THE LIFE OF MAMMALS

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Frontispiece: a young orangutan, Sumatra

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CONTENTS

at the edge of a forest river. They are unmistakable. There are four toes on the front feet and three on the back. Even in the muddy ground away from the rivers, the prints are easy to identify. But the animal itself, in spite of being by far the biggest inhabitant of these rain forests, is surprisingly difficult to detect in the shady gloom.

You may first become aware of its presence, as it stands quietly feeding maybe twenty yards away, when you hear the snap and rustle of leaves being plucked. The animal is likely to be by itself, unless it is a mature female in which case it may be accompanied by its calf. The youngster will be even more difficult to spot, for if it is within a few weeks of being born it will have a coat dappled with alternating stripes and spots that conceals it very effectively.

There are three species of tapir in South and Central America. There is a fourth in South-East Asia which is known as the Malayan tapir, though it is also found in Sumatra to the south and Thailand and Burma to the north. Until quite recently it also lived in Borneo. It differs from its South American cousins chiefly in its colour, for while the front part of its body and its hind legs are black, its rear half is greyish white, a strange piebald coloration that is said to help the animal's concealment by breaking up its outline.

The forests of South-east Asia are also inhabited by another forest browser with a very ancient history. Today its main stronghold is Sumatra, but there are relict populations in Borneo, the Malay peninsula and perhaps Burma. Like the tapirs, it is donkey-sized and has a reduced number of toes, three on both front and back legs. It is the hairy rhinoceros. Only about three hundred still exist today. It seems likely that it digests its food in much the same way as the tapir does.

But one group of early browsers in the first forests, the chevrotains, evolved a more complex and efficient digestive apparatus. There are two species, one smaller than the other in the South-east Asian forests. There is a third, the water chevrotain in West Africa, and a fourth in India. Such a wide distribution is a strong indication of the chevrotains' antiquity, suggesting that they appeared at a time when tropical forests were more continuous than they are today.

Chevrotains stand about a foot high and have pencil-thin legs, large lustrous eyes and small ears. Like the forest rhino and tapirs, they are largely solitary creatures though the males when they encounter one another may fight. Although they are sometimes called mouse-deer, they do not have antlers. Their only offensive weapons are two teeth, one on either side of the upper jaw, that are enlarged into short tusks. Being so small, and feebly armed, they are an easy meal for leopards or pythons, so unlike tapirs and the hairy rhinos, they do not amble

Brazilian tapir South America ▷
Malayan tapir and calf ▷

nonchalantly through the forest browsing in an unhurried confident way. Instead, they feed quickly, collecting fallen fruit and leaves from low bushes and swallowing them immediately. They then retire to a secluded hiding place and deploy the technique that, it seems, they were the first to pioneer. They ruminate.

Small lumps of their hastily gathered meals are retrieved from a front compartment of their stomach where they had been stored and brought back up the throat, one at a time, to be given a second more intensive chewing with the back molars. That done, the chevrotain swallows the lump again. This time it continues past the first chamber of the stomach and into a second where it is fermented in a bacterial broth. It is a technique that today is used by many species of leaf-eating mammals.

The broad-leaved forests first developed in places where there was an abundance of rain and still today most require plenty of water at least during some part

△ *Hairy rhinoceros, Sumatra*

of the year if they are to maintain their hold. Around thirty million years ago they were more widespread than they are now. But then there was a steady cooling of the climate. Patterns of rainfall changed and wide expanses of the land became less well-watered. This gave the chance for a relatively new kind of plant to come into its own – grass. Slowly a green carpet spread across these ill-watered lands and some mammals ventured out of the forests in order to graze upon it.

Many rodents that had gnawed seeds and roots and leaf buds in the forest, moved out on to the plains and became grass-eaters. Rabbits ventured out as well. They were once classified as rodents but they differ in several important respects, one being that alongside the two large chisel-shaped teeth at the front of the mouth that are a rodent characteristic, they have two smaller teeth, one on each side of the large pair. That is enough to award them a group to themselves and to call them lagomorphs. However, it seems that whether the

Chevrotain, South-east Asia △

relationship between the two groups is close or remote, rodents and lagomorphs share the same none-too-distant ancestors.

