At the end of 1982/early 1983 a sub-adult rhino visited the Ketambe Research Station a few times (A plastercast was made by Dr. H.D. Rijksen). This station is at least 20 kilometres from any of the existing rhino areas and the only previous record of a rhino there dates from 1971. Occasionally rhino are also reported from other places, far from the known centres of rhino distribution. It might be that these wandering individuals are mainly sub-adults, like the one in Ketambe, forced to explore new territory to establish a home range when the main rhino areas are already 'full'.

CHAPTER 7 - DAILY ACTIVITIES OF THE RHINO

In the following chapters we will look at the daily activities of the rhino. Many of these aspects of the rhino's life have been described in detail by previous field surveys (Borner, 1979; Flynn, 1978; see also van Strien, 1974). A major shortcoming of the use of indirect evidence of animal movements for the analysis of the daily activities is the difficulty in estimating the age of the tracks or other signs. It is usually possible to tell if tracks and other signs are very fresh, no more than a few hours old, from the freshness of mudsmears, scratches on bark, trampled plants etc. But these very fresh tracks were rare and usually it is difficult to be more precise in dating than to say for instance 'last night', 'previous day' or '2 to 3 days ago'.

With older tracks it is even more difficult to make an estimate of their age. Under the moist conditions of the tropical forest, drying and discolouring of mud, faeces, scratches and bruises on plants, can be very slow. Mudsmears known to be several days old were found to be still wet and appeared freshly made. The wounds on broken and snapped twigs can remain moist and light-coloured for days or even weeks, so that they appear to be freshly damaged. Moreover there are great local differences: a track can appear very fresh in one place, and several days old only a few meters further on.

On the few occasions when a rhino was met, it was usually a complete surprise. Although we were following fresh tracks, there was nothing to indicate that the rhino had passed only minutes before. In one case it was even judged from the discolouring of the faeces that the track was probably two days old, yet we met the rhino only a few hundred metres further on. In other cases we followed what seemed to be very fresh tracks very cautiously in the hopes of seeing a rhino, but after some time it became obvious that the track was at least many hours or even days old.

7.1 - The system of trails

One of the characteristic aspects of a rhino area, at least in the mountains, is the existence of an extensive network of wide, clear and well-used game trails. The trails generally follow the rivers and the ridges, forming a huge network for easy travel, and used not only by the rhino, but also by other forest animals and man. Very little clearing is needed to follow a rhino trail and on the bigger trails one can easily walk 15 to 20 kilometres in a day. When a trail has to be cut in difficult terrain like the upper Mamas, one can not expect to travel more than 5 kilometres per day and often less. It was only because of the existence of the rhino trails that such a large area could be surveyed in the time available. See figure 2.5 for the location of the trails that formed the patrol network.

Trails are generally better developed in the larger valleys and on the main ridges. The trails along the major rivers like the Mamas and some parts of its tributaries are well developed and cross the river frequently to cut off bends in the river. Where the trail crosses the river the banks are generally eroded by heavy use. At a few places along the Mamas the trail crosses a low spur, here the trail has worn away a narrow trench, to 4 metres deep at the centre. These deep cuts are caused by heavy animal traffic. On steep slopes rain washes out the trails, but nowhere is soil erosion serious.

The trails along the bigger rivers often branch, with side trails going to alternative crossing places or vanishing into the vegetation. At the foot of a main ridge there are sometimes well defined side trails leading up to the ridge. The trails along the smaller streams are much less developed. As long as the streambed is flat the animals follow the stream, but cutting off the largest bends. Where the streambed is steeper the trail leaves the stream, but occasionally minor trails cross the rivulet.

Where the banks of the Mamas are steep the trails go up the slopes, generally following a spur between the river and a small side stream, to reach more level ground, after which the trail continues more or less parallel to the river. North of camp Aceh the trails leave the river for a few kilometres, because the Mamas enters a narrow steep-sided valley. Where the valley broadens again the trails descend again to the river until camp Uning. Just north of this camp the Mamas enters a deep gorge and the trails rise again and follow the edges of the gorge.

The trails on the ridges are even better defined than those along the river, probably because of the drier and harder soil and the less vigorous undergrowth. On every spur and ridge there is a trail, but those on the main ridges of the watersheds are the best developed. These trails are between 40 and 100 cm wide and are generally worn with use. On the trail the soil is bare with a little moss. The vegetation alongside the trail is meagre, and most of the saplings and trees are bent, broken or otherwise damaged by animals passing.

As one would expect the trails follow the easiest route, avoiding unnecessary gradients. They circle small peaks on the ridges and on steep gradients, more than about 15°, they zigzag or climb gradually along the side of the ridge, to avoid the steeper parts. There are usually few side trails along the ridges, only where two ridges join. In some of the passes trails cross the ridge, but these are little used and often barely visible. Large trails join the main ridges two to three kilometres west of the Mamas, on the gentler slopes below the steep ridges. These parts of the trail system are used frequently by the rhinos (see chapter 5.4.2).

The best developed trails are found at middle altitudes, between 1400 and 1800 metres, but the trails converge on the highest mountain tops in the study area. In the low stunted forest or shrub of the higher slopes the trails form narrow tunnels, deeply worn in the thick layer of moss and organic detritus that covers the soil. At some places trails are especially well developed, mainly around the saltlicks, where they converge from all sides.

Although many forest animals make use of the trails, it appears that it is mainly rhinos and elephants that are responsible for shaping the trails. Elephants generally follow only certain routes, along the main rivers and some of the ridges, but rarely venture away from their traditional routes. The trails along the Mamas and those over the Tenang and Silukluk watershed and entering the study area are mainly made and maintained by elephants. But the rest of the trails over the ridges are chiefly made and used by the rhino.

It is not only the weight and foot movement of the passing rhino that shape the trail, but also their habit of scratching the soil and bending and breaking of saplings which keeps the trails free of vegetation. Smaller animals also help to keep the trails open and clear. Sambar, barking deer and tiger make use of the trails and occasionally scratch the soil there, wild boar and hog badgers grub along the trails and pheasants were often found scratching on the trails. Although smaller animals help to maintain the trails, they appear to have very little influence in the development of a trail system, because in areas where the rhino and the elephant are absent there are no game trails, except occasional low tunnels through the thicket.

In areas where the rhino has been exterminated by man trails disappear gradually. On the ridges behind the Ketambe Reseach Station the trails are still visible, although rhino have not used the area for at least 10 to 15 years. The trails were deeply worn, indicating that former traffic must once have been heavy, but now the trails are overgrown and with young trees (their trunks thick as an arm) growing in the middle.

The fact that trails disappear once the rhino is gone may have an influence on other animals, limiting their mobility. Tracks of tiger and wild dog often followed the trails for long distances and seem to do most of their travelling over the game trails. Deer, pig and bear also use the trails regularly. Although none of these animals are absent in areas where there are no game trails, the greater mobility offered by a network of game trails might have a positive influence on their chances for survival, certainly for the large carnivores.

7.2 - The daily movements

Anyone who spends some time in a rhino area will get the impression that the Sumatran rhino is an inexhaustable walker, constantly on the move along trails and through the forest. One can follow a track for hours without seeing much signs of other activity than walking. With remarkable ease rhinos push through thick, tangled and often thorny vegetation, and unless the animal is heading for a saltlick, their movements appear rather haphazard and purposeless. Faeces and urine are found along the rhino's track; the animal will have made use of one of the wallows it encounters or it has lain down somewhere. It will have made a mark here and there by scratching the soil or breaking saplings, but traces of feeding will generally be rare. Occasionally the rhino will have eaten a few leaves along the trail, but to find evidence of more systematic feeding, one often has to follow a track for several kilometres.

The main trails are frequently used by the rhino, but often only for a relatively short distance. In chapter 5.4.2 we noted that only 55% of the tracks followed the trail for a whole section (average length 775 metres) or more. Elsewhere the track followed the trail for less than half a kilometre, often for only a few metres. In some cases tracks crossed the trail at right angles. In some cases the rhino followed a trail from the river to the top of the mountain and beyond, but it often wandered off the trail and followed a parallel route through the forest for a few hundred metres.

In the field it appeared that on the main trails most of the animal's movements were uphill. The number of uphill and downhill movements on the main ridges were counted. A total of 43 uphill tracks were counted against 22 downhill tracks, confirming the initial impression from the field. It appears that when climbing rhinos prefer to use the easier ridge trails.

When a rhino is walking off the trails, it usually more or less follows the contours of the slope, moving gradually up or down, crossing small streams and the minor ridges. On a bigger ridge the animal usually follows the trail for a short distance. When a rhino starts feeding it often travels in wide circles, frequently returning to or crossing its own trail. Following such a trail is almost impossible. In other instances the rhino wanders from side to side while feeding.

In their daily movements the rhinos are probably mainly guided by the topography, with the rivers and the ridge trails being important landmarks. Marks made along the trails may help in orientation, as signs that the rhino is on familiar ground (see chapter 7.4). It appears that rhinos can smell wallows from some distance, because many times rhino tracks suddenly changed direction and headed straight to a wallow in thick vegetation some 50 to 100 metres away. After a bath animals often returned to the previous trail, giving the impression that they have a good sense of direction. Several times tracks deviated from a trail that was blocked by a fallen tree several metres ahead, suggested that the rhino had spotted the obstacle from some distance. This suggests that the rhino's eyesight is not as poor as previously believed (van Strien, 1974). In thick tropical vegetation the rhino's eyesight is probably as adequate as ours is.

The rhino does not particularly like to follow rivers and streams, but will follow a flat streambed for a little way. Generally rhinos leave the streambed soon, apparently preferring to travel along the slopes. Open marshy areas, covered with long grass and sedges, as on the Sungei Tenang - Sungei Silukluk watershed, are clearly avoided. Occasionally rhino tracks were found crossing these marshes, but the main trails carefully circled the swampy open area.

It will be clear from the individual distribution maps presented in figures 5.8 to 5.11, that there is no fixed pattern of movements with animals all following regular routes. Apart from the traditional routes to saltlicks rhinos seem to wander through their range at will, but normally do not leave a specific area, their home range. Animals seem to use topography as an important means of orientation.

The Mamas river, and to a lesser extent the main tributaries, serve as boundaries of the individual ranges (see chapter 5.1.4). Almost without exception a rhino, upon reaching the Mamas river, returned in the direction it had come from. This habit, and the animal's tendency to following the contours and use the main ridges in upward direction, means that the rhino will almost automatically be guided back towards the centre of its range. This pattern of movements is also the most energy efficient. Climbing is unavoidable in a mountain area and costs much energy, but by following the contours along the slopes or following the gradual ridges, the rhino avoids the steepest slopes, thus saves energy.

During this study there was usually no time available to follow single tracks for longer than necessary to make some casts, and when a track was followed it was generally impossible to make reliable estimates of the time and duration of the different activities of the rhino. It is therefore impossible to give estimates of average daily ranges, duration and rhythm of activities like feeding, wallowing, resting etc. Only in a few special cases, for instance when the animal was met, could the time and duration of certain activities be estimated.

Once a rhino was met twice on one single track. This happened on the 7th expedition, when at dusk (15 October 1976; 18.30 h) a rhino with a calf were seen swimming in the Mamas in front of camp Uning. The next morning the track was followed until we met the two animals again at the northern periphery of the study area and a day later the track was followed in the opposite direction. The tracks were later identified as female 440 with calf 400, then about 5 months of age and about half the height of its mother. Their route is shown in figure 5.9B.

The trail started at about 1600 metres, 3.5 km northeast of saltlick 1, where the rhinos had been feeding on the young growth on a landslide. Apparently they had fed there before, because there were also older tracks. From this feeding place they followed a well-marked trail to the saltlick. They passed two wallows, took a bath in a small wallow and descended on a zigzag course to the saltlick, mostly following good trails, except for the last 700 metres. Between the feeding area and the saltlick the animals defaecated twice, the faeces of cow and calf a few metres apart.

Upon reaching the Mamas they swam 50 metres downstream, and climbed up the rocky bank in front of the camp. Before the animals came into view, swimming side by side in the fast flowing river, loud squeaking and snorting sounds were heard. After clambering onto the flat rocks that border the river, the rhinos walked side by side for another 5 metres along the bank, before disappearing into the forest. They did not show any sign of alarm at our presence.

The rhinos probably used only a few hours to cover this distance, including the mudbath, and they probably spent the morning feeding and resting and departed after noon for the saltlick. From the river they passed the saltlick and headed for the main trail to the north. They passed several of the springs making up saltlick 1, but it was not possible to see whether they had drunk some saline water, or simply walked through.

From the saltlick they followed the main trail for almost 4 kilometres till it crossed a side river of the Mamas. They kept to the trail, except where it crossed a stream, when they followed the streambed. But they always returned to the trail.

About 1 kilometre from the saltlick the rhinos took another bath in a wallow along the trail. There were no traces of feeding along the trail and faeces were dropped in a small stream. Along this part of their route were six soil scrapes, apparently made by the female. Where the trail crossed one of the bigger streams, almost 4 km from the saltlick, the rhinos left the trail and followed the stream for about 250 metres. The stream is 4 to 5 metres wide in a rather flat bed. Soon after leaving this stream they started to feed on the undergrowth. At a few places the rhinos had lain down.

At 13.45 h an alarm snort and rustling of vegetation was heard ahead. Moments later the cow was seen running in the direction of the stream. The cow's track was followed for a short distance, until it became clear that the infant was not following, and the survey team left the animals to avoid further disturbance. The cow walked fast, with long strides, and there was a very strong smell of urine all along the trail, and here and there some fresh faeces.

It is not likely that the rhinos took more than a few hours to cover the four kilometres from the saltlick to the feeding site, even including the wallow. Humans need about 4 hours to walk the same route, and a rhino at ease will probably travel little faster. It was estimated that the pair arrived at the feeding site before midnight, and remained there for the rest of the night and the whole morning, feeding and resting, untill they were disturbed by the patrol team.

Very fresh tracks of the same pair were followed on the 9th expedition (12 April, 1977) when the calf was about one year of age. In the early morning a fresh track was found about 300 metres north of saltlick 1, travelling south. These tracks were very freshly made since a patrol the previous afternoon and the same tracks were also met the same morning 3 kilometres further south. The tracks must have been made during the night.

This time the tracks did not lead to the saltlick, but south, parallel to the Mamas, more or less following the contours. The pair walked in a zigzag fashion through the forest, only occasionally following minor trails. About 3 km south of camp Uning they descended to the Mamas and immediately returned up the same slope again. Here the tracks were found in the early morning. The animals proceeded south, occasionally following trails untill they came to the steep slopes along one of the side rivers of the Mamas and they turned back to the north and the patrol trail. The trail was lost, but tracks of the same pair were seen at several places crossing the patrol trail. They obviously had made more rounds in the area.

Probably the track the patrol followed was made during one night, and possibly a few hours of the next morning. A few times the rhinos had eaten a few leaves from a sapling or bush and in three places fresh faeces were found. No scratches were seen but there was one record of urine sprayed on the vegetation. The route, taking 20 hours or less, included seven baths in a wallow, and the rhinos used all wallows they passed.

On the 7th expedition, another rhino was met south of camp Pinus. This rhino was later identified as being female 196, who shortly afterwards gave birth to calf 200. In the afternoon very fresh tracks were found at saltlick 6, coming from the direction of Medan Badak and leaving the lick, to travel south, parallel to the river. The tracks were estimated to have been made not earlier than the previous evening. The track continued south for about 1.5 kilometres. Then the rhino crossed the Sungei Pinus, and started to feed on the undergrowth, crisscrossing the area, and recrossing the narrow stream many times. The rhino also wallowed in a muddy place in the stream.

After feeding the rhino retraced its steps for a short distance and started to climb a rather steep slope zigzagging through the forest. Upon reaching the ridge it followed a trail south for about 150 metres. Then the animal left the trail to travel west. There, at 10.30 h, we met up with the rhino, who dashed off in alarm unseen. This place was about 1 kilometre from the feeding site.

Along the track fresh faeces were found four times and the rhino made two soil scrapes. Away from the feeding site the rhino had taken a few plants along the route. The rhino passed a few wallows, but only took a bath in the stream. The track that was followed was probably made in about one day, or slightly longer. Since the distance covered was relatively short, the rhino cannot have spent much time in walking and must have spent most of the time, at least for a whole night, plodding around at the feeding site, leaving there early in the morning.

On the 16th expedition (3 June 1979) a very fresh track of juvenile 148 was found in the early morning, close to camp Central. It must have been made that night, because the track was not there the previous afternoon. At 9.20 h this rhino was met at 1700 metres by part of the team, about 4 km further west. The rhino came from the summit west of camp Central and followed the large trail over the northern ridge down to the Mamas river. There it walked around a bit and briefly crossed the river. Then it retraced its steps, following the trail to the summit and proceeded south. On both sides of the river the rhino browsed on the undergrowth and took a bath in a muddy spot. One soil scrape was made near a wallow close to the river and along the route five times sets of fresh faeces were found.

The rhino walked more than 12 km in probably less than 20 hours, and probably half of this distance at night. It fed only sporadically along the Mamas and probably stayed only a short time near the river. It seems that the rhino descended to the Mamas during the night, browsed for a while, then started back very early in the morning. It could be that the whole trip lasted less than 12 hours.

Other tracks were followed for some time during this study, but no reliable estimates could be made of the time the rhino engaged in various activities. As described above, the animal's activity consisted of alternating periods of intensive feeding in a small area and periods of

steady walking. Intensive feeding appears to last for several hours and the animals occasionally lay down during feeding, probably to rest. They also may take a mudbath in a wallow or suitable place in the feeding area. In the few cases described above intensive feeding occurred late at night and in the morning, and such behaviour may be the normal pattern.

