cannon has killed about 350 rhinoceros in less than four years. He and a butcher by the name of Tiran "worked" mainly in the Cameroons, in Ubangi, and Chad. At times they switched from ivory hunting to rhinoceros because killing the rhinos was easier and their horns had increased in price. These people

They are poor swimmers

How many black rhinoceros are left?

What white big game hunters did

supplied modern firearms to the natives who eagerly participated in the shooting. The British big game hunter John A. Hunter brags about having killed more than one thousand and six hundred rhinoceros and more than one thousand elephants, partly of his own volition but also by order of the government who wished to prepare the land, for example the Wakamba, for settlements. In 1947 he killed three hundred rhinoceros there and, in the following year, another five hundred. Later it was found that this area was hardly suitable for settlements. The most difficult to understand are the so-called "sport-hunters" who, just for the fun of it, without any economic gain, have travelled in Africa and killed as many of these unsuspecting animals as possible. There are reports about a Dr. Kolb who has killed one hundred and fifty rhinoceros in East Africa.

It might be of special interest for psychologists to analyse the mentality of such wholesale killers from their letters and reports. These "Big Game Hunters" obviously are an entirely different type of man from those hunters in Europe who care for the game and spend large sums in order to preserve or to improve the game population. Since traditionally big game hunting in Africa has been described as something worthy of heroes, one may presume that a personal feeling of inferiority, destructive tendencies, and a certain addiction for fame have led to such slaughter. However, the rhinoceros hunt especially has never been a dangerous, heroic deed. During the many years he lived in Africa, the English explorer Frederick Selous (1851-1917) had not heard of a single instance where a European rhinoceros hunter had been killed by a rhino.

Unlike the roaming elephants, rhinoceros rarely return to areas where they once were exterminated. There is only one way to reintroduce them: They must be caught in other places, transported in boxes, and set free in that area. This was done in the 1950's in the Garamba National Park in Rwanda. During the last few years, we have caught sixteen rhinoceros, many of them seriously wounded, in the hunting areas of Tanzania and brought them to the island of Rubondo in Lake Victoria. Meanwhile, they have reproduced there. Following habit and instinct, rhinoceros will stay in their home range after it becomes settled by man and disturbances increase.

Since we now obtain our information on these gray giants no longer from big game hunters but from patient scientists and game wardens, we have learned more about their life. Studies on their behavior really began only in 1960. In contrast to many other species of animals, black rhinoceros do not have territories from which they chase conspecifics. However, at certain times of the year as well as the day, one may find the same animal in the same place engaged in the same activity. Once a day a rhino takes a specific, well-trodden, wide path to get a drink. The distance between the pasture and the waterhole may be eight to

Ethological studies in national parks

ten kilometers. Usually the rhino begins to graze only in the afternoon, spending the rest of the day in the shadow of a tree or in a wallow. At night at the waterhole, the animals may play, chasing each other, hissing and snorting. Where they are not pursued by man, as for example in the Ngorongoro Crater or in Amboseli, they are in the open all day long.

From the more intensive observations in the Ngorongoro Crater, we learned that individual black rhinoceros do exclusively remain in a specific home range, as was originally thought. This open protected area in Tanzania measures two hundred and sixty square kilometers; it is possible to count from an airplane how many rhinoceros are there at a given time. In January, 1958, my son and I counted nineteen rhinoceros there. Molly's count in March, 1959, revealed forty-two animals. Hans Klingel, between June, 1963 and May, 1965, found a population of sixty-one rhinoceros in the Ngorongoro area; thirty four of which seemed to be more or less permanent residents of the bottom land crater. J. Goddard, a biologist who lived in the Crater for three years until 1966, knew each animal individually, and regularly took photographs of them. During this period, he saw one hundred and nine rhinoceros in the crater. These varying figures are due to the fact, as Goddard presumes, that the great majority of the rhinoceros live the whole year round in the area above the rim of the Crater. Most of the permanent residents, especially the bulls, were found regularly in distinct areas, according to Klingel; but it may also happen that single animals of both sexes lose their home range, moving permanently to another area.

Black rhinoceros like especially to eat branches, which they grip with their upper lip as with a finger of a hand. When grazing on a pasture, in many cases, they pull out tiny little bushes only. According to the observations of Fraser-Darling, a rhinoceros daily pulled out two hundred and fifty little whistling acacias. In Natal (South Africa), two black rhinoceros were seen breaking off a rather large Mtomboti tree (*Spirostachya africanus*). One of the animals held the trunk of the tree between the two horns and then pushed, slowly shifting the weight of his body with a circling movement. When the tree broke off and lay on the ground, the two animals ate the shoots from the tops of the branches. Rhinoceros also eat the very prickly branches of thornbush and do not mind the sticky white juice of the Euphorbias. Klingel repeatedly observed a group of four animals who ate Wildebeest droppings. There they did not consume any plants at all but went straight from one pile to the next. They probably satisfied a need for minerals and trace elements.