Rabbits have their own particular way of digesting leaves. They eat their own droppings. As they doze in their burrows at night, they excrete black sticky pellets, but as soon as these emerge from the anus, the rabbit turns round, takes them into its mouth and swallows them. Back in its stomach the pellets are given a second digestive processing. What is left after this is then voided a few hours later when the rabbits are feeding outside their burrows, as the round dry pellets that you see littering the ground in a rabbit warren.

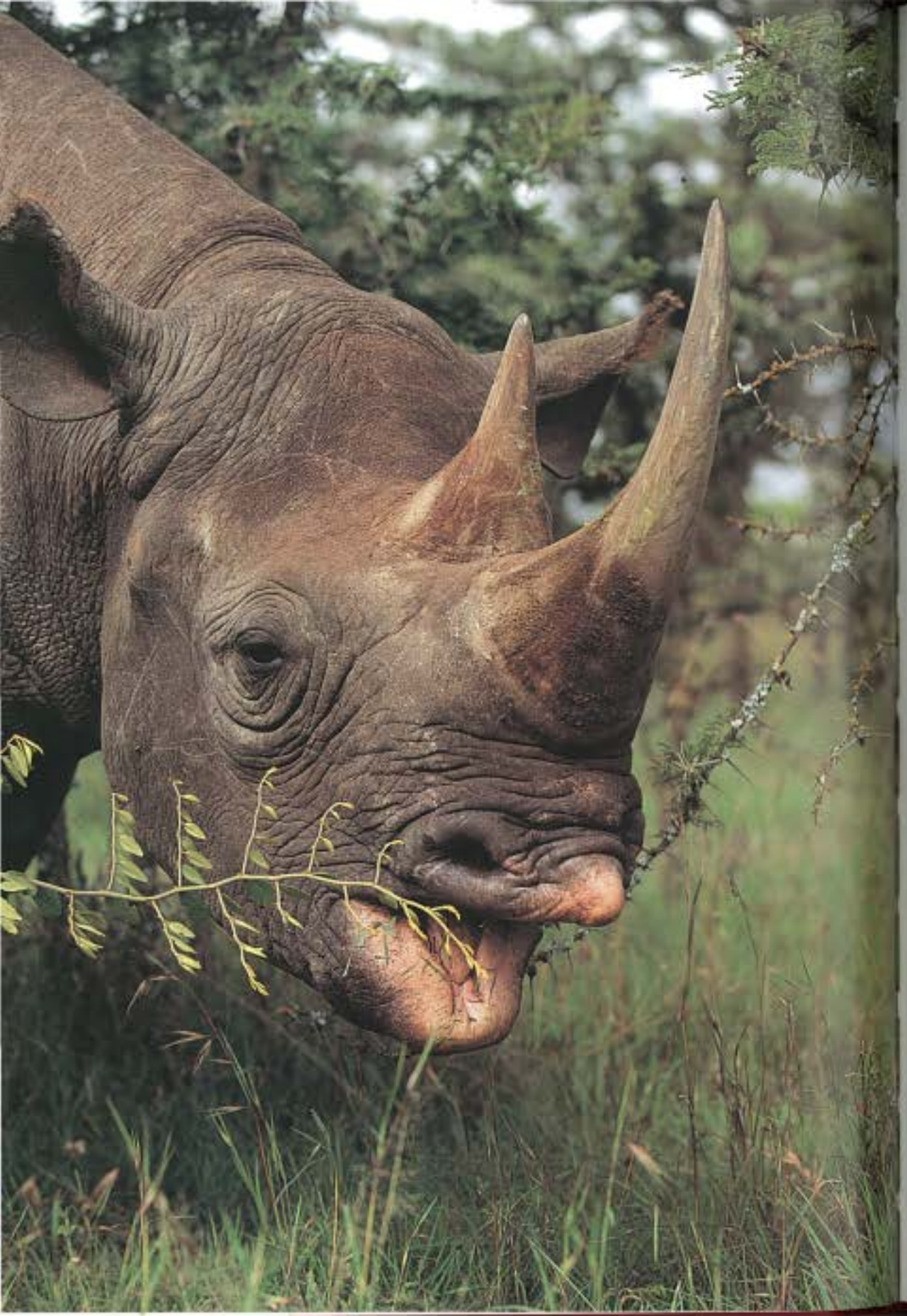
But it was not only leaf-eaters that ventured out of the forests on to the newly established grasslands. Hunting mammals – cats and dogs, both big and small – followed them. Hawks and eagles flew out from their nests in forest trees to patrol the skies above. Out on the open plains, there were far fewer places for leaf-eaters to shelter than there had been in the forest.