While travelling rhinos appeared to walk steadily, stopping only for an occasional bath in one of the wallows along the route. Sometimes a few bites were taken from a plant along the trail, but often the rhino did not eat anything for several kilometres. Occasionally a soil scratch, or other mark, was made along the route and the rhino defaecated once about every 1 to 3 km. When a rhino started to walk after a period of intensive feeding it usually continued for several kilometres and up to 12 km were covered in less than a day. Walking occurred both by day and night and the rhinos apparently had no problem in following the trails in almost total darkness. A mudbath was taken at least once per day, but usually more often. Sometimes all wallows encountered were used, and the rhino took seven baths in the course of one night. In other cases the rhino walked for several kilometres, passing a number of wallows, before a bath was taken.

7.3 - Wallows and wallowing

7.3.1 - Location and form of the wallows

The mudbath plays an important role in the daily life of the Sumatran rhino. Several times a day rhinos take a bath in a muddy place, often at a special wallow, and cover the body with a layer of mud, which keeps the skin moist and probably also protects the animals against biting insects. The mud seems vital for keeping the skin and the animal healthy. If an animal in captivity is denied the use of good bathing facilities its skin becomes cracked and inflamed, and the animal soon dies (van Strien, 1974).

Mud pools or wallows that are regularly used by rhino have a specific form and are a prominent feature of rhino areas. Other animals also use the wallows, such as wild boar, deer and occasionally elephants, but the rhino is the most frequent bather and his activities determine the size and shape of the wallows. It is easy to see from the size of the pool and from scratches on the banks whether the wallow is used by rhinos or not.

Rhinos bathe both in special wallows, and at other muddy places they happen upon during their travels. Occasionally they wallow in muddy patches by the river, in a small stream, in a saltlick or even in a peaty marsh on the mountain top. In flat areas, along the Mamas and in the Sungei Tenang-Silukluk area, there are very few typical wallows, because there are many other places where a rhino can take a mudbath, but on the mountain slopes, where wet places are few, the rhinos use the same spot repeatedly, thus creating a typical rhino wallow.

Wallows are made in places where the drainage is poor and the soil remains wet for some time, often found on flat areas on the mountain tops, in saddles or on little plateaux on the slopes. Sometimes a pool formed behind a fallen tree trunk or in the cavity left by an uprooted tree is used. The visiting rhinos deepen these wallows by roiling in the mud, digging until an oblong pit, some 2 to 3 metres long is formed. When the wallow is freshly used it is filled with a slimy soft mud, but after a while the soil particles settle and the water becomes clear.

Many wallows dry out after some days without rain, but some retain water for several weeks. During the study it was never so dry that there were no places to wallow on the ridges, and it is not likely that the availability of places to wallow influences rhino distribution in the study area. Even after three weeks without rain, an exceptional event in the Mamas, several of the wallows along the ridges still contained sufficient water for rhinos to bathe.

In many places only one wallow is made, but sometimes several pits are dug out, though only a few seem to be in current use. The others are overgrown or filled with leaves. Large wallow complexes are common along the main trails. In one place the complex included 30 different pits. Trails lead to the pits and most of the vegetation around the wallows is trampled and smeared with mud.

The rhino digs soil from banks next to the pit with its horn and feet, probably to thicken the mud in the wallow, and thus forms a vertical wall besides the wallow. Vertical groves cut by the horn are often found on the wall. Repeated use causes the wallow to become deeper and deeper dug into the slope and the vertical wall becomes higher and higher. Sometimes the wallow burrows under soil and roots. In several cases the wallow had been dug in a few metres, forming a wall one or two metres high. In one wallow the digging had proceeded about 1? metres, encircling a big tree on the slope, and forming a wall of some three metres high. Su[ch] wallows must have been in use for many years.

There are a large number of wallows in the Mamas, with 170 different locations recorded, but there are many more. Whenever a rhino was followed outside the patrol network, new wallows were encountered along the route. Along the patrol trails 113 wallows and wallow complexes were found (one per 1.4 kilometre) and these are shown on the distribution maps in fig-

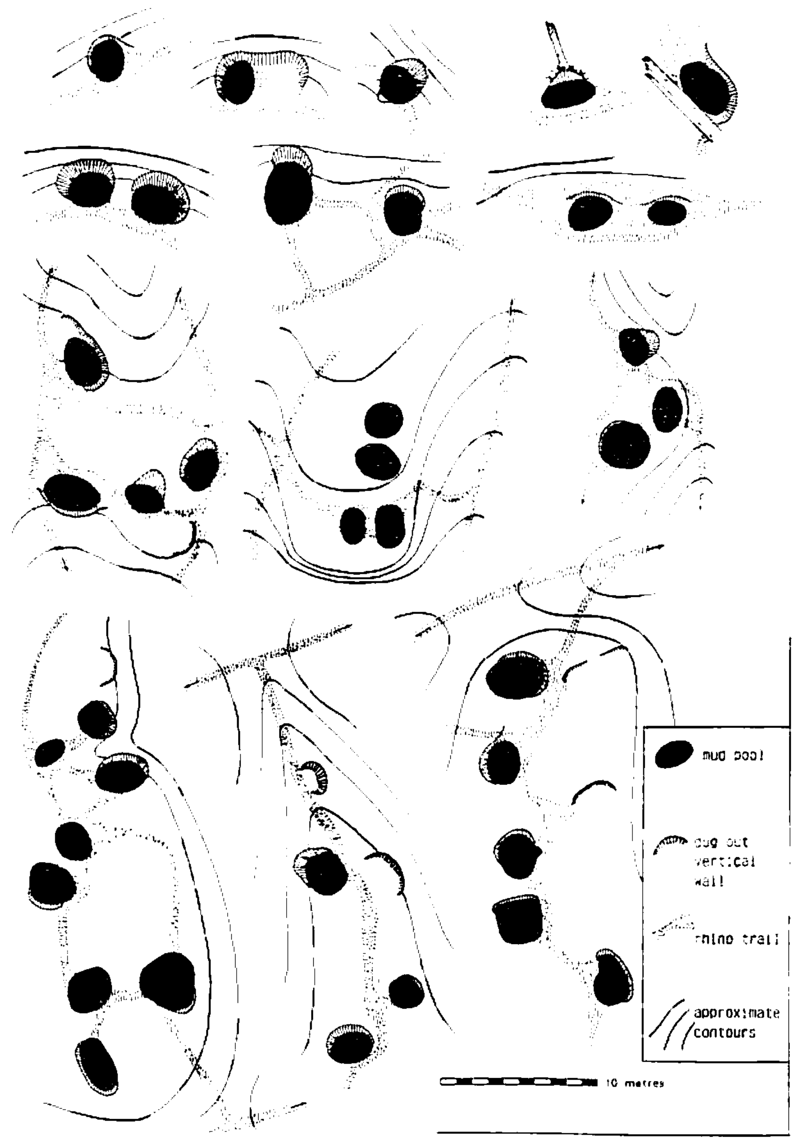


Figure 7.1 - Sketches of wallows and wallow complexes found in the study area. All drawings are on the same scale

ures 5.8 to 5.11. In time changes take place as new pits are made and others abandoned or covered with fallen wood. Sometimes pits which have not been used for many years are reopened.

During the first few expeditions all wallows encountered (89) were measured and a sketch map made of the location. A selection of the sketches is drawn to scale in figure 7.1. The wallows are on average 2.75 x 2.10 m.

7.3.2 - Pattern of use of the wallows

Wallowing is an important part of the daily routine of the Sumatran rhino, but how often a bath is taken varies greatly. In a period of 24 hours or less one animal (see chapter 7.2) used all 7 wallows along its path. In another case the rhino wallowed only once in about the same period. Also sometimes a rhino was found to use almost all wallows on its route, in other cases animals walked for several kilometres, passing a number of wallows, without taking a bath. Once a rhino used two wallows a mere 50 metres apart.

A reliable figure for the number of times that a rhino wallows per day cannot be given, but all evidence indicates that animals bathe at least once per day and usually more frequently. We did not notice more frequent use in dry periods, as was reported by Borner (1979). It is impossible to study the relation between weather and use of wallows from the available data, but in periods of very heavy rains, when the soil is muddy and the vegetation remains wet for days, the rhinos still used wallows, and in periods of prolonged draught, when the number of wallows that still contain water is reduced, rhinos sometimes walked past some of the few remaining wallows.

Wallows are used both by day and night, as is evident from the four tracks described in chapter 7.2. It is difficult to estimate the duration of an average mudbath, but from the condition of the mud in a freshly used wallow and the amount of mud splashed around, the rhino normally spends some time in the wallow, perhaps several hours. Three of the ten animals met during the study were disturbed at a wallow.

The number of fresh rhino tracks were counted at 106 wallows and wallow complexes along the patrol network. The sum of the time intervals between the last rains and the moment of inspection (see chapter 5.4) was calculated for each wallow. From 106 wallows 36 fresh tracks of rhinos that had used the wallow were recorded in 81 910 hours of observation time, an average frequency of use once every 94.8 days or a little less than four times per year.

If each wallow is used only four times a year, and each rhino takes at least one bath per day, there must be a large number of wallows - one hundred or more - within each rhino's home range. There must be many more wallows in the area than those found along the survey trails. Whenever a track was followed off the main trails it soon led to a wallow, and rhinos appear to be able to smell wallows from some distance (see chapter 7.2).

During the first two years of the study an attempt was made to record the use of wallows. Yarn was stretched a few centimetres above the water of the wallow. A broken or dislodged thread shows that the wallow had been used since the yarn was fixed. 42 wallows were fitted with yarn, but the experiment was discontinued because it told no more than other signs around the wallow. Although it is easy to see whether a wallow had been used since the previous visit, it was seldom clear how many times it had been used. On each expedition the yarn was renewed. The accumulated time between placing the yarn and inspecting was 8085 days during which 65 rhino visits were made, once every 124.4 days.

Wallows are not used exclusively by one rhino, but several rhinos may use the same pits. Ten wallows were known to have been used by at least two rhinos and two wallows by three different rhinos. Probably a wallow can be used by any rhino that happens to pass nearby.

7.4 - Marks and marking behaviour

Another feature worth noting in a rhino area are the marks made by rhinos along the trails; soil scrapes, broken and twisted saplings and faeces or urine. Such marks, generally only found along the trails, may be visual and olfactory signals, intentionally left by the passing rhino. Borner (1979) made a careful study of these phenomena and little can be added to his descriptions. From field records of the marks made by the identified rhinos in this study, it is possible to determine how often such marks are made by the different sex and age classes and this might indicate their function.

The most common mark is a scratch in the soil, made by a single movement of the hind-feet, which leaves a bare patch of soil some 50 cm wide and 70 cm long and several cm deep, and they are usually made at an oblique angle on the side of the trail. It seemed in this study that the hindfeet are always used for scraping, but Borner (1979), who made more detailed observations reported 10 per cent of the scrapes made by the forefeet. Other animals (tiger, deer, barking deer) also make scrapes along the trails, but these are generally much smaller. Scrapes made by sambar deer can sometimes be mistaken for rhino's as they may be similar in size and sometimes associated with broken saplings.

Scrapes often occur with other signs. One or two saplings close to the scrape may be bent or broken and sometimes even twisted around, while the bark and the twigs and leaves are usually severely bruised by the rhino's teeth or horn or by rubbing. Faeces are sometimes deposited on the scrape and kicked backwards into the vegetation, and urine is sprayed over the vegetation or splashed on the soil. Occasionally rhinos deliberately twist saplings, breaking the top and twisting it one or more times around the lower part of the trunk.

Tree bending and twisting, kicking of faeces and spraying of urine are also found away from scrapes. Such sign may be made singly or in combination. Rhinos do not seem to leave marks at regular intervals. Sometimes no marks are made for several kilometres, but elsewhere scrapes may occur every hundred metres or less and rhinos break or twist almost all the saplings along the trail. Generally however a travelling rhino leaves only a few marks as it walks along a trail and these are usually single scrapes.

The smell of the faeces and urine is only noticeable for a short time in the wet tropical climate, but the scrapes and the broken and twisted saplings are visible for a longer period, especially at higher altitudes. Borner (1979) discusses similarities in the marking behaviour of the Sumatran rhino and the other rhino species, and concludes such behaviour is a means of indirect communication, leaving signals for other rhinos that visit the same locality and helping a resident to recognize his whereabouts. Twisting of saplings is seen by Borner as a form of marking behaviour usually performed by dominant bulls. Flynn (1978) assumes that these rhino marks are territorial markers, mainly aimed at keeping other rhinos away, a spacing mechanism to reduce exploitation of a limited food resource.

Few scrapes or other marks could be assigned with certainty to a particular rhino and only when the track was very fresh and the soil conditions such that the track could be followed step by step. On fresh trails the number and sort of marks made by an individual rhino were recorded. The length of the tracks was measured on the distribution maps. In table VI below the total number of marks of all types, the total length of the tracks and the number of marks per kilometre of track are given for the different age and sex classes.

Table VI: Frequency of marking

	length of tracks	number of marks	marks per kilometre track
young sub-adults	40.5 km	2	0.05
older sub-adults	19.2 km	21	1.09
females	53.9 km	22	0.41
males	35.5 km	16	0.45
other adults	17.8 km	5	0.28
Total	166.9 km	66	0.40

On average a rhino makes a mark every 2.5 km or so. Adults, both male and female, follow this pattern, but the young sub-adults (animals in the first 2 or 3 years of independent life) rarely make marks while older sub-adults seem to mark more frequently than the rest of the population.

Although fresh tracks of juveniles were frequently followed these animals rarely left marks. Even for juvenile 410, fresh tracks of whom were found almost every expedition for 1½ years after separation, only one broken sapling was recorded, when the rhino was about three years of age. On another occasion this animal may have left a scrape spayed with urine. The only other mark left by a young sub-adult was a single soil scrape made by rhino 148 close to a wallow (see chapter 7.2).

In contrast to the very young rhinos the older sub-adults show a high frequency of marking, more than double the value found for the adults. Of the 6 older sub-adults the 4 better known animals were found to have made marks: two sub-adults known from a few short tracks north of camp Uning failed to score. The most frequently encountered sub-adult, rhino 140, showed up on 10 expeditions and 5 times left one or more marks: 4 scrapes, 3 scrapes with faeces, and one scrape with broken saplings and sprayed urine. For the other three sub-adults a total of 11 more scrapes, one broken sapling and once scattered faeces were recorded.

Five of the eight adult females made marks, mostly scrapes (16), while 4 were scrapes with faeces and 2 scrapes with sprayed urine. Bent or broken saplings were never found in association with a female track. Most of the marks were found in the periods that the females were without young, some were recorded for females accompanied by young. Female 440 left scrapes and scrapes with faeces or sprayed urine (see chapter 7.2).

On average males did not make more marks than females, but the frequency of marking seems to differ greatly between individual males. Most of the marks recorded for the males were made by male 610, who scored 1.8 marks per kilometre. This animal had one of the largest footprints, and is probably large in body size. This male ranges over a large area and is the only male ever found together with another rhino. Male 520, with a somewhat smaller foot, lives in a smaller range, which overlaps extensively the range of male 610. Although male 520 was the most frequently recorded rhino, it made only three marks. Most marks (12) recorded for the males were scrapes, with 2 scrapes with faeces or urine and 2 scrapes with broken saplings.

All age and sex classes marked trails with soil scrapes, either single or in combination with faeces and urine or bent or broken saplings, and such behaviour is certainly not the exclusive behaviour of males or dominant males. Although only 16 marks were recorded for males, it appears that combination markings, such as scrapes with faeces or urine and broken or twisted saplings are the speciality of males. The difference in marking behaviour of males 610 and 520, both living in roughly the same area, may mean that bigger males make more marks. Such marking may be a sign of dominance. It may be that marks are made mainly at the core of the home range and not over the whole male range, because some other males, who are less frequently present in the study area, seldom made marks. Females probably mark more often in their non-breeding ranges than when accompanied by a calf, and breaking and twisting saplings is not female behaviour.

In the first few years of life, when the rhino lives in a rather restricted area, close to where it was born, the youngster seldom makes marks, but later, as older sub-adult they range over larger areas and more often leave marks. It could be that this frequent marking is associated with the establishment of a permanent home range. Several of the older sub-adults broke saplings, which could mean that they are young males, as has already been suggested in chapter 5.2.3.

The scarcety of marks made by very young rhinos and the larger number made by young animals nearing adulthood and the bigger males, suggests that the marks are not only a means of orientation, but that they also serve a territorial function. It may be that rhinos indeed have a tendency to avoid areas where fresh marks indicate the presence of other rhinos, which would, as Flynn (1978) suggested keep the animals evenly spaced. In the Mamas study area the males and the females were indeed rather evenly spread (see chapter 5.1.4). There might be separate spacing mechanisms for males and females, because there appear to be differences in marking behaviour, with broken and twisted sapling left only by males.

7.5 - Faeces and defaecation

The faeces of the Sumatran rhino are very characteristic, and even old faeces of many weeks or months are easily recognizable. Each dung heap consists of 10 or more roundish or ovoid balls, about 7 to 9 centimetres in diameter, together weighing 2.5 to 6.5 kilograms. Fresh faeces are yellow brown or buff in colour, but exposed to air turn dark brown within a day or so. Under water the lighter colour remains longer. The smell of rhino dung is not very pungent, much like horse dung.

The faeces are solid, consisting of coarse plant remains, leaf veins and fragments of leaves stalks and twigs. The stalks and twigs are bitten into 1 to 2 centimetre long sections, barked and split lengthwise. These white bits of wood, of uniform length, are typical of rhino faeces, and remain visible for a long period. Even when the rest of the faeces have been decomposed completely, the twig fragments can still be found on the ground. In elephant dung the woody remains are always long and thoroughly masticated so that only bundles of long fibres remain. Tapir faeces are rather similar to those of rhinos, with many coarse fragments, but the balls are much smaller, 4 to 6 centimetres. Old tapir faeces can be mistaken for rhino faeces in areas where both species occur.