In some areas these gray giants dig up the mineral soil with their horns. It is said that they tear up their own dung heaps in the same manner. The usual method is just to use their hind legs such as when

The diet of the  
African black  
rhinoceros

Behavior while  
defecating

How rhinoceros  
sleep

Rhinoceros among  
themselves

a dog covers his fresh feces by scratching soil over them. In contrast to elephants, rhinoceros do not urinate and defecate at the same time. However, different individuals, bulls as well as females, may defecate on the same heap. Only in rare cases do they pause briefly to deposit their droppings right on their paths. The dung heaps probably do not mark a specific area as an individual's territory. Rudolf Schenkel, while doing research on the black rhinoceros in the Tsavo National Park in Kenya in 1964 and 1965, thought that the animals in an area maintain olfactory contact with each other. For similar reasons, the female rhinoceros may spray urine on their paths when walking. Bulls sometimes attack bushes first with their horns and then with their feet until they finally spray urine over them.

Herbert Gebbing studied the sleeping habits of rhinoceros in 1957 at the Frankfurt Zoo. Usually, the animals lie on their bellies, slightly to one side, with the front legs pulled in an angle under the body and the hind legs stretched out forward. The head rests forward on the ground. Only in rare cases does the animal lie completely on one side, stretching out all four legs. The rhinoceros seem to rest in this position in especially deep sleep. Their sleep lasts quite long, an average of eight to nine hours a night. Usually they rest without interruption for two, three, or even five hours, and they are not disturbed by familiar noises. Two or three times during the night they get up to defecate. According to Gerda Schütt, the rhinoceros of the Hanover Zoo slept for nine and a half hours; within this period they were up for almost three hours in which they ate almost without interruption. As soon as one of them got up, the other one usually would wake up too. If it did not, the first rhino would push the other with its head until it too stood up.

Except in wallows, one will find black rhinoceros always singly or in small groups of up to five animals at most. If there are two of them, in most cases, it will be a mother with her more or less grown up young or a bull and a female; rarely will two bulls be together. Rhinoceros who stand together may caress each other with their lips or rub their chin on the other animal. In 1958, game warden Ellis saw a group of adult rhinoceros females one evening in the Nairobi National Park coming out of the woods; three of the animals walked side by side, while the fourth walked behind them. The animal in the middle was obviously in labor. When the animals became aware of being observed, they stopped, but one of the females kept rubbing the flank of the mother-to-be with the side of her head and horn. Finally, they retreated into the bushes. Three days later, a newborn calf was seen there.

When rhinoceros encounter each other, the meeting sometimes may seem antagonistic, but, in most cases, it is peaceful. For example, there may be a mother standing with her child. Suddenly a big bull appears

from behind a bush. All heads go up, the female snorts, and the bull snorts too; both of these huge creatures raise their tails straight up. The bull paws the ground several times with the hind legs and snorts. Then, almost simultaneously, both animals lower their heads and dash towards each other. One is prepared to hear the terrible clash of two heavyweights crashing into each other. Then, suddenly, at a distance of six meters, both stand still and look at each other with their heads erect. The ears are turned towards the other. Then the bull turns aside and walks to the water, and shortly after that, the female, too, turns around. However, a short while later all three stand together.

Elephants clearly are recognized as superior by rhinoceros, although the two species hardly ever have reason to fight. One day in Uganda, on a narrow path, an elephant and a rhinoceros were slowly walking towards each other. They did not become aware of the other's presence until they were fifteen meters apart. The elephant spread his ears widely and walked straight towards the rhinoceros, who stopped and lifted his head. When the elephant attacked, the rhino moved backwards, shaking his head from one side to the other, and snorting loudly. The next short forward movement of the elephant drove away the rhinoceros, which disappeared in a gallop in the direction from which it had come. Later, the two animals were seen grazing not far from each other without seeming to notice the other's presence. Mrs. Trappe once found a rhinoceros in the area of the Ngurdoto National Park which had apparently been pierced by elephant tusks, since the surrounding ground was covered with elephant footprints. There are several reports of similar cases. In 1960, game warden Koos observed a bitter fight between a rhinoceros bull and an elephant in the Kruger National Park. Obviously, the elephant was unwilling to let the rhinoceros drink water, but the rhino insisted. During the following fight, both animals fell three meters down the steep slope of the river bank and continued fighting in the water. Large pools of blood led to the place where the rhinoceros finally lay dead. He had four holes made by the elephant's tusks in his body as well as other injuries. It has been observed repeatedly that elephants covered rhinoceros, which they had killed, completely with branches and twigs.