Rabbits, voles and ground squirrels were able to create hiding places for

△ *Columbian ground squirrel, Canada*

themselves. They excavated burrows and flourished in vast numbers. Prairie dogs – which, in spite of their name are not dogs but sizeable ground squirrels form immense towns. One such in Texas, years ago, was said to cover 64,000 square kilometres and contain 400 million inhabitants. The biggest of these plains-living rodents is the South American viscacha, a cousin of the forest-living nut-burying agouti. It looks like an immense guinea pig, over two feet long, with a broad black band that runs across its nose from cheek to cheek like a grotesque moustache. The tunnels it excavates are so big that you can stand in the entrance of one up to your waist. They live in large colonies, underground cities with dozens of entrances and hundreds of yards of interconnecting passages. On the surface of the ground, in the centre of these huge warrens, there are usually several untidy heaps of stones. These were lugged to the surface by the viscachas during their burrowing operations and laboriously dragged into piles. Why is not certain. The viscachas, however, are certainly

Viscachas, Argentina ▷



compulsive collectors. If you lose something when out riding in viscacha country, the place to look for it is in the piles on the top of the nearest *viscacheria*.

Some leaf-eaters that moved out on to the plains, however, were altogether too big to find safety in holes. They had to protect themselves in a different way. Some did so by becoming even bigger. The small forest rhinoceroses grew into two-ton monsters with skins so tough that even the claws of a lion or a tiger can make little impression on them. In India, the one-horned rhino developed a skin so thick it is pleated into joints to allow the body within a little movement. On the African savannahs, two different kinds of rhinos evolved, the black and the so-called white. In fact the two species are very similar in colour but the white owes its name to a misunderstanding of the Afrikaans name 'weit'. This refers to the animals 'wide' upper lip, which is very different from that of the slightly smaller black rhino, whose upper lip is prolonged into a mobile point. Well able to take care of themselves and with a need to wander widely in search of the great quantities of grass they must have to sustain their immense bulk, adult rhinos are largely solitary animals. They are also extremely intolerant of company and not only readily charge an approaching human being but one another. Almost a third of female black rhinos and a half of the males die from wounds.

Another giant has taken to the rivers. The hippopotamus is not perhaps immediately thought of as an eater of grass, since its spends all its days in water, but in fact it lives on little else. At night, it clambers out of the river, usually along well-defined and long-established paths and comes up to feed on the plain. Smooth green lawns beside a gently flowing river may look idyllic camp sites, but in Africa it may be very ill-advised to pitch a tent on them if a quick inspection reveals a muddy well-trodden gap in the river bank and large droppings on the grass.

The hippos do not use their teeth like conventional grazers. Instead they nip the grass with their huge leathery lips, ripping up the leaves with sways of the head. They may walk for a couple of miles away from the river and enterprising individuals may even spend a day in a distant mud wallow so that they can feed on pastures even farther away the following night. Most however, return to the river by daybreak.