Seeds are found only rarely in rhino faeces. Once seedlings (Mangifera sp.) were seen to have sprouted from rhino dung, but in the upper Mamas it seems that rhinos are of little or no importance in fruit dispersal.

Old dung heaps are common along the main trails, especially on the higher ridges, where decomposition is slow and there is little litter production in the sub-montane forests. To determine the rate of decomposition, two fresh dung heaps, one at 1250 metres the other at 1700 metres altitude, were marked and inspected on a number of successive expeditions.

The dung at 1250 metres was still clearly visible after almost 4 months, but about half was already covered with dead leaves and a mass of mushrooms. After about 7½ months the heap was still recognizable from the growth of mushrooms, but only a few twig fragments remained.

After 10 months the dung had disappeared, although there were still a few mushrooms growing on the site.

The faeces at 1700 metres were still obvious after two months, with some of the balls still intact, but growing fungi. Even after 9 months the dung was still recognizable with some parts of the balls distinguishable among a patch of twig fragments. After 12 months the dung was three quarters covered with leaves, but the mass of twigs was still clearly visible and mushrooms were still growing there. This site was not visited again, but from its condition at the last inspection it can be concluded that a dungheap at this altitude remains recognizable for at least 1½ year.

In the lower regions of the study area faeces might remain visible for only half a year or less. Dung is soon covered with litter and much of the fresh dung heap is quickly removed by dung beetles. One large dung beetle, about 6 cm in length, is commonly found in rhino dung. At higher altitudes there are few dung beetles, litter fall is less and decomposition is slower. On the higher ridges faeces are still recognisable after 1½ years, and to the trained eye even longer. After the faeces have disappeared, the place can still be recognised from the mass of coral-like treeroots which have formed on the soil surface under the former dungheap. On the ridges with low forest rhino faeces will remain visible for several years. On the well-travelled trails of the main ridges the rhino faeces may be an important source of minerals for these very poor soils.

The more frequent occurence of dungheaps at the higher altitudes is illustrated by a dungheap count made on the 14th expedition. The numbers of recognisable dungheaps for each section of the patrol trails were recorded and the totals for each altitudinal section were divided by the total length of the inspected sections in that zone. The results are shown in table VII below.

Table VII: Number of dungheaps per kilometre of trail.

Altitudinal zone	no of dungheaps	no of dungheaps per km of trail
1200 - 1400 m	8	0.19
1400 - 1600 m	25	1.28
1600 - 1800 m	22	2.70
1800 - 2000 m	5	3.27

Although we have no reliable figure for the number of defaecations a rhino makes each day, the frequency with which fresh faeces were found indicates that an animal must defaecate several times during the day, as is customary for large herbivores which ingest vast quantities of plant matter. Whenever a fresh track was followed fresh dung was found. The rhino apparently stands still during defaecation, depositing the dung in a neat pile at the side of the trail.

Many faeces were found by rivers and streams, generally in shallow water. Rhinos seemed to choose to defaecate in small streams, but several times faeces was found in the Mamas and other larger rivers, generally in shallow water, but sometimes also in deeper places. When an animal's followed track crossed a stream often faeces were found in the water, and sometimes the rhino had dropped a few balls of dung in every stream it happened to cross. Defaecation in wallows however seems to be very rare; faeces were only once found in a wallow and the rhino had not bathed there.

The rhino's habit of defaecation in streams has been described often (van Strien, 1974; Borner, 1979). Such behaviour may serve a special function or be a physical reaction brought about by having "cold feet". Because it is difficult to envisage that a stream can be effectively marked with faeces, or that it would be meaningful for the rhino to hide its faeces in the water, it seems more likely that defaecation in water is a purely physical response.

It is worth considering whether or not the Sumatran rhino uses special places for defaecation or has a tendency to defaecate in the vicinity of existing dungheaps. The use of special latrines has been described for the Indian rhino and also for the African species (Laurie, 1978). But while certain authors suggest that the Sumatran rhino always use special places for defaecation, other sources state that they do it only occasionally or only very seldom (van Strien, 1974).

Borner (1979) writes that the majority of dungheaps in his study area, were located on top or close to other dungheaps. Usually two or three heaps were found together, and the largest concentration consisted of 10 heaps. Flynn (1978) never found dungheaps in Endau-Rompin, and reports that dung is usually dropped in shallow water along the side of a small stream.

During this survey real piles of faeces were never found, but a few times a small number (4 - 6) of fresh dung heaps were found together. These seemed to be the work of one or more rhinos that had spent a long period in a small area, and had returned to the same spot to defaecate. In a few cases older faeces were also found at the same place. More usually faeces were dropped along the rhino's route, in a stream or on land. In many instances dung was deposited close to old heaps, giving the impression that the presence of old dung had stimulated the rhino to defaecate. The faeces of a calf were often found close to the cow's and sometimes the cow's dung was deposited on top of the calf's dung.

The distance between dung heaps encountered on the patrol routes were measured for most routes during the first 9 expeditions and some routes on the 16th expedition. The measuring started with the first dung heap encountered and ended with the last on the day's route. A total of 262 dung heaps were recorded. The frequency diagram of the distance classes that were used (0-100 m: 10 m classes. 100-1000 m: 100 m classes. >1000 m: 1000 m classes) is shown in figure 7.2.

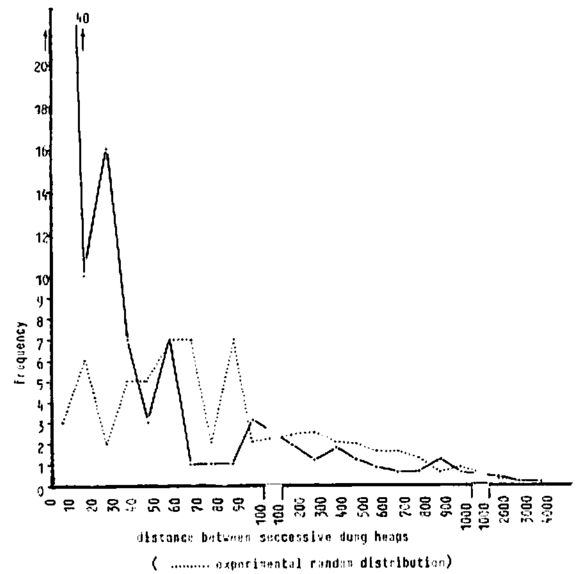


Figure 7.2 - The distances between successive dung heaps along the partol trails, compared with an experimental random distribution

The dotted line in this figure is an experimental random distribution for the same number of dung heaps over the same length of trails, derived from a random number generator. Dung was encountered close together more frequently than one would expect if it were deposited randomly. Some 18% of the dung heaps are found within 10 metres of another heap (12% closer than 5 metres). In the field almost 30% of the heaps are less than 30 metres from the next, while in the experimental random distribution the expected figure is only 5%. These figures suggest that the Sumatran rhino is indeed stimulated to defaecate by the presence of other, usually old, dungheaps.

7.6 - Urine and urination

Rhino urine has a characteristic scent, pungent but not unpleasant and with a sweetish tinge. The scent is persistent and even to the human nose is still perceptible after some days if the rains have not been heavy. The urine is often sprayed over the vegetation and drops can be seen on the leaves. When fresh the urine is virtually colourless, but later turns brown or reddish and becomes glutinous as it dries. When urine is sprayed over soft or young leaves they wilt and become blackish or purplish.

Although it is known from captive animals that both males and females can squirt their urine backwards (van Strien, 1974), the finding of sprayed urine is often regarded as proof of the animal's masculinity. This is certainly not justified, although males (whose penis is directed backwards in rest) may squirt more frequently than do females.

Borner (1979) found that for 95% of the urinations the urine was sprayed backwards over the vegetation. This suggests that squirting is customary for all rhinos, male and female, and that downward urination is exceptional. In most cases noted in this study the urine had been sprayed over the vegetation and soil and only rarely formed a clear wet spot on the ground. On two occasions females are known to have made a scrape with sprayed urine; in one case the female was accompanied by a calf (see chapter 7.4).

The white slime in the urine, described by Borner (1979) was recorded only once during this study, not in an urine spray, but on the ground. It was produced by a female in the Pinus area.

CHAPTER 8 - FEEDING AND THE MINERAL BALANCE

8.1 - The food

Traces of feeding were rarely found during this survey. Feeding does not necessarily take place along the big game trails, and therefore feeding sites were generally only found when a track was followed outside the patrol network, but little time could be spared to follow single tracks.

Samples were taken of any plant eaten by a rhino for identification and the size and the parts eaten were recorded. The samples were preserved in alcohol and afterwards dried. During the study some 150 samples were collected and identified by the staff of the National Herbarium of the Netherlands in Leyden, where the samples are preserved. As most of the material was leaves without flowers or fruits, many samples could only be identified tentatively to family or genus.

The Sumatran rhinoceros is a typical browser, eating leaves and stems of broad-leaved herbs, shrubs and trees. Food is usually taken from some distance above the ground and rhinos also break down saplings and small trees. A large amount of fodder occurs within reach of a rhino in the mountain forests of Gunung Leuser and the animal appears to be an opportunistic feeder, taking a mouthful here and there, rather than feeding intensively and systematically from one source.

Periods of feeding seem to be alternated with periods of travel when only occasionally a mouthful is taken along the route (see chapter 7.2). When feeding the rhino moves in a zigzag fashion or in wide circles, feeding on the softer parts of the plants within reach. It seems not to be very selective when feeding and samples all the plants along its route. Much of the undergrowth in a feeding area is flattened and trampled by the rhino, and the devastation remains visible for many weeks.

It is difficult to speak about special feeding areas, although some areas offer much more fodder for a rhino than others, and when freshly used give the impression of a favourite place because of the damage done to the undergrowth. But visits to such 'feeding areas' may be months or even years apart, much longer than is needed for recovery of the vegetation.

It is often stated that leaves and twigs of saplings and small trees are the favourite food of the Sumatran rhino (van Strien, 1974; Flynn, 1980), but that is not the case in the upper Mamas. Rhinos certainly take a lot of this type of food, but they browse more often and more intensively on the rich undergrowth of large herbaceous and suffruticose plants that is common in the upper Mamas. In these areas they do not touch the saplings and small trees, but feed exclusively on the soft leaves and succulent stems of the groundcover plants.

The canopy in the submontane forest is not so high and dense as in the lowlands, with more vigorous plant growth at ground level. On the ridges the undergrowth is meagre, probably because the soils are dry and leached, but elsewhere on the slopes, especially in the valley bottoms, the undergrowth is lush. Here the soil is covered with a dense layer of soft, shiny green plants with fleshy leaves and thick succulent stems, some one to one and a half metres high, and the rhinos feed on the succulent leaves and upper stems.

The Sumatran rhino in the Mamas appears to prefer the herbaceous undergrowth (which also has a higher content of minerals - see chapter 8.3) over the leaves and twigs of saplings and small trees, but where the undergrowth is thin rhinos turn to browse on the saplings. In the Endau-Rompin area in Malaysia almost 98% of rhino food was saplings (Flynn, 1980), but this area lies at a lower altitude, and the undergrowth is thinner than in the Mamas.

Plants from the family Urticaceae are well represented in the undergrowth and in the rhino's diet, particularly Elatostema spp., which is probably the most frequently eaten plant. Other Urticaceae were sampled more than once - Pilea, Urtica grandidentata, Boehmeria, Cypholophus, Pouzolzia. Other popular foods, for which the rhino seemed to have a preference are Cyrtandra and Chiritha spp. (Gesneriaceae), and to a lesser extent Strobilanthes spp. (Acanthaceae). Piper spp. (Piperaceae) and Begonia spp. (Begoniaceae). Other herbs eaten include: Chloranthus (Chloranthaceae), Impatiens (Balsaminaceae), Psychotria and Maschalocorymbus corymborus (Rubiaceae), Blumea (Compositae), Forrestia (Commelinaceae), Homalomena, Schismatoglottis and Raphidophora (Araceaea).

In open clearings and along the river banks the undergrowth is thicker than in the forest, some two metres or more high, but composed of similar plants. Several times rhino were found to have fed here on many of the species mentioned above. Occasionally the plentiful giant gingers, Zingiberaceae, were eaten. The rhino chews on the thick ginger stems to extract the soft and juicy pith. Rhinos also ate the heart of the giant Colocasia (Araceae). Wild banana (Musa), very common in places, was never eaten by rhino. These huge soft-stemmed plants, a favourite food of the elephants, are not touched by the rhino.

Rhino also fed in places where the forest was regenerating after tree falls or landslides. The thick mass of herbs, shrubs and soft-wooded trees provides ample fodder and feeding in these areas can be rather intense and concentrated. Here the following herbs and smaller shrubs were sampled: Begonia (Begoniaceae), Melastoma malabathricum (Melastomaceae), Microglossa pyrifolia and Eupatorium inulifolium (Compositae), Cyrtandra (Gesneriaceae), Gomphostemma (Labiatae), and a number of larger shrubs, lianas or small trees: Kadsura (Schisandraceae), Debregeasia (Urticaceae), Ficus (Moraceae), Macaranga and Suregada (Euphorbiaceae), Meliosma lepidota (Sabiaceae), Sambucus (Caprifoliaceae), Turpinia (Staphyleaceae), Clerodendron (Verbenaceae).

On the ridges and higher slopes, where ground cover is thin, the rhino took a great variety of food plants. Feeding there was usually less intense with the animal moving in a more or less straight line through the forest, breaking most of the saplings and small trees it passed. The leaves and the younger parts of the stems are bitten off and eaten. Sometimes only a few branches are eaten, at other times the whole crown is systematically defoliated.

Most of the saplings are snapped off some distance above the ground. The rhino usually breaks the trunk by biting and not by pushing. Teeth marks are often visible in the bark above the break. Sometimes the horn is also used to bring down trees, occasionally a branch or tree was found that had apparently been pulled down by hooking the horn behind it. The estimated lengths of the saplings and small trees on which rhinos browsed varied from 2 to about 12 metres, with an average of about 4.5 metres (n=52). The thickest specimens broken were about 8 cm in diameter.

A great many different species of saplings were eaten and only a few were recorded more than once. Only three genera - Garcinia (Guttiferae), Linociera (Oleaceae) and Styrax (Styracaceae) were collected on several occasions and these plants seem to be rhino favourites. Other trees that could be identified are: Disepalum anomalum (Annonaceae), Horsfieldia glabra and Knema sumatrana (Myristicaceae), Litsea, Dehaasia and Cinnamomum (Lauraceae), Prunus grisea (Rosaceae), Hemiscolopia trimera (Flacourtiaceae), Saurauia (Saurauiaceae), Calophyllum (Guttiferae), Schima noronhae (Theaceae), Trigonobalanus verticillata (Fagaceae), Eugenia (Myrtaceae), Leptonychia (Sterculiaceae), Santiria laevigata (Burseraceae), Dysoxylum, Chisocheton and Toona sureni (Meliaceae), Mallotus, Endospermum, Securinega and Alchornea (Euphorbiaceae), Mangifera quadrifida (Anacardiaceae), Mastixia trichotoma (Cornaceae), Vaccinium korthalsii (Ericaceae), Rapanea (Myrsinaceae), Pavetta, Lasianthus, Urophyllum, Randia and Ophiorrhiza (Rubiaceae), Ehretia acuminata (Boraginaceae), Podocarpus imbricatus (Gymnospermae - Podocarpaceae).

The small, stemless thorny palms common in the forest, especially on the lower parts of the ridges, were rarely sampled. Occasionally the heart of a palm or a thick rattan (Calamus) was eaten. Pandanaceae are rare in the Mamas and a rhino fed only once on a Freycinetia. Once the top of a sedge, Scleria (Cyperaceae), was eaten in the forest, but usually grasses and sedges are not eaten. The few open marshy places are covered with a thick mat of grasses (mainly Isachne) and sedges (Scirpus mucronatus, Cyperus and some Carex), but rhinos were never found to have grazed there and these sites were usually avoided (see also chapter 5.4.2).

Fruits are not an important part of the rhino's diet in the Mamas, and fallen fruits are seldom found. Wild mangoes (Mangifera - stones were found once in faeces, see chapter 7.5) are very rare and the only fruits that are often found on the ground are kandis (Garcinia). These fruits are eaten by deer and pigs, but rhino were never known to take this, at times plentiful, food.

Signs of feeding were found in all parts of the study area and at all altitudes, up to 2000 metres. Above 1600 metres feeding appeared to be less frequent, and it was never observed in the stunted montane forest and the sub-alpine shrubs on the highest ridges. Rhinos traverse these areas on their wanderings and push through the scrub, that is for humans almost impenetrable, but they do not feed on the small hard leaves of the montane plants. Rhinos do feed however on the undergrowth and saplings at similar altitudes on the slopes and in the valleys where the forest is still fairly high.

8.2 - Availability of food

In an area like the upper Mamas study area there seems to be an abundance of food the year round. Rhino food plants are common over most of the area, and one gets the impression that a rhino does not need to go very far to fill its stomach. Although the dark-green understory seems lush, growth there is very limited. Saplings that have been broken off along the trails produce only a few meagre soft sprouts after many months, and growth is rapid only along the open river banks. There a freshly cut trail will be overgrown in a couple of weeks, bu in the forest it remains visible for many months.

A detailed analysis of the amount of food available for the rhino and of the productivity of rhino food plants was beyond the scope of the present study. To get a rough idea of these parameters a few samples were taken and weighed. At two locations a small plot was made in the more or less homogeneous vegetation. One location was under a high closed canopy, with rather meagre undergrowth. The other was close to a river with lush undergrowth. From one half of the plot all undergrowth was collected, from the other half only the leaves and top shoots that a rhino would eat. After about three months all new growth on the plots was collected and weighed. The plots were not fenced, but it is certain that they were not visited by rhino in the meantime, nor were there signs of browsing by animals.