The relationships between rhinoceros and other large animals are not at all as clear. A game warden in the Murchison Falls National Park once saw a black rhinoceros chase a group of twelve waterbucks over a distance of about one hundred meters. This was all the antelopes would put up with. Turning around, they attacked the grey giant who retreated quickly into the brush and did not show up any more. On another occasion, a rhinoceros attacked a herd of about three hundred and fifty Cape buffalo, who were grazing in a line about four hundred meters wide. The rhinoceros ran almost playfully along the line of the unsuspecting buffalos, chasing them in all directions, and then he

#### Behavior towards other animals

walked on. In the Nairobi National Park, Guggisberg also saw a group of zebras playfully attacking a rhinoceros who finally retreated. However, mutual toleration is far more frequent, sometimes even leading to a kind of friendship between rhinoceros and other species of animals. A. Ritchie reports on two rhinoceros who were seen over a long period together with a large herd of Cape buffalo. They even slept regularly in the midst of the buffalo in a clearing in the forest, lying right next to them.

In other cases, animals of a different species may help the rhinoceros to rid itself of parasites. In Natal, a female rhinoceros was rolling in a creek and two turtles were seen tugging hard at her fissured skin. This was obviously painful for the rhino because she repeatedly jumped to her feet. However, she made no attempt to attack the turtles. On another occasion, again in Natal, at least six turtles approached a rhinoceros who lay in a puddle and started to pull the ticks out of his skin. They would rise up to seventeen centimeters above the water level in order to reach the parasites. In order to pull off the ticks, the turtles would push their forefeet against the rhino's body, take the ticks in their mouths, and then pull until the parasites came out. When the turtles worked in the more sensitive parts of the rhino's skin, he quivered several times, but the turtles did not pay any attention to this.

It is also said that the cattle egret picks the parasites from rhinoceros. Indeed, the cattle egrets follow the rhinos all day long, even sitting on their backs. But they seem only interested in catching the insects stirred up by the large animals. They do not pick ticks from the rhinos; this was confirmed by an analysis of their stomach contents.

Occasionally, rhinoceros calves are killed by lions. In 1966, in the Manyara National Park (Tanzania), several lions attacked a rhinoceros mother with her calf and drove them towards the entrance gate of the park. About fifty meters from the administration building, they caught the calf while the mother called loudly as if for help. Two passing cars were chased back by the rhinoceros mother, but the furious animal was driven off by shouts and rocks. The lions left the remains of the calf and walked off. In the Ngorongoro Crater a subadult rhinoceros was found killed by lions; he had severe injuries at the throat. Since there were no signs of a fight, one may presume that the lions broke the animal's neck. Although the lions stayed for one day with the dead rhinoceros, they made no attempt to eat it. The next day they moved on.

Usually, however, rhinoceros do not pay any attention to lions, even if the large cats walk closely past them. Once in a while, especially at waterholes, they are killed by other large animals. Guggisberg once watched a rhinoceros about to drink from a clear spring-fed pond in the Tsavo National Park. There a hippopotamus surfaced, grabbed the rhino's right front leg, pulled him down, and tore him to pieces with

his huge tusks. Selous even photographed an adult female rhinoceros that was pulled under water by a crocodile and drowned.

When two black rhinoceros fight with each other, which occurs rarely enough, it is quite a spectacular sight. As a rule, the two opponents are not—as is the case with deer and horned ungulates—two males that are jealous or may be fighting for a territory, but two quarreling females or a female fighting a bull. Sometimes, however, what appears to be a "fight" is actually just play. Our pair of black rhinoceros in the Frankfurt Zoo would often play for hours with horns pressed together. More often the calf will play in this manner with its mother or father. But even in serious fights rhinoceros rarely injure each other. The many wounds at their shoulders and flanks have other causes. There are many hypotheses, and for a while it was believed that they had been caused or enlarged by the pecks from the beaks of the ox peckers.

This is a distinct possibility. Because the rhinoceros are plagued by many parasites which are pulled out by these birds, such crescent-shaped wounds may easily result. J. G. Schillings found extremely thin worms in these wounds which are transferred by a mosquito. The black rhinoceros are also plagued by several other animal parasites. In their stomachs live the larvae of a species of fly which attach themselves by their mandibles to the stomach walls and live off the tissue fluids and blood. As soon as they have metamorphosed, they pass through the anus and pupate in the soil. The large-headed flies which result do not take any food, but stay close to the rhinoceros and deposit their eggs usually near their heads and horns. It is unknown how the larva get from there into the stomach. Besides these parasites, twenty-six different species of ticks were found on the black and square-lipped rhinoceros, in addition to one species of leech and several species of tapeworms. All these rhinoceros parasites are not dangerous to man or domesticated animals. Rhinos in a zoo are usually free of these parasites because there are no intermediate hosts to transfer the parasites in the new environment.