Life in the water has brought considerable changes to the hippo body. Their eyes, ears and nostrils are placed high on the head so that they can see, hear and smell what is going on above the surface while remaining totally submerged except for the very top of their heads. They do not have any sweat glands to

◁ *Black rhinoceros, Kenya*

Swimming hippopotamus, Kenya ▷▷

help cool their bodies. The river water does that for them. They have also lost virtually all their hair. Hair does not function as an insulator in water and in any case a hippo is in little danger of getting seriously chilled there or even out on land at night. The absence of hair risks a back getting sunburnt during the day. The hippo's skin, however, is protected in a different way – with a kind of sun cream. Numerous glands in its skin produce a mucus that turns a reddish brown on exposure to air. Even so, their naked skin is very permeable and loses liquid so easily and quickly that a hippo out of water in the sunshine rapidly becomes seriously dehydrated. As a consequence almost the only time a hippo will venture out of water during the day is when it is raining.

The hippo's front teeth, no longer used for collecting grass, have become adapted instead for display and for fighting. The males threaten one another by yawning, opening their mouths to an alarming degree and showing off the great yellowing tusks on either side of their jaws. If such threats are not enough to settle an argument, rival males will fight, stabbing at one another with their front incisors which may become badly chipped in the process.

Why hippos should have taken to this amphibious existence can only be a guess. It can hardly have been to escape enemies, for lions, the only land predators that animals of their size need fear, are more active at night than they are during the day. In any case, rivers harbour predators and crocodiles can and do attack young hippo calves.

Perhaps it was the easy life that enticed hippos into the river. Lazing around in tepid water does not demand a great expenditure of energy. The water, after all, supports the huge body and only slight movements are needed to move from one place to another if there should be any need to do so – which there is not for most of the time. With such few demands on one's energy, there is no need for huge meals and indeed a hippo has a surprisingly small appetite for an animal that may weigh up to three tons.

Size is, in itself, an advantage to a grass eater. The longer a leaf-eater can keep a meal in its stomach the better chance it has of digesting it properly. The longer it is kept, the bigger the storage vat required and the bigger the frame that is needed to carry such a large container. So there is a tendency among vegetarians to grow large.

The elephant has taken this trend to extremes and has a particular need to, for its food consists not only of leaves but on occasion coarse woody twigs that require a very long time indeed to be processed. Its ancestors, some believe, came not from the forests but from the rivers. They were somewhat pig-like in shape

and the size of a small hippopotamus. When they emerged and started to graze on the plains they became very big indeed. Their stomachs are so large they can retain their meals for a very long time. Our own food takes about twenty-four hours to pass through our bodies. An elephant's takes two and a half days.

North America developed its own particular group of grazers. One was a creature about the size of a hare. It had four toes on its fore legs but only two on its back. Its descendants grew steadily bigger, diversified with several different species and eventually spread both westwards across the land bridge to Asia and also southwards along the Panamanian land link that led to South America. They all had long necks, relatively small heads, a cleft upper lip and only two toes on their front legs as well as their hind. Eventually, around ten thousand years ago, the North American species became extinct, but their descendants elsewhere still flourish.

The Asiatic branch of the family are the camels. They have become adapted to living in desert conditions. They can close their nostrils to keep out sand during sandstorms. They will eat the driest thorniest vegetation that no other animal will touch and they can store food as fat in the humps on their backs that sustain them during long periods of famine. They have also modified the physiological workings of their bodies so that they can exist on a minimum of water. Their droppings are extremely dry and their urine very concentrated. They can allow the temperatures of their bodies to rise to heights that few other mammals can tolerate and so do not have to expend precious liquid on sweat until cooling in that way becomes absolutely necessary. As a consequence of all these adaptations, they can live for two months without drinking. When at last they do reach water, they are able to take up thirty gallons at a single sitting.

Such stalwart creatures can survive in the harshest deserts and human beings when they encountered them were quick to domesticate them. Using them as carriers of food and water, people were able to make journeys across deserts that none could have made unaided. This domestication took place around four thousand years ago, so long ago in fact that it was assumed that no wild Asiatic camels still existed. In 1878, however, a Russian explorer, Przewalski discovered some camels in the deserts of Lop-nur in what is now far western China, north of Tibet. They were smaller than domesticated camels, a rather paler brown in colour with two relatively small conical humps on their backs. He believed that they were truly wild animals. Their descendants still survive and genetic studies have now confirmed that these are indeed wild stock.