From the total amount of undergrowth (about ½ to 1½ kg per sq m) the leaves and stems suitable as rhino food weighed between 260 and 520 grammes (fresh weight) per square metre. Regrowth of leaves and stems varied from 0.7 (in the forest) to 3.8 (near the river) grams per day per square metre. It seems from these figures that the average production of browse suitable for the rhino is probably not more than 1 gram per day per square metre. There are a few hundreds of grams of browse standing on each square metre, but it takes a long time, up to a year or so, for replacement.

Very little is known about the energy requirements of a Sumatran rhino. A young rhino female captive in Malaysia consumed about 50 kg of leaves and 1 to 1½ kg of pelleted dry food per day (pers. comm. Mohd. Khan). The basal metabolic rate of a mammal in kcal per day is approximately seventy times the three-fourth power of the body weight in kg (Moen, 1973). A rhino of 900 kg weight requires a daily intake of about 57 kg of browse (fresh weight), if for maintenance it needs about twice the basal metabolic rate, and if browse contains 80% moisture and 2000 kcal per kg dry weight.

The Sumatran rhino may have an average consumption of somewhat more than 50 kg of browse per day. With a production of 1 gram of browse per day per square-metre, one rhino would require a range of at least 5 or 6 hectares to provide sufficient food. In the Mamas there is about one rhino per 700 hectares (see chapter 5.3.1), which seems to confirm the impression that there food is abundant for the present rhino population. On the other hand the slow rate of reproduction with long periods between successive births (see chapter 6.4) implies that food may be a limiting factor. It may be that it is not the quantity of food available but the quality that is a limiting factor for reproduction and population levels.

8.3 - The mineral balance

All rhinos in the study area paid regular visits to mineral-rich springs and the obvious conclusion is that they do this to take in extra minerals to offset an inbalance or deficiency in their diet. From other studies, mainly referring to arid areas in Africa and America, it appears that animals using saltlicks are primarily seeking extra Sodium. Tropical vegetation is usually low in available Na and may contain inadequate levels for herbivores. Elsewhere it appears that animals are seeking other elements (Mg, P) or clay minerals (Kreulen & Jager, 1984). For the rhinos in Gunung Leuser clay minerals cannot play a role, because they usually only drink saline water at the licks.

On one occasion a rhino entered one of the camps and had scraped in the ashes of the fire. Other herbivores (deer, serow) did the same, and presumably ashes are ingested. In the Sungei Dusun reserve in Malaysia rhino come regularly to the ashes of the cooking fire at the guard post (pers. comm. Mohd. Khan).

Samples of all the saltlicks and of several foodplants were analysed for the elements that are most important for animals. Mineral requirements for rhino are not known and therefore the mineral requirements for the horse are used for comparison (Maynard, Loosi, Hinz & Warner, 1979). The anatomy of the alimentary tract of the Sumatran rhino is in many aspects similar to the horse's (Garrod, 1873). The foodplant samples were dried in the sun or in a tin over a fire. The mineral contents of the plant samples were analysed by the laboratory of the Pusat Penelitian dan Pengembangan Ternak, Ciawi, Indonesia. The samples of the saltlicks were analysed by the Analytical Laboratories of P.T. Superintending Company of Indonesia in Jakarta.

8.3.1 - Mineral contents of the foodplants

Three of the foodplant samples were a mixture of species that are usually eaten by rhino. Two (I and II) consisted of the tops of the plants collected in the plots described above, the third mixture (Medan Badak) consisted of tops of plants eaten by a rhino in the forest fringe around Medan Badak (see chapter 2.3.2). The other samples were all taken from plants freshly browsed during the 17th expedition. The species were identified by the Herbarium Bogoriensis in Bogor.

Table VIII: Mineral contents of foodplant samples.

Sample	Mineral composition (in per cents on dry matter basis)							
	Ash	Crude proteins	Ca	P	Mg	K	Na	Mn
Undergrowth								
Mixture I	15.92	15.63	5.01	.22	.53	3.31	.082	.011
Mixture II	14.45	11.63	3.61	.16	.49	3.85	.064	.0129
Mixture Medan Badak	28.04	24.13	6.76	.37	.55	6.31	.055	.0208
Elatostema (Urticaceae)	18.64	6.38	4.40	.09	.36	.89	.01	-
Average for undergrowth	19.26	14.44	4.95	.21	.48	3.68	.053	.0149
(Standard deviation)	(6.10)	(7.49)	(1.34)	(.12)	(.09)	(2.71)	(.031)	(.0052)
Saplings								
Disepalum anomalum (Annonac.)	4.14	9.75	.51	.07	.37	.91	.01	-
Ficus ribes (Moraceae)	16.19	13.29	3.06	.21	.36	.87	<.01	-
Garcinia (Guttiferae)	6.49	7.81	1.63	.08	.36	.38	<.01	-
Hemiscolopia trimera (Flacourt.)	8.05	5.56	2.29	.08	.29	.74	.01	-
Schima noronhae (Theaceae)	5.29	11.38	1.17	.09	.22	.63	<.01	-
Styrax agretis (Styracaceae)	6.08	14.13	1.35	.13	.21	.83	.01	-
Styrax paralleloneurum (Styrac.)	3.83	11.80	.63	.07	.33	.56	.10	-
Toona sureni (Meliaceae)	7.54	8.19	1.85	.18	.32	.59	.01	-
Average for saplings	7.20	10.24	1.56	.11	.31	.50	ca.02	-
(Standard deviation)	(3.91)	(2.94)	(.85)	(.05)	(.06)	(.24)		
Average all samples	11.22	11.64	2.69	.15	.37	1.59	ca.03	
(Standard deviation)	(7.43)	(5.01)	(1.93)	(.09)	(.11)	(1.89)		
Faeces								
(Average 5 samples)	12.90	9.32	1.83	.24	.26	1.58	.06	.134
(Standard deviation)	(4.53)	(1.76)	(2.69)	(.03)	(.08)	(.95)	(.04)	(.044)
Minimum requirements in diet for the horse 1) maintenance		8.5	.3	.2	.09	.4	.35	.004
Gestation		11.0	.5	.35				
Lactation		14.0	.5	.35				
Growth					.1	.5	.35	.004

1) After: Maynard, Loosi, Hintz & Warner, 1979.

While the crude protein contents of the undergrowth and the sapling samples is not very different, the mineral concentrations in the undergrowth samples are considerably higher, which might explain the rhino's preference for this type of browse. For all elements analysed the average concentration in the undergrowth samples is almost twice the concentration in the saplings. If we compare the average concentration of minerals in the samples with the minimum requirements for the horse, the supply of only two elements (phosphorus and sodium) seems to be insufficient. The concentration of the other elements and the proteins is more than sufficient for adequate nutrition.

The concentration of phosphorus in the rhino food samples is slightly below the minimum requirements for the horse. During pregnancy and lactation the animal's requirements of phosphorus are considerably higher and in that period an additional supply might be benificial.

The ratio of calcium to phosphorus in the diet must be considered, because the absorption of one of these elements is influenced by the concentration of the other. Ideally the intake of both elements should be similar, but a mature horse can cope with a calcium to phosphorus ratio of 6 : 1, if phosphorus intake is sufficient (National research council, 1978). In the rhino's food the ratio is about 18 : 1 and the phosphorus intake is low, so there may be an imbalance in the calcium - phosphorus metabolism, and extra phosphorus may be beneficial, especially for a pregnant or nursing female.

Flynn (1980, 1981) reports on mineral analyses of a large number of rhino foodplants (mainly saplings) from Endau-Rompin, Malaysia. The average contents of ash, crude proteins, potassium and magnesium are similar to the values found for the upper Mamas, but the average contents of calcium (.89) and phosphorus (.072) are much lower in Flynn's samples. Nevertheless saltlicks are unknown in Endau-Rompin and the rhinos are apparently able to survive on a low phosphorus diet, unless they have some unknown source of minerals. Flynn (1980) suggests that fruits might be an important source of phosphorus.

In the Mamas the average concentration of sodium in the rhino's food is more than ten times lower than the recommended minimum dosage for the horse. The actual requirements of sodium have not been determined for the horse (National research council, 1978), but additional salt is recommended even though the sodium concentrations in horse fodder are usually between .1 and .5 %. For cattle of weight up to 300 kg the minimum dietary concentration of sodium is .06 % of dry matter weight (Kreulen & Jager, 1984). An average concentration of .03 % sodium in the diet could lead to deficiency.

8.3.2 - Mineral contents of the saltlicks

From most saltlicks water samples were taken for analysis of the mineral contents. As a control water was also analysed from the Mamas river at camp Central. Water and not soil samples were taken, because it appeared that the rhino usually only drank water, from puddles on the saltlick or directly from the spring. Sometimes rhinos dig with the horn, but there were no signs that the rhino had actually eaten soil. The results of the analysis are shown below in table IX.

Table IX: Mineral contents of the saltlicks.

	Concentration in Mg per Litre										
	Ca	PO_4	Mg	K	Na	Mn	Fe	SO_4	Cl	NO_3	CO_3
Mamas	12.38	.053	2.17	.36	.66	trace	.055	4.57	5.04	.30	und.
Saltlick											
2	214.18	.054	128.11	31.03	55.38	.016	.055	11.04	21.86	1.48	und.
3	120.27	1.36	141.27	30.73	55.77	und.	.11	39.96	21.86	1.48	und.
4	38.26	1.03	2.33	1.02	38.26	trace	.055	14.84	8.41	.70	und.
5	41.20	.38	6.87	.42	39.38	trace	trace	50.23	21.86	.52	und.
6 A	27.71	-	5.35	1.85	107.27	trace	trace	31.21	5.04	1.14	und.
6 B	55.28	120	7.09	1.26	72.73	trace	trace	42.62	65.59	.84	und.
Average	82.82	24.56	48.50	11.05	61.47	-	-	31.65	24.10	1.03	-

(und. = undetectable)

There is much variation in mineral composition between the saltlicks. All sampies were high in calcium, sodium and sulphate, but there was considerable variation in levels of magnesium, potassium and phosphate. Phosphate is only high in saltlick 6 B (the large saltlick east of the Sungei Pinus), where by consuming a few litres of water a rhino may make a significant addition to its intake of this mineral. But nursing females, whose need for phosphorus is highest, were never found at this lick. In the other licks the phosphorus contents are much lower. Even at saltlicks 3 and 4, that were visited by females with calves, the amount of 1 milligram per litre seems insignificant compared to the amount found in rhino food plants which contain about 1500 milligrams per kg of dry matter. Therefore it seems unlikely that the need for extra phosphorus is the reason why rhino use saltlicks.

The concentration of sodium in the saltlick water is much higher (at 61 mg/l about 100 times), than the concentration in the Mamas river. This is not a high sodium content (seawater contains about 11030 mg/litre). One litre of water from the saltlick contains only as much sodium as 1 kg of rhino fodder. However the minerals in the saltlick water are mainly in solution and are readily absorbable, while much of the minerals taken in the food are excreted unabsorbed (see the faeces samples in table VIII).

Most rhinos visit a saltlick once a month, but females with calf visit on average once every two weeks and some males might make more frequent visits (see chapter 5.6). It is difficult to envisage the importance of imbibing a few litres of saltlick water every month or even every two weeks. Even if the animal were to drink a bucketful of water every time it went to the saltlick the amount of minerals it would obtain is much less than from a day's intake of fodder. Although there is probably a deficiency of sodium in the diet it is unlikely that rhinos visit the saltlicks for only a few hundred milligrams of sodium.

The fact that all rhinos visit a saltlick regularly is a clear indication that saltlicks are important to the rhinos. The increased frequency of visits by nursing females, whose requirements for minerals are higher, point to a possible physiological benefit from the intake of saltlick water. It may be access to extra minerals during the nursing phase that makes the female and calf stay in the neighbourhood of the saltlicks, but visits during later life may serve another function. The physiological benefits of the minerals in the saltlick water will be short-term, if there are any, but the visits of adult rhinos to a saltlick might be more a question of a habit acquired during the first years of life, the continuation of which is stimulated by the experience that saltlicks are good places to "meet" other rhinos (see chapter 6.2). For the adult rhino the social contacts made at the saltlicks may be more important than the minerals supplied by the saltlick.

CHAPTER 9 - SUMMARY AND EVALUATION OF THE RESULTS

The Sumatran rhino is solitary for most of its life. The home range of a rhino overlaps with the home ranges of several other rhinos and animals occasionally meet, but they do not stay together for any length of time. It may be that young sub-adults, in their first years of independence, form loose associations occasionally, but later they travel alone, wandering round their vast home ranges. A male and female seem to come together for only a short period for mating. Non-breeding females may have very little contact with other rhinos, because they occupy a relatively small range and leave it only occasionally to visit a saltlick.

The adult males seem to be more actively searching for contact. They cover a large area and are very active around the saltlicks, apparently searching for signs of other rhinos. Although males have more frequent contact with other rhinos, they never associate with an other rhino for more than a few days. If longer-lasting bonds were usual, the tracks of two or more animals walking together would be found more frequently.

A rhino calf remains close to its mother till they separate. When very young the calf stays very close, but older calves do not wander more than a few metres away from the trail of the cow. When the calf is about 16 to 17 months old it separates from the cow. Maternal care for the young is limited to the infant's period of rapid growth, and when the youngster has reached about three-quarters of the adult size, it leaves the cow. There may still be occasional contact between the cow and her independent offspring, but most of the time the young rhino travels singly.

While nursing a calf the female rhino moves from her non-breeding range higher on the slopes, to the vicinity of a saltlick. Already during pregnancy the females may make more frequent trips to the saltlicks. The calf is probably born close to a saltlick and during the whole period of nursing cow and calf remain in a relatively small area, about 10 to 15 sq km, around one of the licks. The pair visit the lick about once every three weeks, about two to three times as often as non-breeding females and sub-adults. When there are several females with a calf around one saltlick, their ranges usually overlap and the pairs may meet occasionally. Tracks criss-cross the area, and several routes are used to approach the saltlick.

After leaving the cow the calf remains in the area where it was nursed. The cow returns to her non-breeding range, further away from the saltlick. The newly independent rhino, the young sub-adult, initially uses a relatively small area, 10 sq km or less, part of the range it used with its mother. The young rhino roams over the area intensively, often returning to the same places; it seems as though the animal is familiarizing itself with the location. The animal gradually extends its range into adjacent areas, where it was never found with the cow. For at least two or three years the young sub-adults remain in the neighbourhood of the place where they were born and nursed. During this time they grow slowly, and after about three years their footprints are still smaller than those of an average adult and clearly recognisable as from a young rhino.

The older sub-adults, aged at least six or seven years by the end of the study occupied relatively large ranges and many were only found occasionally. Animals gradually extend their home range for a number of years with older sub-adults travelling widely into new areas, probably to find a gap between the existing adult ranges. It seems to take several years before a Sumatran rhino is adult and has established a permanent home range. A young rhino remains in the 'nursing area' till it is at least four years of age and it is probably not sexually mature before the age of 7 or 8 years.

The adult rhinos have permanent home ranges which are spread rather evenly over the study area, with the centres of the home ranges on the major ridges. The non-breeding females remain in relatively small ranges, no more than about 10 sq km, on the higher parts of the ridges, away from the valleys and the rivers. The tracks of non-breeding females were rarely met, usually only when the animals visited a saltlick and it appears that these normally travel little along the large game trails, perhaps once every 6 weeks to visit a saltlick. The rhino then follows a specific route to the saltlick and returns to its home range immediately, usually along the same route.

The ranges of the females in the non-breeding period seem to be well separated and the records do not show any overlap in range, except close to the saltlicks. The paucity of records for non-breeding females makes it difficult to draw firm conclusions, but it seems that they have more or less exclusive territories. It is not clear how the spacing of the female home ranges is accomplished, but it may be that females tend to avoid areas where other females have left tracks and signs. Nursing mothers with calves do not avoid other female's tracks in the vicinity of the saltlick.

Although we have no precise records it seems that the interval between births is at least 3 to 4 years, somewhat longer than the time that a female carries and nurses a calf. It may be that the long birth interval is necessary for the female to build up sufficient reserves for another reproductive effort. Although rhino food plants are abundant, they are not particularly rich in nutrients and minerals and the female probably needs a period of limited mobility and seclusion to recover condition between births.

Adult males range over much larger areas, 25 to 30 sq km or more. It seems that male home ranges have a core area where most activity is concentrated. Peripheral areas are visited less frequently and then the animal often follows the game trails for long distances. On average males visit the saltlicks about as often as sub-adults and non-breeding females, but males with ranges close to the lick, visit them much more often. From the saltlicks males usually make several forays in different directions, giving the impression that they are searching for other tracks. Males visit a regular saltlick, but may occasionally also travel to other licks.

Male ranges overlap considerably, but it appears that the core areas are distinct and rather evenly spaced over the area. There might be some form of hierarchy among males, because some animals make more marks along the trails than others. Visual and olfactory signs are left by rhinos along the large game trails. They include soil scrapes, faeces, sprayed urine and bent or twisted saplings, in various combinations. All rhinos mark in this way, both males and females. Young sub-adults rarely mark, while the older sub-adults are the most active markers of all groups. Marking may be associated with the process of establishing a permanent home range. The more complicated signs, those consisting of soil scrapes, bent saplings, faeces and/or urine are usually only made by males, and could indicate male territoriality.

Saltlicks are an important focal point for rhinos in the Mamas study area. Each lick is visited regularly by several rhinos, and each rhino appears to visit one particular saltlick, not always the one closest to the centre of its home range. A rhino generally uses one particular route to the licks, following it consistently on every visit. Each of the six saltlicks discovered in the study area is used by 5 to 7 different rhinos, each animal visiting a lick on average 6 to 7 times per year. The consistency with which a rhino visits a certain lick suggests that all rhinos using a saltlick may be related. Sadly many rhinos also end their life near a saltlick, because hunting activities are centred at these places.