In recent times, procedures were developed that permit the immobilization of large mammals by shooting them with darts containing narcotic or paralyzing drugs (see p. 69). Since that time it has become much easier to capture rhinoceros, to move them to other areas, or to treat injured ones in the wild. Thanks to this method, it was possible in the Amboseli National Park in 1962 to remove the badly injured eye of the famous "Gertie." She recovered tolerably after twenty-four hours.

When a female rhino is in heat, the bull stands opposite to her. The animals sniff at each other's mouths, frequently making gargling sounds. Almost regularly, the female then attacks the bull and butts hard into his flank. The bull tolerates this, even though the butts are



Fig. 2-b.

The fights of rhinoceros are fair duels which are performed according to specific rules. Serious injuries rarely occur, and often these fights are mere play. (Black rhinoceros, *Diceros bicornis*.)

The mating behavior of the African black rhinoceros

sometimes so hard that he has to burp. If a second bull appears, he may dance around her in a circle. But in spite of this, the two males do not fight; the female chooses her favorite. During this part of the courtship, the animals snort, sniff, grunt, or occasionally squeak. I have never heard a loud, penetrating whistle in the wild, such as I heard from our bull in the zoo. Perhaps it expresses surprise. It is possible to attract rhinoceros by imitating the snorting and sniffing.

Black rhinoceros mate throughout the year and can have offspring at all times of the year. Martin Johnson once watched the courtship of a rhinoceros pair from his car at a very close distance. Both animals circled each other with short, stiff-legged steps. After half an hour, the bull smelled the car, snorted with surprise, and stormed into the bushes with his tail erect.

"Of course, we expected the female to do the same," Johnson's report continues. "But this did not happen. It almost seemed as if she had not even seen her mate disappear. Apparently she was quite surprised that his amorous efforts had suddenly ceased. But then she became aware of us and she started her mating behavior all over again, obviously treating our car like a rhinoceros. That a car may suddenly become the object of a rhinoceros female's admiration was quite an unusual experience for us. This new amorous adventure was not restricted to a moment only. The creature tried for fifteen minutes or so to attract the attention of our silent, motionless car. Then she retreated virtuously, and when nothing happened, she stopped, and pranced clumsily. She seductively took a tuft of grass and threw it into the air. She gracefully approached us in a stilted walk, and came even closer than before. Then she smelled our scent. With an angry snort, the animal stopped her flirting. Down came her head, up came her tail, and she headed straight for us; in the next moment she dashed against our fender. Because the clatter of the metal and our yelling were new sounds to the rhino's ears, she snorted once more angrily and then took off in the direction of the salt lick."

The actual copulation we have repeatedly observed here in the Frankfurt Zoo. This event has rarely been observed in the wild. Frank Poppleton describes a bull who stood with the soles of his front feet on the female's back and remained in this position for thirty-five minutes. The animals held their heads parallel and moved slowly forward in a circle. When the bull had dismounted, the female turned to him and the two looked at each other for some minutes. My associate, Dr. Scherpner, observed in Tsavo Park a copulation which lasted 21 to 22 minutes. In 1964 and 1965, John Goddard observed copulating rhinoceros six times in the Ngorongoro Crater. In one instance, the male and the female stayed together for four months after the mating. Two other pairs split up soon after mating, but they were observed courting one month later, and again separated after that.

The first successful  
breeding in a zoo

Mervyn Cowie, the former director of the Kenya National parks, was present when a bull mounted two females in succession within a short time. In the time between he was attacked—as is usual in rhinoceros—by the first female.

Since 1941 the black rhinoceros have reproduced in zoological gardens. It took place for the first time at the Brookfield Zoo in Chicago. The second "black" zoo-rhinoceros was born in Rio de Janeiro. The first one in Europe was born in 1950 in the Frankfurt Zoo. At the Frankfurt birth, 17 liters of amniotic fluid came out first. Our female rhinoceros, "Katharina the Great," was so tame that she could be milked before giving birth. The first distinct signs of labor appeared only one and a half hours before the actual birth. The cow permitted the veterinarian to pull out the baby, which weighed twenty-five kilos. After a few seconds, the ears of the newborn moved. Two minutes later the mother belatedly attacked the assistants present in her stall. Then she smelled at the baby, but she did not lick it.

The development of  
young

The newborn rose to its feet ten minutes later; one hour after birth it was walking around in a lively manner. After four hours, it found the mother's udder and drank. Not until nine and a half hours later did it lay down for one hour. At birth the frontal horn of the young was only a stump one centimeter thick, and the second one was just a white spot. Rhinoceros born in other zoological gardens weighed only twenty kilograms at birth, but one in Hannover was thirty-eight kilograms. So far, twin births have never been observed in rhinos. To the best of my knowledge, until now all black rhinoceros born in zoological gardens could be raised. So far we raised two at the Frankfurt Zoo. In Rio, as well as in Frankfurt, the females were mounted regularly during the gestation period, since they were always kept together with the bulls. Eight days after the birth, our rhinoceros female was again completely tame with the keeper and all persons with whom she was familiar. We could go into her stall, ride on her back, and play with the young.