Another species of camel, known as the dromedary, lives in Arabia. This has

Wild Asiatic camels, Mongolia ▷▷

only one hump and has become specifically adapted to the baking heat of these more southerly deserts. It too was domesticated at a very early date, put by some specialists as being six thousand years ago, but no wild stock can now be found.

The South American descendants of those ancestral North American camels also were domesticated at a very early date. They have become the traditional beasts of burden in the Andes – llamas and the longer-haired alpacas. But neither of these creatures exist in the wild. Both are thought to be the result of many centuries for domesticated breeding, though exactly what their lineage may be is disputed. There are however two wild forms that still survive, the guanaco which is brown with white underparts and the vicuna which is smaller, paler in colour and particularly graceful.

The plains of North America, fifty million years ago, were also grazed by another small herbivore. A distant relation of the ancestral rhinos, it walked, like them, on three toes. It found safety from the carnivores of the time – huge wolf-like dogs and sabre-toothed cats – in speed. The longer your legs in proportion to your body, the bigger your stride and the faster you can run. This animal's central toe became elongated and its nail thickened into a hoof. The other two toes on either side became shorter. It was the ancestral horse.

Horses first appeared in North America. As the grasslands spread, so these animals colonised them and evolved into bigger and more varied forms. During this time, a land bridge existed between North America and Asia across what is now the Bering Strait. The increasingly successful horses crossed it and spread across Asia and into Europe. Prehistoric man twenty-five thousand years ago hunted them and drew pictures of them on the walls of caves. They are believed to be the ancestors of all domesticated horses. Great herds of them survived into recent times. The Russian explorer, Przewalski, who discovered the wild camels, also found small herds of wild horses in central Asia and the species was given his name. But by this time, they had been hunted so intensively that few were left. By the beginning of the twentieth century, all wild specimens seemed to have disappeared totally. But some survived in zoos and their offspring are now being released in their former lands in the hope of preventing the species from disappearing altogether.

But other species of horses continued the family's spread from Europe down into the Middle East and into Africa. Donkeys managed to find enough to eat in dry stony country, and zebras flourished on the more fertile open savannahs of Africa. Why zebras should have developed stripes is something of a mystery. The old suggestion that the conspicuous black and white patterns help to break up the

animal's profile and so assist in making it less conspicuous is no longer thought to be true. Anyone travelling in Africa who gazes at a herd of zebra on the horizon will find it hard to believe that the theory can ever have been thought credible. Even half a mile away the animals are very conspicuous indeed and certainly much more so than the sandy, tawny coloured lions that may be crouched invisibly in the thicker grass, stalking them. Nor, when you see a lion breaking cover and leaping on to a galloping zebra's haunches, can you believe that the stripes in any way dazzle the hunter. Another suggestion has been made that the alternate bands of black and white absorb heat in a different way and so create faint currents in the air that help to keep the animal cool. One function, however, has been demonstrated. The stripes, which vary significantly from one animal to another, certainly serve to identify an individual to other members in its group.

Zebras and horses have their own solution to the problem of digesting grass. They do not retain their meals in their stomachs for great lengths of time like rhinos, nor do they eat their droppings like rabbits. Instead, they have developed an extremely long addition to their hind-gut, called the caecum, which

Przewalski's horse, relocated in the Cévennes, France △

significantly increases the length of time taken for their food to pass through their bodies.

The most successful of all the large grass-eaters, however, belong to a different group altogether. They are cousins of the forest-living chevrotains. The evidence of this relationship can be seen in their toes. Chevrotains have only two functioning toes on each foot, though the African species has two much reduced digits on either side of each leg that do not touch the ground. Their plains-living descendants are similarly two toed. These are the cloven-hoofed grass-eaters – deer and cattle, antelopes and gazelles. And they too, like the chevrotains, ruminate in order to digest their meals of leaves.