Rhinos drink mineral-rich water at the licks most probably to compensate for a deficiency or imbalance in the mineral composition of the food. In a number of samples of plants eaten by rhinos, the sodium (Na) concentration was found to be very low, also the phosphorus (P) concentration, especially in relation to the calcium (Ca) concentration, was low. If there is a deficiency it is probably in one of these elements. The mineral concentrations in the water of the saltlicks vary considerably. All have about 100 times more sodium than surface water, but the concentration of phosphorous varies between the licks. The amount of minerals that a rhino may imbibe at each visit to a lick is small, less than in a day's intake of fodder. So it is not clear how important one visit a month is for maintaining the animals mineral balance. It is more probable that for adult rhinos the social function of a lick, as a place for meeting other rhinos, is more important than the extra minerals.

The daily movements of the rhino seem to be controled by the terrain, and on the slopes they follow the contours or ridges. The larger rivers are important boundaries for rhino. Rhinos have no problem in crossing the rivers, and do so frequently, but they usually do not stay on the other side, but recross the river. The bigger the river the more important it seems to be as a boundary, and the Mamas river forms the boundary of the home range of almost all known individuals. The tracks of only two older sub-adults were found on both sides of the river. The big game trails on the ridges are more often used by the rhino for climbing than descending. This and the habit of turning back at the major rivers, means that a wandering rhino automatically turns back to the centre of its home range, which is usually located on one of the main ridges.

When not following a trail the rhinos more or less follow the contours of the slope, crossing small streams and minor ridges. Animals often follow wide trails for some distance or may leave it to wander over the slopes. As they travel rhinos browse or take a mudbath in a wallow. Faeces and urine are found along the animal's trail and occasionally the rhinos lie down.

The Sumatran rhino feeds on leaves and twigs of a great many plant species. Fallen fruits are also taken, but these were rare in the Mamas area. When feeding the animal moves in a zigzag fashion through the forest, often going around in circles, browsing on the soft parts of the plants within its reach. Periods of feeding alternate with periods of travel, when the animal often walks several kilometres without feeding, except for an occasional bite from a plant along the trail. When feeding the rhino seems to prefer places with a dense undergrowth of soft, juicy plants. In the mountain forests of Gunung Leuser there is very dense undergrowth along the streams and on the lower slopes, and these seem to be the favoured feeding places. Rhinos also feed on the young regrowth on landslides and at tree falls. Where there is less undergrowth the rhino feeds on small saplings, pushing them over to browse on the crowns, but this type of food appears to be less favoured and also contains less nutrients and minerals. Feeding occurs mainly at night and in the early morning.

Rhinos feed on a great many plant species taking only a little material of anyone species. The rhino does not appear to be selective while feeding, but a few species seemed to be favour-

ites, while others, like wild bananas, are ignored. There seems to be abundant food for the rhino in the upper Mamas. Over a large part of the area the forest supports dense undergrowth with numerous accessible saplings. The standing crop of rhino food plants is certainly large, but the production of new growth is very slow. An area that has been browsed and trampled by rhino, takes a long time to recover. This might explain the need for the continuous travels of the rhino. Although productivity is low in the understory there seems to be considerably more food available than can be consumed by the present rhino population (estimated at 13 to 14 rhinos per 100 sq km), and it is probably not the quantity but the quality of the food that is a limiting factor for the population.

Rhino faeces are often dropped in streams or along the rhino's trail. The faeces, with characteristic twig fragments, remain visible for a long time, especially at the higher altitudes. The Sumatran rhinos prefer to drop their faeces close to other faeces, but large dung piles are not made. All animals, male and female, normally spray urine backwards over the vegetation.

The wallows are a characteristic feature of any rhino area. The pits are often used for a long time and rhino's digging in the banks give the wallow a characteristic shape. It seems that a rhino takes a bath at least once a day and sometimes several times a day. Wallows are used day and night, but rhinos probably spend more time in wallows during daytime. Each wallow is used by several rhinos and on average the wallows along the main trails were used about 4 times per year.

The major difficulty in interpreting the data was the disjunct and patchy nature of the records for most of the rhinos. For many individuals there were only few records, spread out over a long period of time; this not only made the identification of the plastercasts more difficult, it made it more difficult to draw conclusions about rhino behaviour and activity from the available data.

The remoteness and inaccessibility of the area and our financial limitations made it impossible to maintain a permanent presence in the study area. Because this study focussed on tracks we decided to use the days in the study area to find as many tracks as possible. This required the survey team to keep on the move and left little time for more detailed study of single tracks. By following tracks for a longer period and distance one can discover much about the daily routine of the rhino, information that could only be gathered incidently in this study. Ideally one should monitor movements of the rhino over a large area and also follow single tracks for a number of days.

Interpretation of the data is limited by the difficulties in ageing the tracks. One can only estimate the time and the duration of the various behaviours and activities of a rhino from very fresh tracks or when the animal is actually met. These occasions are very rare and normally one can only guess the approximate age of the tracks. Therefore track studies are of little value for studying the animal's daily rhythm, unless one can trail single animals for a few days. With very experienced trackers it is possible to follow a rhino closely, without disturbing it, but this requires a more permanent presence in the study area.

CHAPTER 10 - RECOMMENDATIONS FOR FUTURE STUDIES

Among the first things one wishes to know for study or management of a rhino population, is its status, more specifically how many animals are there and where. Establishing the extent of the rhino population is relatively simple. By compiling reliable reports one can get a rough idea of the rhino's distribution and the data can be complemented by making short field-trips to various localities to check whether rhinos are present or not. An experienced observer will be able to see in one or two days if rhino have recently been in the area or not. For a reliable estimate of numbers however, much longer and more thorough studies are needed.

Other field studies on Sumatran rhino (Borner, 1979; Flynn & Abdullah, 1983) and Javan rhino (Schenkel & Schenkel-Hulliger, 1969) used simple census techniques based on print width measurements; such methods do not give very satisfactory results. In this study a much more refined technique was employed using plastercasts of foot prints, but the field work and later evaluation was complicated and very time consuming. Studies of several years are unrealistic for every rhino area, and usually a researcher can spend no more than a few weeks surveying any area. Accordingly results and experiences of the present study were analysed with the intention of developing a quick census method to give reliable estimates of rhino numbers.

In this chapter the techniques used to estimate the number of rhinos present in an area will be discussed and compared. The value of print width measurements will be analysed by comparison of the results of a simulated print width analysis on the material collected in the study area, with the results of the plastercast analysis. The section concludes with a discussion of the usefulness of the different standard measurements and track counts for censussing Sumatran rhino populations.

10.1 - Plastercasts in comparison to print measurements

The first scientist to do a systematic study of a rhino population by means of track analysis was Strickland (1967), who studied the rhinos in the Sungei Dusun reserve in Malaysia. He measured the width of prints, from edge of outer toe to edge of inner toe, but found great variability in print width depending on soil type. He identified three individual animals (prints of 16-18 cm, 19-21 cm, 21-23 cm), but was convinced that there were more individuals present in the reserve.

During his survey of the Gunung Leuser Reserve, Kurt (1970) also used track measurements. He measured the width of the print, the width of the front hoof and the width of the side hoofs, of clear, complete prints in hard soil. Although he does not elaborate on the criteria used for distinction between different individuals, it is clear from the values given in table 7 of his report that he accepts an individual variance in print width of up to 7 cm, and that he considers a difference of 2 or more cm between the means as sufficient for distinction. No estimates of numbers of rhinos or density were given.

From 1973 till 1975 Borner (1979) studied the Sumatran rhino in an area that partly overlaps the southern extension of the present study area. He measured more than 1000 prints from 67 fresh tracks. He measured the width of the hindfoot, and also, when possible, the width of the forefoot. He measured at least 10 prints on hard soil, and considered two tracks to be made by different animals, if the standard deviations of the mean hindfoot width did not overlap. The difference between hindfoot and forefoot width was used to give additional clue. He could identify 6 single individuals and 5 cow and calf pairs in his study area. In figure 23 Borner (1979) gives a graph of means (19.5 - 23 cm) and standard deviations (0.3 - 1.0 cm) of 22 different tracks of solitary animals. A difference in the means between two tracks of about 1 cm appeared to be large enough to indicate a different rhino.

Borner (1979) does not attempt to calculate a density from the 16 individuals he could identify from print size in his study area, but he gives a 'guesstimate' of 20 to 40 animals for the 1000 sq km core area in Gunung Leuser. This implies that, using the formula for the calculation of the population size as given on page 62 of Borner's paper, an individual rhino's home range would be between 500 and 1000 sq km.

From 1975 till 1980 Flynn conducted several censuses in the Endau-Rompin area in central Malaysia. Several survey teams simultaneously surveyed the large study area following regular routes and taking measurements of rhino tracks. This method has also been used in the Ujung Kulon reserve to census Javan rhino (Schenkel & Schenkel-Hulliger, 1969). Both the size of individual prints and distance between the tracks is measured. Whenever possible 10 clear prints are measured on firm, level ground and soil condition and age of the tracks are noted. The maximum width between the side hoofs is measured on the soil surface.

In their final analysis of the census results Flynn & Abdullah (1983) calculated for each set of measurements a 95% confidence interval around the median (not the mean), and a multiple analysis of variance was employed to compare the samples and to decide which pairs were made by different animals. Further tracks of the same size and age, but separated by more than 8 km in distance, were also considered different individuals. This yielded a minimum count of the rhinos occupying the study area.

Flynn & Abdullah (1983) assumed that their census method detected all rhinos within 2 km of the census routes, thus covering 75% of the total study area. Each census between 6 and 8 rhinos could be identified, and it was concluded that 10 rhinos normally occurred in the study area of 400 sq km, i.e. there was a rhino density of 2.5 rhino per 100 sq km. The density in the area around their study area appeared to be two or three times lower or about 1 rhino per 100 sq km. They estimated a total of 20 to 25 rhinos for the 1600 sq km of suitable habitat remaining in the Endau-Rompin area.

The densities calculated by Borner (1979) for the whole of Gunung Leuser (2-4 per 100 sq km) and those from Flynn & Abdullah (1983) for Endau-Rompin (2.5 per 100 sq km) are considerably lower than the density calculated in this study for the upper Mamas in Gunung Leuser (13-14 per 100 sq km). However Borner's figure of 16 rhinos living in his main study area, which partly covers the upper Mamas, compares well with the results of the present study, but his total estimate for the whole Gunung Leuser population, implying a density of 2 to 4 rhinos per 100 sq km, seems to be inconsistent with the results from his main study area.

The low densities calculated by Flynn and Abdullah (1983) are surprising because the Endau-Rompin area seems in many aspects to be comparable with Gunung Leuser. Both rhino areas are large and mountainous, with a similar climate and vegetation and both are relatively undisturbed by recent poaching. There seems to be no good reason for a rhino density four or five times higher in Gunung Leuser than it is in Endau-Rompin. In the past few years the author made two short trips to a part of the Endau-Rompin area (Upper Selai in 1977 and 1982) and during both trips numerous sign of rhino were encountered. The trail system and the wallows are certainly less well developed than in Gunung Leuser, but otherwise there were no apparent differences in the frequency of tracks and other signs of rhino. From my admittedly short visits to the area and the number of rhino tracks found, I believe that the difference in calculated densities for the two areas is due to different census methods rather than to real differences in rhino density.

Even with the most accurate measurements of a long series of prints, only some of the rhinos can be separated on the print width alone. Moreover the assumption of Flynn & Abdullah (1983) that the census detects all rhinos within 2 km from the census routes, is probably too optimistic, and therefore in the following calculations a distance of 1 kilometre has been used instead. The maximum distance of 8 km between tracks of the same rhino seems appropriate and implies a maximum range of about 50 sq km, a figure supported by the results of this study (see chapter 5.2). Tracks of the same rhino were rarely encountered more than 8 km apart.

To asses the usefulness of different census methods for estimating populations of Sumatran rhino, the data collected in the Mamas were analysed again using, as much as possible, the methods of Flynn & Abdullah (1983). This mimics a census in an area with a known minimum density. Each expedition was treated as a separate rhino census. For each track the average width was calculated using all the measurements available, both those taken in the field and those taken from the casts.

All the tracks, with their average widths, were plotted on maps, each expedition being considered separately. Tracks that were considered to be made by the same individual (less than about 10 mm difference in width, less than 8 km apart) were connected by lines, starting from obvious concentrations of similar-sized tracks. The number of individuals that could be detected in this way are summarised in table X below, together with the number of individuals that could be recognised from the casts (See also figure 3.28 - The uncertain records, shown by open circles in this figure, are also counted, because these casts were certainly from different if unidentified rhinos.

The area censused during the expedition was calculated using both the transect width of 2 km on either side of the patrol route, recommended by Flynn and Abdullah, and a transect width of 1 km on either side (see above). These calculations were made only for those expeditions, when most of the study area was patrolled. The calculated areas are shown in table X. Four examples of the maps made for each expedition are shown in figure 10.1 and 10.2.

The number of individuals determined from the print width analysis is in most cases lower than the number that could be recognised from the plastercasts, and it is never more than 10-12 individuals. Print width varies little between individuals (18 to 23 cm), and at most only 5 adult size classes can be recognized, each differing by 1 cm. In a study area 20 km long and 10 km wide only two individuals from each size class can be recognized and only if they are 8 km apart. More individuals can only be separated when there are juveniles. This limitation of the print width analysis was also recognized by Flynn & Abdullah (1983).

Table X: Comparison of track counts using print width and plastercast analysis (data from this study).

Expedition no	Number of rhinos present				Size of the area (sq km)	
	Print width analysis		Plastercast analysis		Strip width on either side of route	
	adults	juveniles	adults	juveniles	2 km	1 km
(2)	4	-	4	-		
(3)	3-4	-	3	-		
4	7-8	-	9	-	227	126
(5)	3-4	-	2	-		
6	10-12	2	13	2	278	156
(7)	8-9	1	4	1		
8	9-10	2-3	9	2	276	164
9	8-10	2-3	10	2	268	154
10	9	4	12	4	245	135
11	8-9	2	15	3	280	153
13	7	-	17	-	224	128
14	9-11	2	19	2	273	156
16	10	1	19	1	277	162
17	7-8	-	15	-	216	123
Average from 14 expeditions	8-10		13-14		256.4	145.6

Great differences were found in rhino ranges when identifications based on print width were compared with those based on the plastercast analysis. Of all the 'individuals' shown in the maps in the figures 10.1 and 10.2, only one was confirmed by the plastercast analysis. In all other 'individuals' there was at least one track that was misassigned and many groups were composed of tracks from three, four or even five different rhinos. Therefore the simple print width analysis is not suitable for anything more than counting numbers, and only with a few widely separated tracks. This method may be useful in areas with a very low density of rhinos, or when few tracks can be found because of bad weather. In periods of extremely heavy rainfall (like expeditions 5 and 7) measurements seem to be more useful than casts (see table X), since casts can seldom be made in periods of heavy rain. As more tracks are found results from the print width analysis underestimate the true population density.

For all the successful expeditions four population densities were calculated using both methods of counting and both calculations for the size of the area (For the print width analysis the median values were used). The results are shown graphically in figure 10.3. The densities based on the print width analysis do not differ much between expeditions, but as has been explained above these values are about the maximum number obtainable from this method. For the earlier expeditions figures from the two methods of counting are rather similar.

In the later expeditions estimates from the plastercast analysis are much higher and in fact rather close to the values calculated from the spatial distribution (see chapter 5.3.1), if a strip of 1 km on either side of the patrol routes is used to calculate the area of the census. The apparent difference in effectiveness of the plastercast analysis between the earlier and the later expeditions must be attributed to the researcher's increased experience. During the second half of the study it was realised that old tracks, with proper treatment, could also produce useable plastercasts, and a much larger number of the tracks found could be identified. To compare the effectiveness of the two methods it is best to consider only the results from the later expeditions, when it is clear that the plastercast analysis gave by far the most realistic results. The average rhino density for the expeditions 10 to 17 is 11.3, compared to 12.9 and 14.4 calculated from the animal's spatial distribution.

The estimate of rhino density obviously varies with the estimated size of the area censused. It seems that in fact the survey teams are not covering a transect width of 2 km on both sides of the trails and that a width of 1 km on either side is much more realistic. One could reduce the strip width to 800 metres to bring the values obtained with the track count more in line to those obtained from the spatial distribution. But since 1 km on either side is a convenient distance to work with and gives conservative estimates, this stip width is recommended for future use. For total population estimates plastercast analysis of prints is a more useful method than measuring print widths.