As early as 1911, the Hungarian explorer Kalman Kittenberger mistakenly killed a furious black rhinoceros which was in the process of giving birth. He opened the dead animal's abdomen and managed to get the young out alive, although it died after eight days. It was only in 1963 that game wardens Malinda and Edy of the Manyara National Park observed the birth of a black rhinoceros in the wild for the first time. They found a female rhinoceros lying on the ground. Taking it for dead, they started to throw rocks at her. When they came closer, they saw the soil around the animal was soaking wet. Within the next few minutes, the rhinoceros suddenly arose; the baby emerged, apparently without causing any difficulty to the mother. After another ten minutes, the calf dropped to the ground. The mother turned around and began to remove the foetal membranes with her lips. Ten minutes

The young nurse for about two years at the mother's two nipples and usually remain with her for three and a half years. If one captures a nursing young rhinoceros, it will become as tame as a domestic animal. In most cases, eight to ten months will pass until the female becomes pregnant again. In Amboseli Park, the first calf stayed with its mother for two and three quarters of a year, the following one three years, and after five years she gave birth to the third one. Black rhinoceros are sexually mature at the age of approximately seven years.

Previously, when a zoological garden kept rhinoceros, they were mostly great Indian rhinoceros. Unfortunately, the great Indian rhinos are now almost extinct, and only a very few may be given to qualified zoos. The first black rhinoceros came to Germany in 1903 to the Berlin Zoo. Now black rhinoceros are the most frequently kept species of rhinoceros in zoos. In 1966, thirty-two of them were kept in zoos in the United States.

The animals usually become very tame in captivity; it is even possible to ride on some adult females' backs. They like being caressed with the palm of the hand over their closed eyes. Probably due to a lack of anything to do, they often rub their horns against concrete walls and iron fences, which reduces them to short stubs. Therefore, a trunk of soft pine wood should be placed in a rhinoceros pen where the animals may rub and polish their horns. They cannot cross a ditch of 1.75 meters in diameter at the upper rim and 1.20 meters of height at the outer wall, even though the inner wall of the ditch is inclined upwards towards the animals. How long they live we only know from zoological gardens. In Brookfield Zoo of Chicago, the breeding pair which came there on May 19, 1935, is still alive (1967). The two animals, who must be by now approximately thirty-three or thirty-four years old, do not show any symptoms of old age. Presumably, rhinoceros may reach an age of about fifty years.

A most impressive animal, which today is found only in a few savannah regions in Africa, is the SQUARE-LIPPED RHINOCEROS (*Ceratotherium simum*; Color plate, p. 37). It is the largest species of rhinoceros. The HRL is 3.6-4 m, the BH (shoulder) is 1.6-2 m, and the weight is approximately 3 tons (in one case approx. 5 t.). There are two horns. A strong shoulder lump, which consists of muscles and epidermal tissues, is not supported by the skeleton. It has wide, almost square-shaped lips that characterize it as a herbivore. Incisors are present only in the embryonic stage; later there are only high crowned premolars and molars:  $\frac{(1) \cdot 0 \cdot 3 \cdot 3}{(1) \cdot 0 \cdot 3 \cdot 3}$ . The gestation period is seventeen to eighteen months; one young is born. There are two subspecies: 1. SOUTHERN SQUARE-LIPPED RHINOCEROS (*Ceratotherium simum simum*). 2. NORTHERN SQUARE-LIPPED RHINOCEROS (*Ceratotherium simum cottoni*).

In place of the lacking incisors, the square-lipped rhinoceros has a

The square-lipped rhinoceros  
by H. G. Klös



Fig. 2-7.  
Former and present distribution of the two subspecies of the square-lipped rhinoceros:  
1. Northern square-lipped rhinoceros (*Ceratotherium simum cottoni*); 2. Southern square-lipped rhinoceros (*Ceratotherium simum simum*). Only in the areas marked with black triangles do square-lipped rhinoceros still exist.

hard, horny edge on the lower lip that facilitates grazing. A too rapid abrasion of the molars by the hard grass which contains silicic acid is prevented, or at least slowed down, by a specific course of development of the teeth. The ridges on the surface of the teeth are especially high and the intermediate space is filled with dentine. Due to this construction, the tooth has achieved extraordinary durability. According to Player and Feely, the square-lipped rhinoceros in Zululand prefer specific grasses like *Urochloa*, *Panicum*, and *Digitaria*.