The lengthening of legs and the reduction in the numbers of toes brought the same benefit to these cloven-hoofed animals as it did to the horses. It enabled them to run at speed, an invaluable talent on the open plains. They also adopted the other safety measure of living in herds. An animal by itself on the African savannahs, is an obvious target for a stalking lion. It has only its own eyes and ears to detect approaching danger. If, however, it feeds in the company of a dozen or more others, there will always be one animal with its head raised and its ears cocked ready to spot a lion before it gets close enough to launch an attack. And if and when that lion does charge, there are so many fleeing bodies that the chances of one particular animal being picked out as prey are much smaller than if the animal was by itself.

Living in big groups, however, complicates an animal's social life. A zebra stallion has to compete with other males if he is to father foals. And a zebra mare may see many alternative males in the herd from whom she might select a mate. She is only sexually receptive for a short period each year. As that time approaches a plains zebra stallion does his best to gather as many mares as possible around him so that he can keep his eye on them – or to be more precise, his nose, for he can tell by the smell of their urine when that important moment is about to arrive. While waiting, he has to chase away any other young stallion who might have similar ambitions. He issues fair warning to young hopefuls approaching his group of mares by wrinkling his lip and exposing his formidable teeth. If an intruding male persists, then there will be a fight. The two circle trying to bite each other's legs. If neither is intimidated, they start to slam one another with their necks. They try to bite and kick. Flanks may be gashed and ears torn. Eventually one – usually the intruder – will back off and gallop away, leaving the victor to claim his prize.

Gazelles have similar mating problems but their battles have become more

◁ *Zebra males fighting, Kenya*

ritualised, more influenced by appearance and gesture and less determined by physical violence. Horns can certainly be used as weapons, but their size and shape are also a good guide to an individual's health and strength. Contests between gazelles, therefore, can be settled economically, without the gross expenditure of any energy and no risk of injury.

A male impala guarding a group of females displays his weaponry by parading up and down with his head erect, his ears held back and his tail clamped firmly down. The mere sight of his gracefully curving horns may well be enough to convince rivals of his superior strength. If, however, another male decides to contest this, he will give notice by raising his tail, showing its pale underside, yawning and flicking his tongue. He then lowers his head inviting battle. The rivals will then go through all the movements of a fight, facing one another head-on, advancing and retreating – but without actually touching one another. Once again, there is an opportunity for one or the other to back down. If both persist, then a third round of the contest begins. Now the two do actually meet and lock horns. Back and forth they push one another. They separate and re-engage, and stab at one another's necks. But blood is seldom shed. One

△ *Zebra male threatening, Kenya*

contestant eventually retreats leaving the victor stalking stiffly around, flaunting his horns with head held high.

It is not only a male's rivals who assess the quality of his horns. So do the females. They, after all, also have a choice in these matters and there is increasing evidence that a female impala will choose to graze beside the male that has the most symmetrical and well-developed regalia on his head.

Females of different kinds of antelope developed different predilections. Each species has horns of a shape that is as characteristic of its kind as is the different coloured plumage of a bird. So horns – straight as rapiers, backwardly curved like scimitars, ridged by spirals or with tips tilted vertically upwards – proclaim not only health and strength, but specific identity.

Horns are bony outgrowths of the skull that are capped with keratin, the same material that forms hooves and our own finger nails. Once they have developed, a male antelope retains them for the rest of his life. But inevitably, as they increase in size with age, they become a heavier burden.

The other great group of cloven-hoofed grass-eaters, the deer, manage to avoid such permanent loads – at least to some extent. They only flaunt the

Impala males fighting, Kenya △

badges of fitness on their heads for part of the year. During the winter, a red deer stag is without any encumbering headgear as he searches the meagre vegetation for food. This is no time to be carrying unnecessary strength-sapping weight. But as spring comes and summer follows, so the stags become better fed and have energy to spare. A pair of bumps appears on their forehead. These grow rapidly upwards, nourished by blood vessels in the skin that covers them. The pillars begin to branch. The older and bigger the individual, the more branches his antlers will develop. Swift though growth is, it nonetheless takes four to five months before antlers are fully developed. Then the skin that covers them begins to split and shrivel until it hangs in tatters from the new white bone of the antlers, often staining them red with blood. The newly crowned males then clean their antlers by knocking them against trees or thrashing them on the ground, preparing them for display and, if necessary, battle.