In the Endau-Rompin area Flynn and Abdullah conducted four censuses. Once they calculated a density of 2 rhinos and three times 2.5 rhinos per 100 sq km. All values calculated for the Mamas using Flynn and Abdullah's methods are higher, which would mean that in Gunung Leuser the rhino density is indeed higher than in Endau-Rompin. How much higher is difficult to

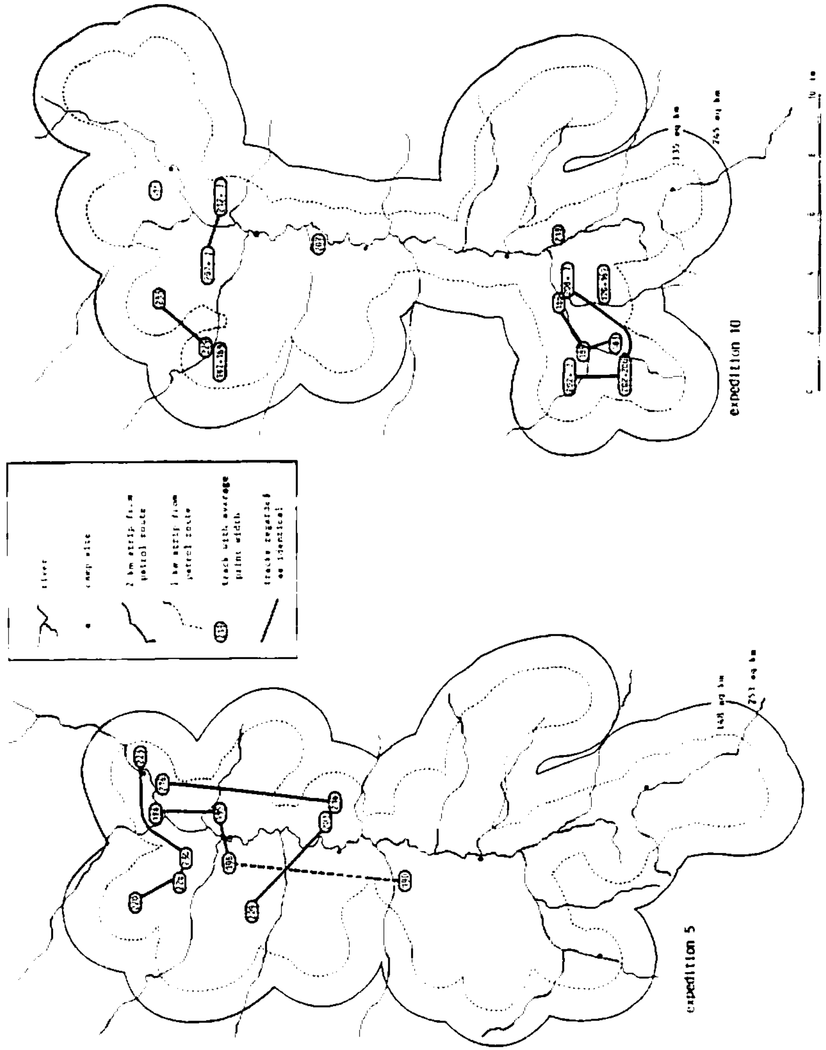


Figure 10.1 and 10.2 - Four examples of the distribution maps used to estimate the number of rhinos observed, using print width only to 'identify' individual rhinos.

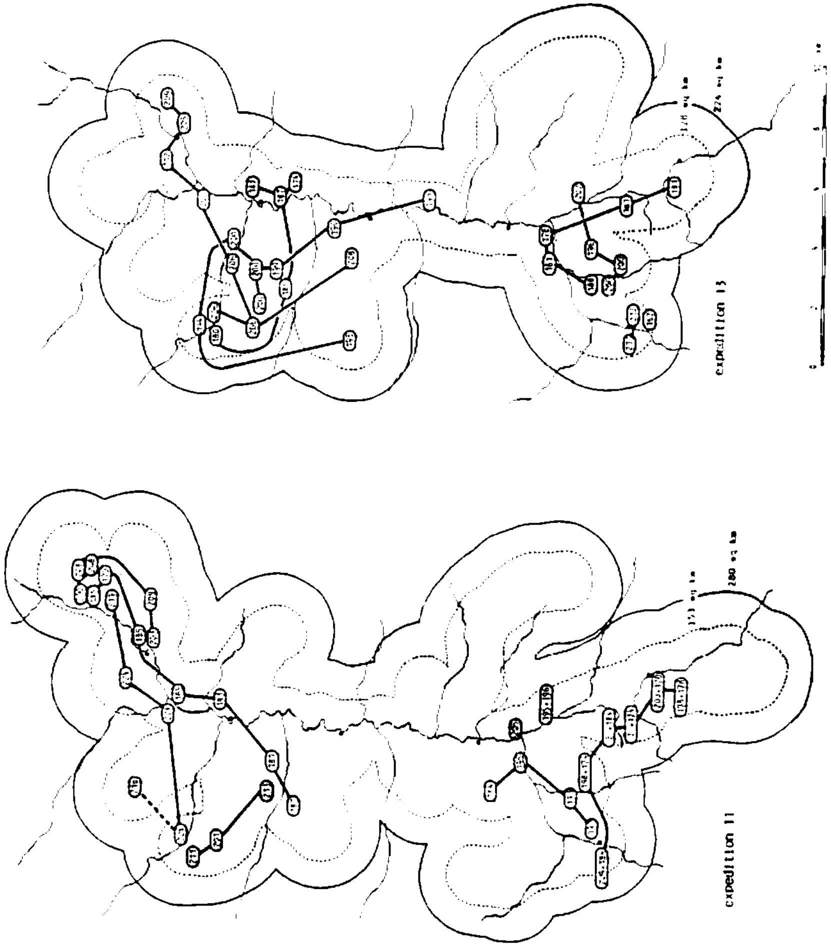


Figure 10.2

say from these figures, because the density of 3.5 rhinos per 100 sq km is about the maximum possible from the method, but it would be highly unlikely that the density in Gunung Leuser is indeed four to five times as high as it is in Endau-Rompin. More probably the density in Endau-Rompin has been underestimated and the total number of rhinos is higher than the 20 to 25 estimated by Flynn & Abdullah (1983).

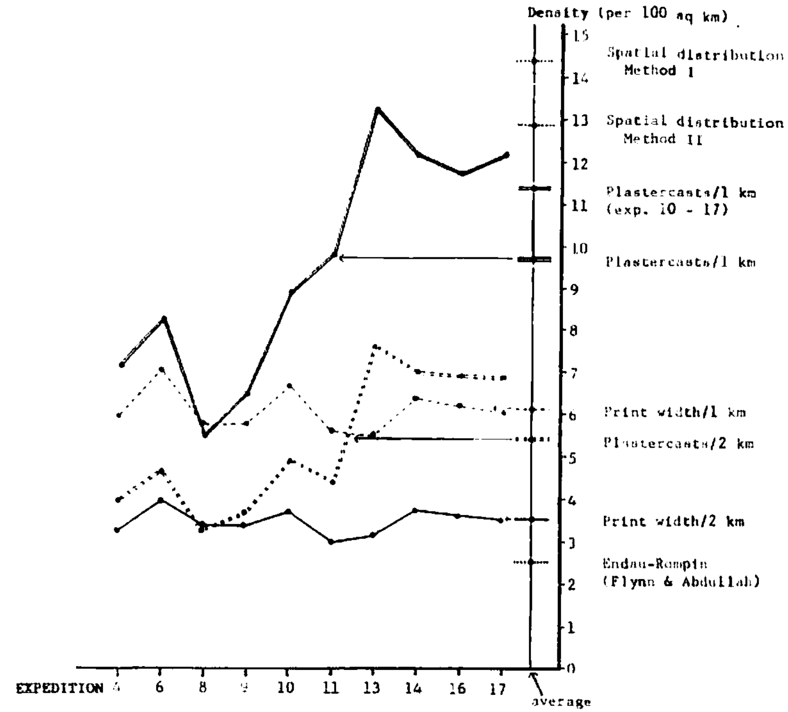


Figure 10.3 - Population density of the Sumatran rhino in the study area calculated from the number of different tracks per expedition. Both print width and plastercast analysis were used and the size of the area was calculated using a 1 km and a 2 km strip on either side of the patrol route. The average figures are compared with the density calculated from the known spatial distribution of animals (method I and II) and with results reported for the Endau-Rompin area (Flynn & Abdullah, 1983)

10.2 - Usefulness of different measurements for censussing rhino populations

Although the techniques based on print width measurements may not distinguish between all rhinos this method had some advantages over the use of plastercasts. Measurements can be made quickly of a large series and evaluation of the results requires little skill or patience; this technique can be mastered with little special training. For future studies and for better management of the remaining rhino areas a simple but reliable technique for census of rhino will be very beneficial.

In this study five standard measurements, described in chapter 3.3.3, were taken during the process of sorting. For identifying plastercasts the standard measurements were not used, because they show considerable individual variation. These measurements (or combination of measurements) were assessed for usefulness in distinguishing between tracks made by different rhino, as an alternative to using plastercasts. All measurements from one rhino were regarded as one sample and we may expect that this sample will show a similar amount of variation as a series of measurements taken from one track in the field.

To illustrate the variation found in the standard measurements of one rhino, the distributions of the measurements in one set (set 49, undoubtedly made by one rhino) and the distribu-

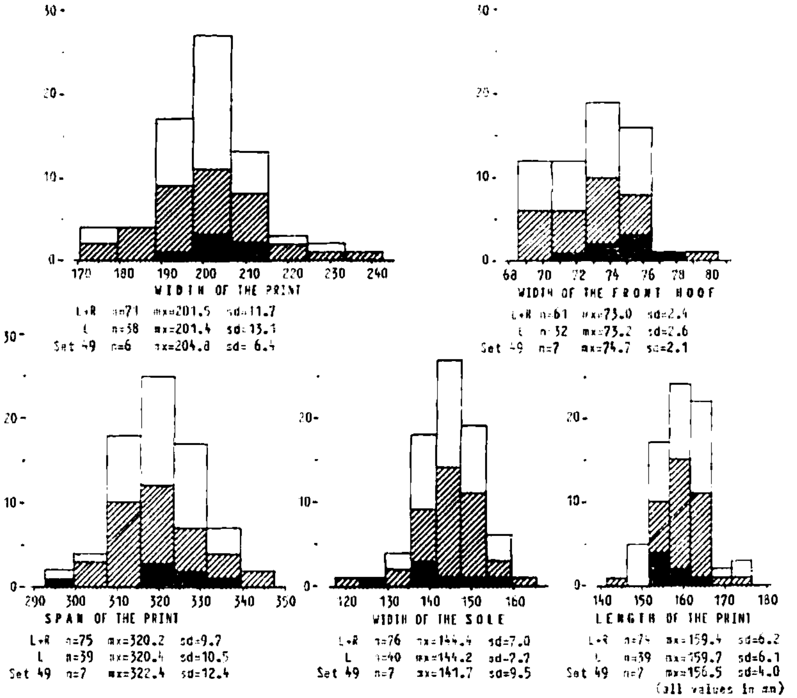


Figure 10.4 - Variability in the five standard measurements taken from the model series 520. The black area represents the values found in set 49 (casts undoubtedly made by the same rhino). The shaded area represents the values taken from the left foot casts, the white area the values from all casts. For the definition of the standard measurements see chapter 3.3.3 and figures 3.6 and 3.7

tion in one of the best series (series 520, including also set 49) are shown in figure 10.4. The black area shows the distribution of the measurements in set 49, the shaded part of the figure shows the distribution of the left foot measurements, the white area the distribution of the values for both feet together. The distribution of the left foot values is similar to the distribution for both feet together and also the means are very close. In all measurements there is a considerable amount of variability, especially in the values for the width of the print. It will be clear that a single measurement is virtually useless for distinguishing of individual's tracks, and that only means from larger samples can be used. The irregular distribution of the width of the front hoof is due to varying soil conditions, that cause biassing towards the lower values (see chapter 3.5.2).

For these measurements no distinction was made between left and right foot prints. Left and right foot are not mirror images of each other but the differences found were mainly of form and position and not of size (see also figure 10.4). Only in the rare cases of extremely long side hoofs (see chapter 3.5.4) were there slight differences in size.

The measurements considered here are taken from the plastercasts and not from tracks in the field. As many casts were broken during transport there could be slight deviations in the position of some hoofs in the mounted cast. There are also different ways to measure the width of the print, the most frequently used measurement. In this study the distance between the tips

of the side hoofs was measured, both on the plastercasts and in the field, with a pair of callipers, but others studies have measured the maximum diameter with a ruler on the soil surface, which may cause slight differences in the valuos obtained.

To find out which of the 5 standard measurements or which combination of measurements is best for distinguishing between different samples an analysis of variance was made for all the standard measurements from 36 series (one 'young' and two single-cast series were excluded). The differences between the means were tested for significance at the 5% level, using the method of Newman and Keuls (de Jonge, 1964). This is an analysis of variance for more than two samples of different sizes, in which the number of intermediate means is taken into account.

The width of the print and the width of the sole were the least useful measurements for distinguishing between individual rhinos. Significant differences were found in less than one-third of the compared means. Only when measurements from a sample of a very large rhino were compared with those of a very small animal was the difference significant, in about 20 intermediate samples there was no significant difference. The span of the print and the length of the print proved to be more useful measurements, with about half of the compared means differing significantly. By far the best results were obtained with the width of the front hoof. For this value almost 78% of the compared means differed significantly, with only about 5 intermediate samples not significantly different.

With the exception of the width of the front hoof the use of only one measurement is of limited value for distinguishing between tracks. To find out which combination of measurements was most useful for identifying individual rhinos the combined results of all five analyses (in figure 10.5) were studied further. Of all the 630 possible comparisons between series 90% differed significantly in at least one of the standard measurements. But from all 176 compared pairs which differed only in one standard measurement, more than 78% differ in the width of the front hoof. The span and the length of the print each contribute only about 3% of the sample's significance; in fact these measurements can easily be omitted, as they are of little help in distinguishing between individual prints.

The width of the front hoof is the most useful diagnostic character, but this measurement can only be taken from a plastercast. If it is not possible to take plaster and to make plastercasts the front hoof width cannot be measured. From the four other measurements only 68% of the compared pairs show a significant difference; this is less than the number that can be distinguished using the front hoof width alone. The next most useful measurement is the span of the print, but the width of the print is the least important value. The best results are obtained by measuring the print span (including the sole) and the length of the print. However the diagnostic value of each of these measurements is so low that it is debatable whether it is worth the trouble to take more than the simplest of measurements, i.e. the width of the print, and then only when casts cannot be made. Additional measurements will only marginally increase the number of individuals whose tracks can be separated. It is probably not even worth the time and energy spent on the field trip.

If casts of front hoofs can be made quite satisfactory results can be expected. The most useful combination of measurements is a combination of the width of the front hoof, together with the width of the print and the length of the print. In 87.9% of the compared pairs of the 36 series one or more of these three showed a significant difference. With this combination of measurements one can separate most of the individual rhino's tracks. With further evidence from morphological features shown by the front hoof casts, the results might be almost as good as with complete plastercasts. It is much easier to find some good prints of front hoofs than it is to find good complete prints and one needs only a small amount of plaster to cast the hoofs.

Results are much more meaningful if the sample includes measurements from 10 or more prints. Best results are obtained with measurements from at least 20 prints in a track. For front hoof measurements one should aim, for practical reasons, at 5 casts each from both the left and right feet.

With about 20 measurements of the width and the length of the print and about 10 casts of front hoofs of every track encountered, most individual rhinos can be recognized easily. A few weeks in the field and about one kilogram of plaster per day is usually sufficient for adaquate results. As can be seen in the figures 3.5 and 10.3 experience is an important factor in this sort of work, and one should expect suboptimal results during the first few censuses.

There were considerable differences in numbers of rhinos found on different expeditions, so if only one census is performed in an area one should expect a rather wide margin of error. The variability of the weather is probably the most important factor influencing the results. Failure to identify all the tracks and migration of rhinos in or out of the area will also affect the results. In very dry conditions one may miss tracks in the field. Under normal conditions one will only find tracks of a few days old, but one can assume that most of the rhinos responsible are still in the study area. During periods of prolonged dry weather tracks remain for a much longer period of time, and the animals responsible may have left the study area. In dry weather conditions one may count too many animals, in very wet condition too few, as some will be missed.

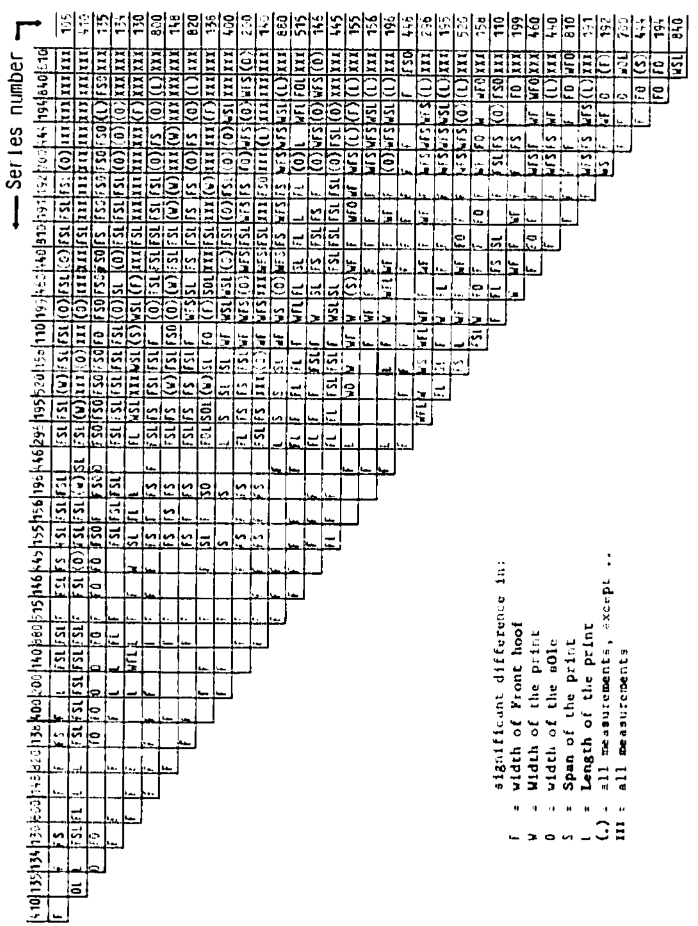


Figure 10.5 - The results of the analysis of variance of all five standard measurements between the different series. The figure shows each pair of series in which significant differences were found between standard measurements

10.3 - Track counts for estimating rhino density

The number of tracks of a species found in a certain area must be related to the number of animals living in that area. Under certain conditions the number of tracks are proportional to the density of the species. By comparison of track count results with those for an area where density of animals is known the density in the survey area can be calculated. For Sumatran rhino tracks counts from other areas can be compared with the upper Mamas.