As in the black rhinoceros, the best developed of the senses is the olfactory. Hearing and vision are rather poor. According to Dieter Backhaus, square-lipped rhinoceros are able to recognize a person, approaching slowly in a favorable wind direction, only at a distance of approximately thirty to thirty-five meters. I found the same to be true in the Umfolozi Preserve. Since square-lipped rhinoceros are much more placid and less aggressive than the black rhinoceros, I could frequently observe them quite easily from a very close distance before they would raise their huge heads, uneasily turn their large ears in all directions, and finally trot away with their tails curled upward. Only once when they were greatly terrified did I see them pull their tails between their hind legs. The light trot of the square-lipped rhinoceros does increase to a considerable speed in situations of danger. Player and Feely report as follows: "The normal type of fast locomotion is an extremely rapid and graceful trot which was measured at a speed of 29 km/hr from a vehicle. When galloping short distances they may attain a speed of 40 km/hr."

The bare skin of the square-lipped rhinoceros, which has only a few bristles at the ear rims and a tail of a dull slate color, is only slightly different from the black rhinoceros. The common name "white rhinoceros" for the square-lipped rhinoceros, therefore, is as confusing as the name "black rhinoceros" is for the other African species. The name probably came from an error in translation; the Boer word *wijde* (wide) was changed, due to a misunderstanding, into the English word white. Furthermore, after the animals have wallowed in the mud, the hot African sun dries it quickly into a crust which covers the body like another skin. Depending upon the soil, these mud crusts are different colors. Therefore it is possible that the name "white rhinoceros" originally was given to animals which had wallowed in a light clay and therefore appeared to be "white."

Like in the black rhinoceros, the anterior horn of the square-lipped rhinoceros may reach a considerable length, while the second horn always remains shorter and bulkier. So far, the record measurement of an anterior horn in the Southern race was, according to Maberly, 1.58 meters. The females' anterior horns often are longer and thinner than those of the males. H. Lang thinks that the frontal horns serve, so to speak, as a bumper: "The horns are carried closely to the ground to



clear the way for the short, column-shaped front legs and the barrel-shaped body. When the animal moves slowly or is grazing, he is constantly nodding his head. It is this abrasion which is the natural cause for the smooth surface of the horns, the flattening of the frontal parts, the wearing out immediately above the base and rear edge of the anterior horn, as well as the frequently found spatula-shape of the second horn. It is not due to the friction during digging and honing against stones." The nose horns, which are rather loosely attached to the skin, represent the weak point in the construction of rhinoceros. The horns, especially long ones, are easily torn off if force is applied. The female square-lipped rhinoceros Kuababa of the Berlin Zoo lost her anterior horn in May, 1963, when she was captured in the Umfolozi Conservation Area. By July, a small elevation became visible on the nose, and in December the length of the horn had reached thirteen centimeters. The new anterior horn kept growing at an average rate of half a centimeter per month. In March, 1967, it had attained a length of 34.5 cm. The behavior of the Northern subspecies has been described in 1959 by Backhaus, and that of the Southern subspecies by Player and Feely in 1960.

In contrast to the black rhinoceros, the square-lipped rhinos are quite sociable animals. One encounters them in smaller groups of sometimes up to eighteen animals, and often an adult bull is with the group. Frequently there are several mothers, each with a small and a subadult calf among them. However, the females with calves will tolerate a bull's presence only until he attempts to mount. As soon as he does this, they will reject him in bitter fights which can result in the death of the bull. The bull, however, will not tolerate a calf very close to him. Therefore, a young accompanied by a female in heat is continuously in danger of being killed by the furious bull. If such a group is alarmed, all animals stand in a circle with their behinds together so that the heads, armed with horns, point outward in all directions.

The individual home ranges are marked with urine by the bulls. The animal sprays the urine backwards with explosive force in two or three jets so that the bushes or grass in the area are covered with small white drops. A strange crescent-shaped drag-spoor described by Hediger in 1915 and by Backhaus in 1959 may also be a part of the marking behavior. Furthermore, the sometimes very high dung heaps, which are frequently found along the various paths of the square-lipped rhinoceros, are quite conspicuous. Apparently, the sight of such a dung heap irresistibly stimulates the square-lipped rhinoceros to defecate. After defecation, the animal makes scratching movements with the hind legs.

The daily activities of the square-lipped rhinoceros seem to depend to a great extent on the weather. In the hot sun these savannah animals

The square-lipped rhinoceros live gregariously

#### Reproduction

retreat into the shade, reappearing only at dawn in the open pastures. They also seek shelter in the bushes from rain or when it is cool. A long period of the day is spent grazing by the rhinos; frequently they graze the whole night long. Like all species of rhinoceros they need wallows for their well-being. Frequently, they first drink at the wallows and then they spend a long time, sometimes even during the night, resting in the mud. Player describes the frequently visited wallows in the Umfolozi Preserve where turtles await the arrival of the rhinoceros, eager to take off their ticks; this agrees with the observations of the black rhinoceros. During the winter, the square-lipped rhinoceros likes to take a sand bath, which takes the place of the summer mud wallow.