The contests between male deer are just as ritualised as those between antelopes and the size of antlers is just as influential in the eyes of both males and females. But then, after the jousts of autumn, their function is over for the year. They weaken around their base and drop off. In American species, this happens in early winter, but in Europe deer may well keep their antlers throughout the winter and beyond, so that within a few weeks of shedding them in spring, they start growing them again.

So eating grass can lead, indirectly, to great social complexities. It can also, in some instances, compel animals to make journeys that are fraught with danger. Many kinds of grass are markedly poor in minerals and grazers must necessarily make good such deficiencies. Mountain goats in Montana climb up sheer cliffs to reach salt licks. In the Upper Amazon, brocket deer wade bravely into quicksands, all the time pumping their fore legs to keep themselves above the surface, in order to reach mineral rich water welling up from the depths. And in Africa, buffalo climb up the slopes of Mount Kenya to altitudes of over nine thousand feet in order to dig out particularly salty iron-rich clay with their horns.

But perhaps the most impressive example of the lengths to which grass-eaters will go to obtain minerals is shown by the elephants of Mount Elgon in Kenya. In one place, on the flanks of this immense extinct volcano there are volcanic deposits that contain abundant salts. Elephants for centuries have visited a cave here. They boldly walk into its depths, along a passage so long and winding that no natural light reaches far into it. In any case, the

◁ *Red deer roaring in rut, Great Britain*

elephants usually visit the cave at night so that even a few yards beyond its mouth the blackness is total.

We installed tiny infra-red lights that to the unaided eye look no brighter than a glowing cigarette end, and watched the animals on specially sensitive electronic cameras. They move through the blackness with the greatest caution. They test each footstep, feeling carefully for a foothold, stepping over huge boulders the position of which they seem to remember from past visits. Eventually they reach the rock face at the far end. Here they use their tusks to gouge out the coarse sandy rock and then pick up lumps of it from the ground at their feet with their trunks and crunch it with their huge molars. Elephant calves usually stay close to their mothers and so they too walk deep into the caves. They do not seem to have acquired the taste for salt and soon become bored in the pitch darkness. You can watch them fumbling around, playing with boulders that they can only feel but cannot see. But it is important that they make the journey, so that they will learn the route into the cave and be able to maintain the tradition. Judging from the depth of the cave, the Mount Elgon elephants must have been collecting minerals from this site for centuries. Indeed, it may well be that these huge caves were actually created by the elephants themselves as, generation after

△ *Elephants tusking for salt in the caves of Mount Elgon, Kenya*

generation, they dug deeper and deeper into the cliff, following the seam that was particularly rich in the minerals they need so badly.

The need for particular minerals is also the fundamental cause of one of the most spectacular of all animal movements, the annual migration of the wildebeest in east Africa. The herds spend the wet season down on the plains of the south-eastern Serengeti in Tanzania. The soils here are volcanic and rich in minerals, but towards the end of May, the rains begin to fail. The grass begins to wither and water holes to dry. The wildebeest herds now start to move away, plodding or gently cantering one behind the other in long columns. They travel north and cross the Mara River into the Masai Mara plains of southern Kenya. Here patchy showers of rain have produced areas of tall grass and there is water to drink from the rivers. But then some time towards the end of the year, just as the rains begin again, the wildebeest start to leave. In vast jostling numbers they surge back across the Mara river. Giant crocodiles, lying in wait for them, take hundreds, but tens of thousands complete the crossing. Why should they leave, when the grass is springing once more on the plains of the Mara? It is because these pastures are severely deficient in phosphorus. That precious and essential mineral they can only find in the newly sprouting

Wildebeest attacked by a crocodile, Tanzania △

Wildebeest crossing the Mara river, Kenya ▷▷

grass of the Serengeti that they were forced to leave when it started to wither six months earlier.