By relating the number of fresh tracks to the kilometre hour (km.h) score (see chapter 5.4.1), the effects of the weather and the intensity of the patrolling can be eliminated. Fresh track counts from different areas or taken on different occasions can be compared. The number of fresh tracks found in relation to the km.h score is presumed to be constant in an area with a certain density of rhinos.

For all expeditions the total km.h score (the sum of the km.h scores for each section patrolled) was calculated and the number of fresh tracks were counted. In this case the tracks were not counted per section but over the whole study area. All tracks found close together and believed made by the same rhino were counted as one animal, as were tracks that followed the same route up and down again. The number of fresh tracks per 10 000 km.h for each expedition is shown in figure 10.6. The expeditions are arranged according to the km.h score, because with an increased score the deviation from the mean is expected to be less.

The km.h scores range from 3000.98 (expedition 3) to 18 108.71 (expedition 14). The variation can be attributed to the varying amount of rain during the expeditions. The number of fresh tracks per 10 000 km.h shows great variation on the lefthand side of the scale, but for the more successful expeditions with high km.h scores the values are much closer to the average. Fresh track counts made during trips with a km.h score of less than 10 000 appear to be useless, because the results are too variable to make a correlation with density.

The total km.h score for all expeditions together is 137 837.18, with 127 fresh tracks, or 9.2 fresh tracks per 10 000 km.h. The average for all the expeditions shown in figure 10.6 is 9.7 with a standard deviation of 3.4. If only the expeditions with a score of more than 10 000 km.h are considered the average is 8.4, with a standard deviation of 1.8. In the upper Mamas

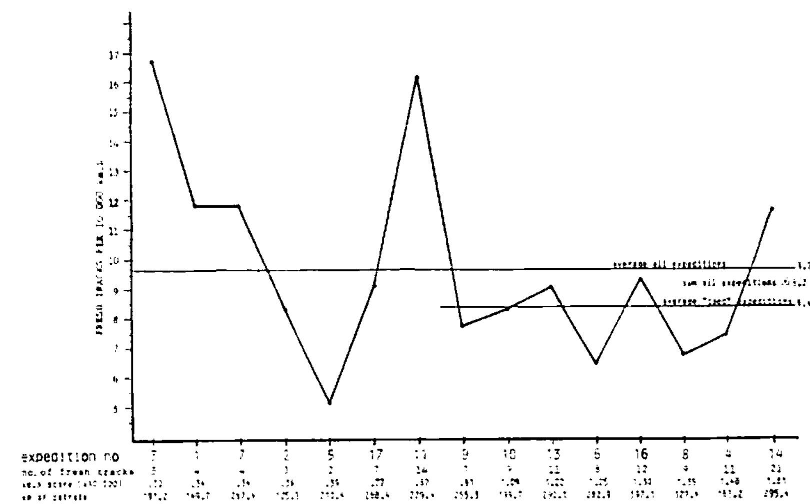


Figure 10.6 - The relationship between the number of fresh tracks found and the "patrolling activity" expressed as the kilometre hour score per expedition. This demonstrates the correlation between the fresh track count and the density of the rhino

the density of rhinos was calculated at about 14 per 100 sq km (see chapter 5.3.1), and on average about 9 fresh tracks are found every 10 000 km.h of patrolling. So one may calculate the density of the rhino in number per 100 sq km as the 14/9 of the number of fresh tracks per 10 000 km.h of patrolling.

Because good results are only possible if one is able to survey more than 10 000 km.h in a certain area - in practice this takes at least three weeks in the field and at least 300 km of patrolling - this method is only recommended to support a rhino census using track identification, or for those making an incidental rhino census during long periods in the field engaged in other research. The procedure for a fresh track count will be described in detail in a separate paper (in press).

10.4 - Censussing rhino

In previous chapters it has been demonstrated that it is possible to make reasonably reliable estimates of numbers and density of Sumatran rhinos using relatively simple census techniques. The use of print width measurements alone is insufficient, and should only be used in areas with a very low density of rhino. Counting fresh tracks can be a useful procedure under certain conditions, but by far the best results are obtained when tracks are identified with the help of plastercasts of front hoofs and sets of two measurements from the prints. The use of plastercasts is essential for a good census, and if casts are made of front hoofs only the researcher needs to carry only small quantities of plaster and finished casts.

Detailed procedures for a census of Sumatran rhino are described in a separate paper (to be published as an instruction manual for those involved in field surveys for the drafting of an international conservation masterplan for the Sumatran rhino, currently undertaken by IUCN). Here only a short description is given.

A fresh track count is most useful if the researcher can spend a relatively long time in the area and can cover a large distance. Under normal conditions in Southeast Asia one must spend at least three weeks in the field and cover at least 300 km of patrol routes, to attain a km.h score of 10 000. It is also possible to accumulate the results from several shorter trips in the same area and this census method could be used successfully by field personnel in conservation areas, who usually spend a considerable amount of time on patrols. On rhino surveys a fresh track count should always be accompanied by track identification.

It is essential to distinguish between fresh (not affected by rain) and old tracks. The patrol route must be carefully mapped on a good large-scale map and is later divided in convenient sections, ½ to 1½ km long. The length of each section must be measured on the route map. Daily records must be kept of rainfall and for each section of the patrol route the approximate number of hours between the end of the last rain and the time of the patrol is calculated. This is multiplied with the length of the section in km and the sum of the products is the km.h score for the survey. The number of clearly distinct fresh tracks is counted and the density of the rhino in the area (number per 100 sq km) is estimated as 14/9 of the the number of fresh tracks (number per 10 000 km.h).

For track identification one can use fresh tracks and also older tracks that have been little blurred by rain. For each track encountered the width and length of a series of prints is measured, using a pair of callipers. The width of the print is measured between the tips of the side hoofs and the length is measured in two stages, from the middle of the line through the anterior edges of the side hoofs to the centre of the fold between the front hoof and sole, and from the last point to the tip of the front hoof (see figure 3.6). At least 20 good prints in fairly firm soil should be measured, preferably on level ground. The width of the sole and the span can also be measured, but these measurements are of little help in distinguishing individuals.

To measure the width of the front hoof one should make a number of casts of good clear prints of front hoofs, carefully cleaned before casting. Five casts of left and five of right foot prints will usually suffice. No more than about 1 kilogram of plaster will be needed for each track. If there is more plaster one can make a few casts of complete prints. The width of the front hoof is measured with a calliper rule (see the examples in figure 3.7). A few of the best plastercasts should be preserved for comparison of the morphological characteristics.

The samples of measurements are tested for significant differences with an appropriate statistical technique (multiple analysis of variance - A simplified method without statistical calculations is described in a separate paper on the census procedures). By combining the groups of samples that show significant differences in the different measurements, the minimum number of rhinos in the study area can be estimated. Tracks found on the same survey but 8 km or more apart are ascribed to different rhinos. The system can be further refined by comparing specimen casts and checking other data, such as dates and directions of movement, for records to support or refute the identification.

The size of the census area is calculated from a map, by drawing a 1 kilometre wide zone around the patrol routes and the density of rhinos is calculated. A suitable study area for Sumatran rhino should be 100 to 200 sq km, covered as completely as possible by patrol routes. The routes should be evenly spaced, about 2 to 4 km apart and with a total length of 75 km or more.

It is difficult to determine the optimum length for a census; it depends very much on the prevailing weather conditions and terrain. Ideally measurements should be gathered from at least 20 to 30 clearly distinct tracks. Under favourable weather conditions this may take 2 to 4 weeks in the field, every day covering 7 or more km of the patrol routes. In periods of heavy daily rainfall it will take much longer and periods of heavy rain should be avoided for a rhino census. The duration of the census can be shortened if more than one team operates simultaneously in the area.

It will be clear that any serious census will require a considerable effort. Apart from the difficulties in penetrating the remote areas where most rhinos are found these days, the researcher will have to spend many days in the rhino area and walk long distances, usually in difficult mountainous terrain. Although the technique is simple, it can only be mastered properly through experience, and one should not expect good results in the first few trials.

10.5 - Recommendations for further ecological study

In this study emphasis was placed on patrolling a large area to collect information on rhino distribution and individual ranges. This left little time for following single tracks and studying other aspects of the rhino's life. Only limited cursory information was obtained on the rhino's daily activity, social system and feeding behaviour. The remoteness of the study area and the difficult access meant that only a relatively small part of the researcher's time could be spent inside the rhino's habitat, which limited the possibilities for more detailed observations on specific tracks and situations.

This study has proved that it is possible to investigate many aspects of the rhino's life without ever coming close to the animal. From careful study of their tracks a great deal can be learned about the activities of individual rhinos. Apart from details of the animal's spatial and temporal distribution, on which this study concentrated, studying tracks gives information of feeding and foodplant choice, daily movements, daily rhythm, social systems and reproduction. Following individual tracks, and more concentrated patrolling of a smaller area will yield more information on those aspects of rhino ecology than was possible in this study.

The Sumatran rhino is the largest herbivore that lives exclusively in the tropical rainforest, a habitat characterized by the constancy of environmental conditions. Only a few species of larger harbivores (tapir, sambar, muntjak, serow and wild pig) share this habitat with the rhino, and in general very little is known about the ecology of these animals, because of the difficulties of observing ground-living animals in the tropical forest. Further study of the rhino's ecology will not only add to our knowledge of this species' biology, but will also give a better understanding of the living conditions on the forest floor. Most zoological research in rainforest to date has concentrated on the ecology of canopy-living animals.

The results of this study form a sound basis for further research on the rhino's ecology in the upper Mamas, if the problems of access to the area can be solved. More detailed studies are only feasible if a permanent base camp can be established in the area and substantial funds allocated for regular helicopter transport of personnel and goods to the area.

Continued research in the upper Mamas is not only recommended from a scientific point of view, but is also urgently needed to protect one of the last viable populations of the Sumatran rhino. The existing management structure of the Gunung Leuser National Park cannot give the rhino adequate protection against poaching. Although there is a special task force for the protection of the rhinos, the rhino area has not been patrolled regularly since the end of this study (1981), and probably rhino poachers have started trapping there again. Since regular surveys of the area are beyond the scope of the park management at present, a research programme based permanently in the upper Mamas, would help prevent the total extermination of the rhino in Gunung Leuser.

CHAPTER 11 - CONSERVATION OF THE SUMATRAN RHINO

11.1 - The chances for survival

The present situation for the Sumatran rhino has been discussed in detail in appendix B. Although this study suggests that there are probably considerably more Sumatran rhinos left than previously believed (see van Strien, 1974), this does not mean that their chances for survival should be rated highly. While there is no immediate reason to worry about the viability of some of the remaining populations, few are safe from poachers or from loss of habitat. More rhino populations are now included within reserve boundaries, but few of these reserves afford more than token protection. In all the countries througnout its distribution the rhino has complete legal protection, but such legislation is rarely enforced. Moreover many reserves are understaffed and underequipped and most are under threat from developments that violate the integrity of the reserve.

Threats vary from area to area and since the situation can change rapidly with new political, economic and military developments rhino populations are nowhere really safe. At present the rhino population in the Taman Negara in west Malaysia is probably most secure. The park is legally well established, it has a good management structure and active guardforce and its integrity has so far been preserved against pressure from development sides. Unfortunately the number of rhinos surviving is probably rather low (see appendix B).

The Endau-Rompin area, harbours the largest Malaysian population, which seems relatively safe. This area has only recently been declared a reserve. There seems to be very little hunting pressure in this region and there is probably a good chance to establish a worthwhile reserve there.

Probably the only rhinos left in Borneo, those in southeast Sabah, are seriously threatened by hunting. Part of their habitat is now protected in the Tabin wildlife reserve, but many rhinos remain outside the reserve area. In several areas there is much pressure on their habitat from the human population for agricultural developments, and the logging operations make most areas accessible to hunters.

By far the largest populations of Sumatran rhino are left on the island of Sumatra, mostly in established reserves. The Gunung Leuser National Park (in fact a conglomerate of 7 adjoining wildlife reserves) has good legal protection and the mountainous topography protects the rhino's habitat. Unfortunately the park guardforce is still inadequate, more from the point of quality than quantity, and there are no means to prevent hunters from entering the park. Unless appropriate measures are taken soon (see chapter 10.5) it is feared that rhino hunting may begin again in the study area now that the research team has left the upper Mamas.

Probably the largest surviving population of Sumatran rhinos occurs in the Kerinci-Seblat area. The area was declared a National Park in 1982, but in fact it is a mosaic of game-, nature-, hunting- and forest reserves. The term 'national park' has no legal meaning in Indonesia and the foresters strongly oppose reserving such a large expanse of land. Management structures for the Kerinci-Seblat park are virtually non-existant. The rhinos are probably fairly well protected by the topography and remoteness of the area and there seems to be little interest in rhino hunting in this part of Sumatra, but the area is under heavy pressure from logging, agriculture and resettlement schemes. There is still time to create an effective protection and management structure for the park, but it is very uncertain whether this will be achieved before the area will be fragmented by further forest clearance.

The Barisan Selatan reserve in southern Sumatra suffers from the same problems. The legal status is fairly clear, but the park management is ineffective and there is heavy pressure from the overpopulated surrounding areas. The reserve is long and narrow and will be fragmented soon.

Elsewhere only the Phu Khio reserve in Thailand seems to warrant special attention. There may be more than a few rhinos left there at present, but information is inadequate. The same is true for the rhino's status in Burma, Thailand, Laos, Vietnam and Cambodia. Viable populations of rhinos may survive in these countries, but a thorough survey is necessary to determine population numbers.

Protection against poaching is important to ensure the short-term survival of the Sumatran rhino, but in the longer term, the size of the population and the size of the available habitat are of prime importance. The smaller the size of the remaining population the less its chances of survival. Smaller populations are much more susceptible to random fluctuations in numbers and have less genetic variability.

In recent years various theories have been developed on the relation between population size and genetic fitness and the relation between the size of the population and its chances for survival. To minimize the negative effects of inbreeding and genetic drift on the fitness of a population its size should not fall below a certain minimum number. For short-term survival - that is over the next few generations - the minimum number of breeding animals is assumed to be an effective population size of 50. For long-term survival, however a minimum effective size of 500 individuals is recommended (Frankel & Soule, 1981).

Although a breeding population of 500 animals is probably necessary to guarantee the population's longterm fitness and survival, this does not mean that smaller populations can be neglected. Much depends on how long the population has survived at a low level. If the population is low only for a short period and is allowed to grow back to a reasonable size, the damage is limited. Only if populations exist for several generations at a very low level will the erosion of the genetic variability become serious and survival become unlikely. For those populations confined to small remnants of habitat capture and translocation or captive breeding might be a better strategy for survival than remaining in situ.

Since the sex ratio is approximately 1:1 and mating is probably random, the effective population size is about equal to the number of fertile adults. The minimum total population (including 40% sub-adults) for immediate fitness and long-term fitness can therefore be estimated at respectively 70 and 700 individuals. None of the existing populations reach the higher value, but the Kerinci Seblat population may number 250 to 500 individuals. At least two of the Sumatran populations - Leuser and Kerinci - number more than the lower value of 70 individuals.

Therefore at the moment none of the remaining Sumatran populations can be said to be fit for long-term survival, using genetic criteria, but a number are certainly 'safe' for the next few generations, if left in peace. If the average density of the Sumatran rhino is taken as 10 animals per 100 sq km, the area that could hold a population large enough to safeguard long-term survival must be at least 7000 sq km. Leuser and Kerinci are both bigger than this, Taman Negara in west Malaysia covers about 60% of this minimum area, but all the other reserves are considerably smaller. From these calculations it seems that only the rhino populations in Leuser and Kerinci and possibly in Taman Negara are assured of long-term survival, provided that the depleted populations are allowed to recover.

This is encouraging because two of these areas (Leuser and Taman Negara) are relatively 'safe' and the third still has the potential to become a safe refuge. With a few more reserves of this size in Borneo, Thailand and Burma and if possible one more in Malaysia the Sumatran rhino could soon be removed from the list of most threatened mammals. In the future it will become more difficult to set aside continuous areas of this size for conservation, but on Borneo and possibly also in Thailand and Burma this is still feasible.

It is more difficult to evaluate the significance of the smaller areas. No reserve should be created and managed for just one species, but in this discussion only the reserve's value for the Sumatran rhinoceros is taken into consideration. Many of the other areas contain rhinos in numbers far below the required minimum, but several are of such size that they could harbour a moderately large population of 100 to 200 animals, which can be expected to survive for a good many generations. The chances for long-term survival must be rated lower there, but it depends solely on one's views on conservation expectations of future developments, how this affects the plans and decisions made now. If one has a static view of conservation and sees reserves as permanent entities, in which the animals are locked up for ever, there is probably not much point in spending energy and effort in preserving populations that have a less than optimal chance for survival.

If reserves are seen as temporary refuges however, the protection of small populations makes almost as much sense as the preservation of larger ones. In the future it may be possible for the species range to expand, or landuse patterns may be established that allow for coexistence between man and the rhino. In this situation it may be better to have several smaller populations, scattered over the country, from which the rhinos can spread.

It is therefore worthwhile to protect any area larger than 500 to 700 sq km which contains at least 4 to 5 rhinos. Animals from smaller populations in smaller areas not already within reserves might be used for translocation or breeding schemes.

The Sumatran rhino is very sensitive to all forms of disturbance. Whenever a rhino is met in the forest it dashes off immediately after being alerted. An alarmed rhino continues to run for a long way, going straight through the densest and thorniest growth, so it is not unlikely that rhinos will leave areas where they are often disturbed by human presence. They retreat into the forest beyond the limits where fisherman and rattan collectors usually venture and therefore they are normally only found in the remoter parts where man does not often go.