So far there is very little known about the reproduction of the square-lipped rhinoceros. There are hardly any observations from the wild. In captivity, only one birth is known. In June 1967, a female square-lipped rhinoceros, which was pregnant when captured, gave birth to a calf in the zoo at Pretoria (South Africa). According to Owen Smith, these large rhinos are fully grown at the age of seven to ten years. While the mating season is usually from July until September, females in heat have been observed at other times of the year. Then the males have bitter fights which may end with the death of one of the opponents. Foster observed a pregnant female rhinoceros over an extended period of time in the Umfolozi Preserve. She could be distinguished by her conspicuous horn, and he estimated her gestation period to be eighteen months (547 days). Usually one young is born, although according to Maberly, there have also been twins. Twenty-four hours after birth the young is able to follow the mother around. It seems to maintain no fixed position with respect to her as it follows its mother, except when it is in danger. Then it is always ahead of the mother, apparently guided by her horn and mouth. At the age of one week, it begins to eat grass, although it usually continues to nurse for another year. Probably an adult square-lipped rhinoceros female may give birth to a calf every two and a half to three and a half years.

#### Former distribution and extermination

Formerly, square-lipped rhinoceros occurred in many parts of Africa. Their former range can be reconstructed only with difficulty from the cave drawings and reports of the first European settlers, hunters, and explorers. The most Northern subspecies lived in the area from Southwestern Sudan through Uganda of the Central African Republic. The habitat of the Southern subspecies reached from the Orange River in the South up to the Zambesi in the North, and from the coast of the Indian Ocean in the East to the Damara country and the Kalahari Desert in the West. In 1785 the great French naturalist Buffon thought that the rhinoceros feared neither "the steel nor the fire of the hunter." But in the nineteenth century, when the days of the European hunters in Africa began, it was shown how inappropriate

Buffon's remarks were. It is shocking to read the contemporary reports on the deaths of the southern square-lipped rhinoceros. For example, Charles J. Anderson wrote in 1858: "In South Africa a large number of rhinoceros are being killed every year. One may get a good idea of the quantity when one hears that Oswell and Vardon killed no less than eighty-nine of them during one year. During my sojourn, I myself killed almost one third of this number."

By 1892, only seventy-five years after its first discovery by the explorer Burchell, the southern square-lipped rhinoceros was considered to be extinct. Fortunately, this was incorrect since a small number of the gray giants had survived in Natal in the valley of the Umfolozi River. It is to the great merit of the South African government that it made this last refuge of the square-lipped rhinoceros into a preserve as early as 1897.

At about the same time, in 1900, Major Gibbons discovered near Lado at the Upper Nile that, besides the moribund southern square-lipped rhinoceros, there existed another northern subspecies. In the Umfolozi Preserve, the population increased steadily owing to the excellent protection it received. In 1930, according to official estimates, there had been only thirty animals, but by 1966 their number had increased to nine hundred and fifty. In contrast, the population of the northern subspecies did not show such an even increase because their habitat covers several African nations. The population in the Central African Republic consists, at most, of ten animals. In the Congo in 1963 about one thousand square-lipped rhinoceros still lived; according to Curry Lindahl, only about one hundred have survived the revolution and the following civil war. In 1928 in Uganda, there were about one hundred thirty square-lipped rhinoceros. Their number increased to three hundred animals in 1951, but in 1962 it was down to only eighty head. The estimates for the Sudan diverge greatly; some informants speak of only a few hundred, while others talk about two thousand. In this case, the second number seems more probable because of the strict laws for their protection.

The Umfolozi Preserve in Natal is two hundred and eighty-eight square kilometers in size, with hilly savannahs between the White and the Black Umfolozi Rivers. During the last few years, the number of square-lipped rhinoceros has increased to such an extent that this preserve has become overpopulated. This increased the danger of epidemics, and the pasture became more and more scarce. Therefore, it was decided to give some of the animals to other preserves and national parks as well as to zoological gardens under scientific supervision. With "Action White Rhinoceros," another interesting chapter began in the exciting history of the square-lipped rhinoceros.

With the development of the capture gun, the catching of large mammals has become easier and less cruel to the animals. Pre-

The discovery of the northern subspecies

In the Umfolozi Preserve

Rhinoceros being resettled

viously, large mammals were captured at great cost in pits or with ropes, causing many casualties; today many of them are shot with a specially constructed gun loaded with an injection-cartridge. The cartridge, when it hits the animal's body, discharges the drug and thus anesthetizes the animal. Of course, the anesthetic in use has to meet certain standards and must be safe within a wide limit. Often it is difficult to estimate the correct weight of an animal in the wild. Therefore, a drug is needed which is equally effective with animals of different weights. The effect should be immediate, before the animal can retreat into the dense brush after being shot with the dart. Furthermore, one must be able to give an antidote afterwards which neutralizes the drug's effect. However, the animal should also be able to recover without an antidote, in case it cannot be found. The answer to all these questions is a compound developed by A. M. Harthoorn which has been tested with good results on the square-lipped rhinoceros of the Umfolozi Preserve.