Dietary inadequacies, coupled with seasonal changes in the weather also cause major problems to caribou. During the summer, the caribou of north-western Canada and Alaska, not far from the continent's northern coast, feed on a wide variety of broad-leaved plants including cotton grass and low dwarf willow. Here the females give birth. But when the weather gets even colder with the coming of the autumn, many of these plants shed their leaves. Even those that keep their leaves become buried beneath snow. The caribou can no longer stay out on the open tundra and they start on a long journey southwards to areas where patches of coniferous forest offer some shelter from the biting winds and blizzards. The journey is several hundred miles long and may take weeks. The animals move slowly, around two miles an hour, and often in single file feeding when they can and travelling both day and night. How far they move in twenty-four hours varies according to snow conditions. Sometimes it may be as much as thirty miles, sometimes only a tenth of that distance. They follow regular pathways, but blizzards and deep snow drifts may

◁ *Wildebeest on migration, Tanzania*

Migrating caribou, Alaska △
Caribou crossing a lake, Canada ▷▷

here and there compel them to vary their route. But at length, they reach their winter feeding grounds.

Here they will stay for several months. The food, however, is poor, consisting largely of a kind of lichen, known inaccurately as reindeer 'moss', that grows over the rocks. To reach it, the caribou may have to sweep aside snow, which they do with their antlers. These have a branch close to their base which projects forward and serves as a shovel. For this reason, females as well as males develop antlers, unlike any other member of the deer family. But the lichen on which they feed, like the grasses of the Masai Mara, are poor in certain minerals. These are essential for the females if they are to produce milk for their young, so even before the warming spring sun has melted the ground, the herd starts to travel north again. The round trip is about a thousand miles long.

With all these stratagems, techniques and physical adaptations, some mammals have managed to become very effective grazers. But grass has also evolved ways to defend itself against the millions of cropping muzzles that attack it daily. Many arm their leaves with tiny blades of silica projecting from their margins. A careless slide of your finger down the leaf of some species can cut your skin and convince you very quickly of their presence. This silica makes the grass so gritty that it wears down the teeth of any animal that chews it. Over millennia, grass-eaters have responded to this. Horses evolved very long teeth, and very deep jaw-bones to accommodate them, and they move upwards as their surfaces are worn down. Elephants have massive grinders that are a foot long. There are two on each side of the jaws of an adult. As they wear, so two more form at the back of the jaws which gradually move forward displacing the old worn down teeth which are then shed. Each is larger than its predecessor, thus compensating for the elephant's increase in size as it ages. But each jaw on each side can only produce six molars. When the last set has arrived and been worn down the aged animal can no longer feed properly and will be close to the end of its life.

Plants and mammals seem to have kept pace with one another on this score, but grasses developed yet another device to maintain their hold on their territory. They grew long horizontal stems lying so close to the ground that they cannot normally be reached by muzzles and nipping teeth. It is from these that new leaves sprout and these leaves grow, not along the length of the blade as others do but from their very base close to the rhizome. So when grass leaves are cropped they can re-grow immediately.

Today there seems to be a truce between grasses and those that eat them. The

organisms that are most likely to displace grasses from their lands are not animals but other plants. If through some change in environmental conditions, a plain covered in grass becomes better-watered, seeds blown or transported from a nearby forest may germinate and get a root-hold. If a bush begins to grow, its roots are likely to collect water needed by the grass. Worse, its spreading branches will cut out the light on which the grass depends. So the grass has to retreat and a bare patch develops on the earth beneath the bush. If that happens over a wide area, the forest could return. But deer and wildebeest, antelopes and rabbits will nip off the shoots of such seeds. Elephants are likely to pull up young bushes. They may even knock down full-grown trees growing on the edges of the forest and open up new territory for grasses.

So grasses have not only achieved a truce with those animals that feed on them. They have now formed an alliance with the grazers that ensures their hold on the pampas of South America, the plains of Europe, the prairies of the American west and the savannahs of Africa – a sizeable proportion of all the fertile land on earth. And on these vast open expanses graze immense herds that constitute the greatest concentration of meat and muscle to be found anywhere on earth.

Elephants feeding on trees, Kenya △