In spite of all these techniques and precautions, the capturing of one of these colossi is still an adventure full of breath-taking suspense. Landrovers, trucks with boxes, and riding horses take off early in the morning for the capture. As soon as a suitable rhinoceros is tracked down in the yellow glow of the savannahs, the marksman approaches the unsuspecting animal step by step against the wind. Every cover is taken advantage of until the distance between the rhinoceros and the marksman is only a few meters. Then he fires the shot, and the animal immediately jumps onto its feet and takes off with incredible speed. Now the men must follow on their agile horses. There is no time left for reflection and cautious looking for trails. They break through brush, jump over ditches, and cause clouds of ants to pour down from the whistling acacias. Even though the horses eventually learn the hard way to avoid the holes of wart hogs, herds of cape buffalo, and thorn bush, often horse and rider still lose shreds of skin in this wild chase.

Finally, after eight or ten minutes, the anesthesia takes effect. The rhinoceros slows down, stands still, staggers, and then lies down. The riders inform their fellows with the truck. The truck comes and the transport box is unloaded. The motionless rhinoceros is given a small injection of the antidote into the vein of the ear. It arises as if on command and can then be led into the box. Ian Player, the supervisor of the Natal Game Reserves, reports: "In areas which the truck could not reach, a small dosage of the antidote was enough to make the animal move. Then it could be led to the truck. Once an adult rhinoceros was led in this manner over a distance of two miles, much to the surprise of the tourists and some native women." The procedures of capture were later modified. Now the marksman drives with the landrover right up to the rhinoceros. In Uganda even a helicopter was used for

the capture. Later, in the camp, the animals are carefully familiarized with the closeness of people and substitute foods. With this procedure, it has been possible since 1962 to send forty-two "white" rhinoceros to twenty-five different zoological gardens throughout the world. (The first square-lipped rhinoceros who were captured without capture guns were in the zoos of Pretoria, Antwerp, London, Washington, and St. Louis.) Furthermore, it was possible to transfer about one hundred and fifty square-lipped rhinoceros to several other protected areas in the South African Republic, Rhodesia, and Uganda. After this success, the square-lipped rhinoceros was removed from the list of species threatened with extinction in 1966.

With "Action White Rhinoceros," it became possible to bridge the time when, in C. Harris' words, "out of each bush looked the ugly head of such a creature" and the present where the square-lipped rhinoceros, after the most dire threat to its survival, has at last regained its foothold in Africa. We hope sincerely that the cruel decades of its extermination belong irrevocably to the past.

Bernhard Grzimek  
Heinz-Georg Klös  
Ernst M. Lang  
Erich Thenius

Distinguishing  
characteristics

### 3 The Even-toed Ungulates

Those extremities of the mammals which originally had five digits and five toes have undergone many and varied changes during phylogeny in the different orders. In the large group called "ungulates," the hoofed animals, such changes led to a better adaptation for walking in almost all cases, while the ability to climb and to grasp gradually disappeared in these animals. For running purposes, the greatest possible simplification of the "component parts" is of utmost advantage (see Vol. XII, "Odd-toed Ungulates"). With the increasing adaptation to walking and running, the significance of the inner and outer digits and toes decreases. The weight of the body is increasingly shifted to the center digits and toes, while superfluous parts of the skeleton finally disappear completely.

However, while in the odd-toed ungulates the center digit and the center toe mainly carry the weight of the body, in the even-toed ungulates this weight is carried by the third and fourth digits and toes. The second and the fifth ones are reduced, but they still are well developed in the hippopotamus. In most of the other even-toed ungulates, they are more or less well developed as "pseudo-toes" which no longer touch the ground or do so only on very soft ground. In camels and giraffes, they have completely disappeared. The first digit and the first toe are lacking in all contemporary even-toed ungulates.

EVEN-TOED UNGULATES (order Artiodactyla): They range in size from small to very large. The HRL is 40 cm (mouse deer) to 400 cm (hippopotamus, giraffe). The BH is from 20 cm in the mouse deer to 330 cm in the giraffe. The weight is 2 kg in the mouse deer to 3200 kg for the hippopotamus. The shape of the body greatly varies. The third and fourth digit and toe are enlarged, carrying the hoof. The second and fifth digits in the hippopotamuses are weaker (carrying the hoof), while in pigs, deer, pronghorns, and horned ungulates they are rudimentary (with or without pseudo-toes). In camels and giraffes, they are completely lacking; the first digit is always lacking.