Logging operations will drive away rhinos from the area (Flynn, 1978), but they may return to the area. In Sabah the rhinos returned 3 to 5 years after logging operations had ceased (pers. comm. J. Payne). So rhinos may survive in areas of forest that are logged. If timber-felling is worked in such a way that the rhinos have a chance to retreat before the logging operations, there is a good chance that the rhino will adapt and survive the timber-felling. Logging operations are not the greatest threat to the rhino population, but hunters and settlers invade the area once logging-operations have opened it up.

Production forests adjacent to smaller reserves should be managed in such a way that the rhino, and other large mammals, get a chance to survive there. This would substantially increase the area available to the population without increasing the reserved land area, yet may only require slight adjustments to the cutting schemes and the strict prevention of hunting and legal or illegal settlement in the area.

Most existing populations are seriously depleted by hunting, and in several areas only a few scattered individuals are left, so even with the most rigorous protection it is far from certain that the populations will recover. In some areas the remaining rhinos might be too scattered or otherwise disturbed to reproduce. Even if animals do breed it will take many years before the population will be back to its optimal level. Recruitment is slow, one young in 4 years or more (see chapter 6.4), and it will take 15 or more years for the population to double, so spectacular results cannot be expected in less than half a century.

11.2 - Design and management of rhino reserves

In the previous chapter we discussed the minimum size for a reserve to protect Sumatran rhino. There is of course no maximum, the larger the better and if other animals are also taken into consideration the recommended minimum size of a reserve should probably be even larger. For instance a reserve designed to protect samples of the whole Sumatran mammal fauna, including such wide ranging species as elephant and tiger, should be much larger than the 7000 sq km recommended for the Sumatran rhinoceros alone.

The Sumatran rhino is not nomadic and males and females are fairly evenly distributed over the area, with overlapping ranges. The amount of suitable habitat available seems to be the main factor determining the carrying capacity. Adult males range over 50 sq km or more and make occasional excursions further afield and juveniles also wander over considerable areas, but for the most part the Sumatran rhino remains in a large but well-defined home range. This and the animal's natural shyness mean that crop-raiding by rhinos is not a serious problem and rhino numbers are so low at present that animals need not venture into less suitable habitat.

If a sufficiently large area of suitable habitat can be protected from any disturbance little else has to be done in the form of management to preserve the rhino population. Formerly the Sumatran rhinos ranged from the flat lowlands to the tops of the highest mountains (van Strien, 1974). Today they have almost completely disappeared form the lowlands, and most remaining populations are found in mountainous areas up to about 2000 meters. In Leuser rhinos live between 1200 and 2000 metres altitude and there are no indications that they are occupying sub-optimal habitat. There are still vast areas of these mid-montane forests and they are of little value for agriculture or forestry, at least not at the moment. Rhinos are less affected than other mammals by the loss of the lowlands, as is happening in most reserves through legal and illegal human settlements.

The habitat suitable for a Sumatran rhino can be defined as closed evergreen forest. Rhinos clearly avoid open places and find their food in the undergrowth and understory in the forest or in patches of dense shrub on landslides, treefalls and along river banks. Almost all surviving rhinos are found in areas of primary forest, but that is probably because of disturbance and hunting in areas where the forest has been cleared by man, than because of a strict preference for this forest type. Old secondary forest may be suitable for Sumatran rhinos, if they are not disturbed there.

In any rhino area human disturbance should be as little as possible. In reserves all activities other than patrols and surveys needed to protect the rhino (and the area) should be banned. In non-sanctuary areas where the rhino must live with some form of human landuse, the form and duration of the human activities should be carefully planned and guided.

If timber extraction is taking place in a rhino area, operations should be carried out in such a way that rhinos will not be driven out permanently. Most importantly the disturbance should be confined to as small an area as possible and for a limited duration. Small blocks of forest should be worked in a tight schedule, so that surveying, opening and finishing of the work follows quickly, and the duration of logging activities can be kept to a minimum. Activity centres should be at least 10 to 15 km apart, so that animals can seek refuge in undisturbed forest between. Strip logging may be effective with logging along parallel strips 10 to 15 km apart.

After logging operations the area should be abandoned and all access routes blocked. The area should be under guard and no activities other than preventive patrols allowed. During logging the work should be supervised by personnel from the conservation agencies, who should also survey the area before the operation commences. Special care should be taken not to disturb saltlicks and other places where rhino concentrate. The access to saltlicks should not be blocked

and in principle no activities should be allowed within about 2 km of a saltlick. If a female rhino with calf has been observed it will be better to ban all activities within 5 km of the saltlick.

The saltlicks are of great importance to the rhinos, at least in the mountainous areas. At lower altitudes they may be less important because of higher mineral concentrations in soil and water, but in the upper Mamas saltlicks form a focal point for the rhinos' distribution and activities. In designing a reserve it is important to know where these saltlicks are situated and to ensure their inclusion, as well as a good proportion of land around the lick, to allow free access. For many reserves this is not the case because the licks are usually found along the sides of the major valleys, where man has often settled already. Most of the saltlicks along the Alas valley are outside the park or are heavily disturbed. This could have contributed, together with the hunting, to the complete disappearance of the rhino from the slopes of the Alas valley since 1960. Now, except on occasional visits, rhinos are not found in the Alas valley despite there being a breeding population only some 10 - 15 km further inside the Gunung Leuser reserve.

In principle all saltlicks in an area should be included within the reserve, and extra care should be taken to avoid disturbance there. If all the area around a saltlick cannot be included in the park a wide corridor should be created to allow unhindered access by the animals. These areas should be well guarded because the concentration of animals attracts hunters.

Another point to consider is the location of the reserve boundaries. The larger rivers are good reserve boundaries as they are important features for the rhino and each individual usually remains on one side of the river. If it crosses the river it usually soon returns to its home side (see chapter 7.2). Boundaries along ridges are not recommended because the rhinos generally use both sides of a ridge and will spend much of their time outside the protection of the reserve.

Many of the valleys around the existing reserves are already heavily populated and usually the reserve boundary is located somewhere on the slopes. The rhinos living there are likely to cross reserve boundaries to visit the river before returning to the forest. On such visits they are in danger of being killed and may cause damage to crops. For new reserves and for extensions of existing reserves boundaries should be located along major rivers and if possible the boundaries of existing reserves should be moved from the slopes to the river bank.

The decline of the Sumatran rhino over most of its historic range is mainly due to heavy hunting pressure for horns and other parts of the body, for which there is a good market. Day to day management of a rhino population will therefore mainly consist of prevention and control of poaching. The vast mountainous reserves where the last rhino populations can be found are very difficult to control. Once people are inside the reserve they can only be detected by ground patrols who are very familiar with the area and who are skilled at reading tracks and are as hardy and daring as the poachers.

This means that in areas liable to rhino hunting special patrol units should be formed, from men familiar with the local terrain and capable of spending long periods in the field with minimal outside assistance. Many park guards have a city background or feel themselves too well educated for such physical endeavour, and it is better to form special units, with former poachers proving able recruits. These people know the area and the trade and can be very good field personnel, provided that their work can be controlled effectively.

In Sumatra rhino hunting usually involves traps and these are relatively easy to find. The hunters must visit their traps regularly and are likely to attract attention and leave very clear trails. Poachers must spend a lot of time and energy to bag a rhino and if the risks of the traps being discovered and destroyed are high, poachers will not take the trouble. Regular patrols in the rhino areas will deter most attempts to poach rhino.

In Borneo it is more difficult, because there rhino are aften hunted on foot, by persistent persuit until the hunters get a chance to shoot the animals. These hunters are capable of living for a long time in the forest with a minimum of equipment, and they are more difficult to track. Here too however, patrol groups manned by former rhino hunters will be an active deterrent to would-be poachers.

11.3 - A strategy for survival of the Sumatran rhino

The Sumatran rhino is one of the most threatened mammal species in the world, with remnant populations scattered over several states. All are legally protected and part of the remaining habitat is protected in reserves. Other Sumatran rhino populations survive in remote parts of Southeast Asia, but very little is known about their status and all are threatened in some degree by hunting or loss of habitat.

To strengthen and coordinate the efforts of the national governments to protect and manage Sumatran rhino populations, a comprehensive and cohesive survival strategy for this species would be of great value. Such a plan should be multinational and collaborative in nature, should cover all aspects of conservation of the rhino over its total range and should be based on sound evaluation of the status of the existing populations. In such a strategy the following points should be included; they are not listed in order of importance.

1- Strengthening the legal basis and the management structures in the existing large reserves that harbour good rhino populations (Sumatra - Gunung Leuser, Kerinci; west Malaysia - Taman Negara, Endau-Rompin; Sabah - Tabin). Where possible park areas should be further extended.

2- Creation of more large (more than 7000 sq km) reserves in areas where relatively large populations of Sumatran rhino are still found. On Borneo such areas could be established in southeast Sabah, and in central Borneo if the rhino survives there. In Malaysia one might try to enlarge the existing reserves. A few large reserves should be established in Thailand and Burma, if good populations of rhinos remain there.

3- Strengthening of existing reserves or creation of new reserves of at least 1000 sq km where rhinos occur. Cooperative management schemes should be developed in adjacent timber production areas so that existing rhino populations are not eliminated and so that rhinos can survive in these areas after logging.

4- In areas where the habitat is under immediate threat and cannot be protected rhinos should be captured and translocated to other reserves or to a captive breeding unit.

5- Establishment of special patrol units in areas where the rhino is endangered by hunting. These units should be staffed with competent personnel and be sufficiently equipped and financed to be able to function properly.

6- Surveys of areas where rhinos are believed to occur to establish their range and to formulate management proposals. All existing reserves should be thoroughly surveyed to determine the distribution and density of rhinos.

7- Continued monitoring of the main rhino populations with a full-scale census at least every five years. This should be done by competent wildlife ecologists in cooperation with the anti poaching patrol units.

8- Better enforcement of the existing legislation concerning the protection of the Sumatran rhinoceros, and where necessary the creation of additional legislation and policing facilities, to deter poachers.

9- A complete ban on, and better control of, all trade in rhino products, and a campaign to replace the use of rhino horn in traditional medicines with other products that have similar effects but are not taken from rare and endangered animals.

10- Establishment and encouragement of research programmes in rhino areas, as their presence is a stimulant to better management and protection.

APPENDIX A: Hoofs of Sumatran rhino

A front hoof from each rhino identified in the study area is shown in figures A.1 to A.5. In figure A.6 and A.7 a selection of side hoofs is shown.

The drawings are slightly reduced in size.

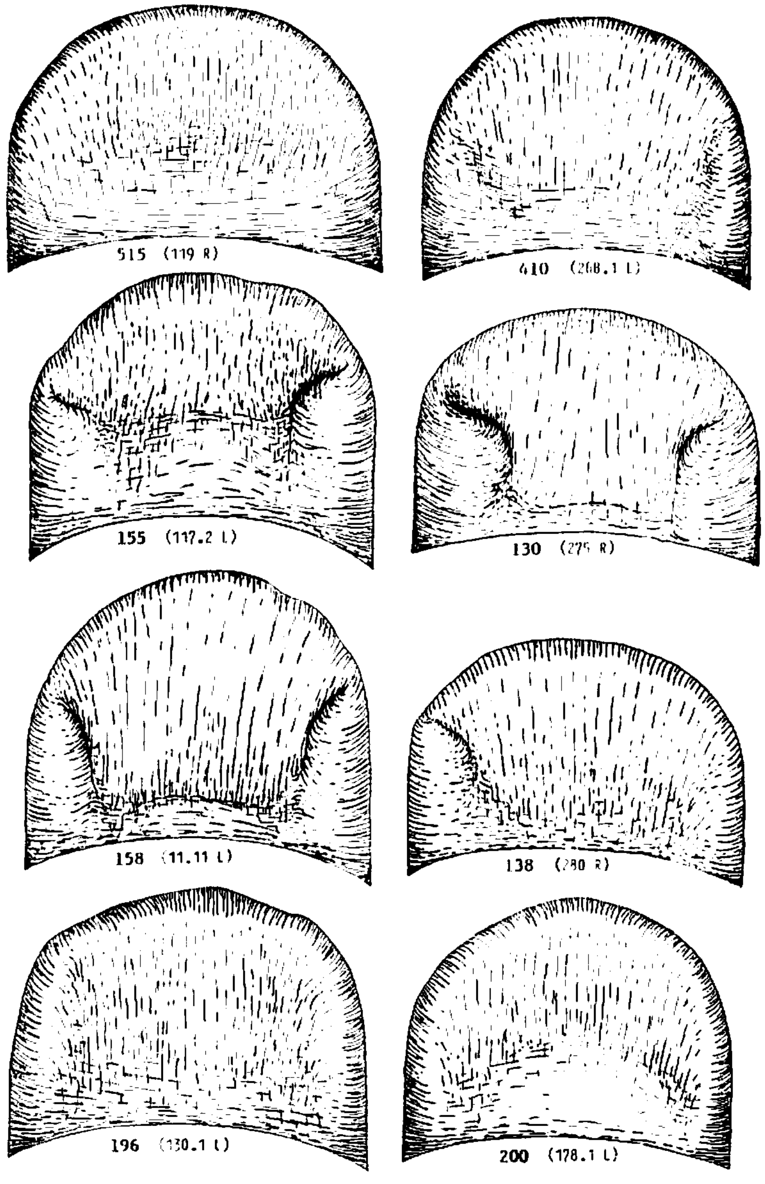


Figure A.1 Females (left) with their young (right) after separation

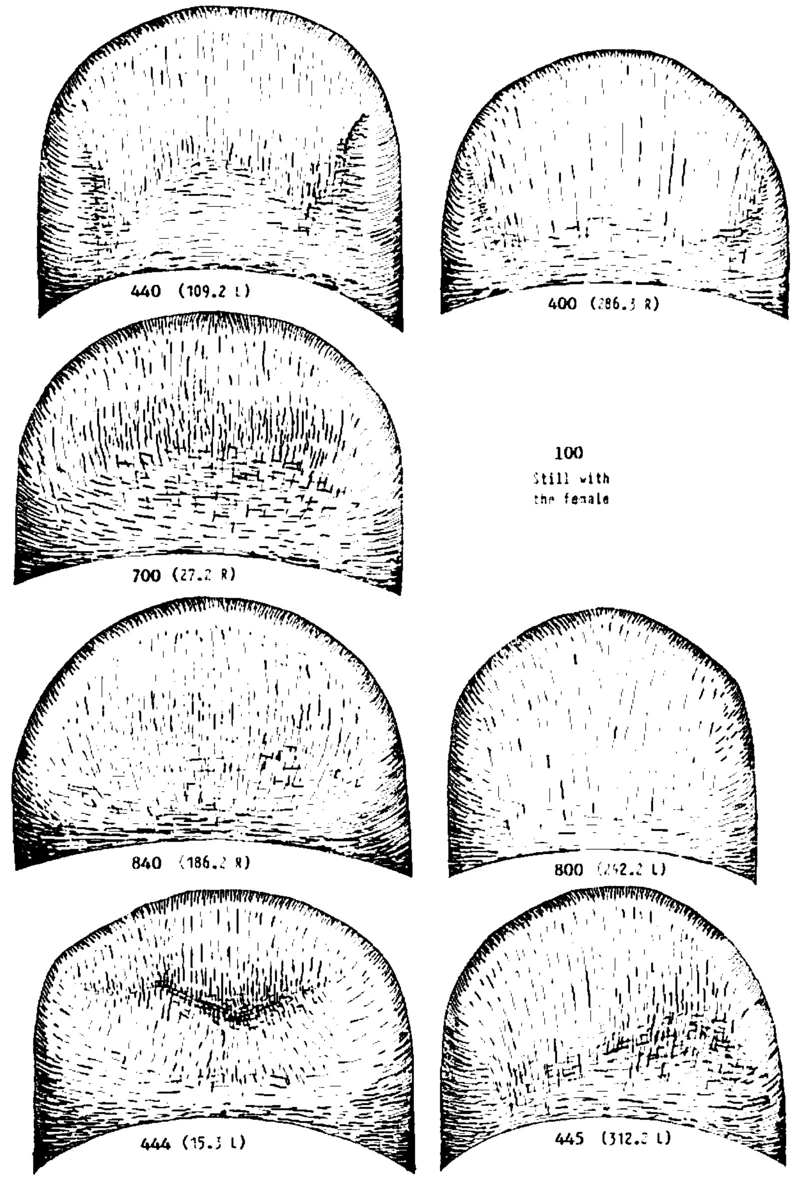
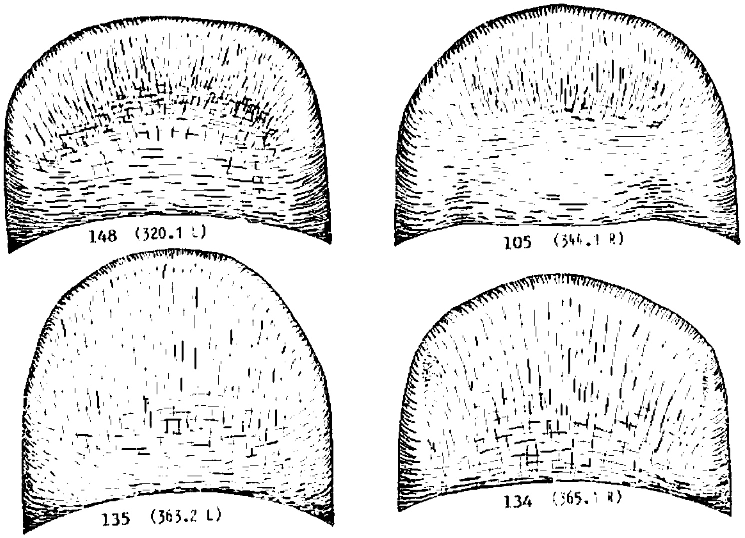
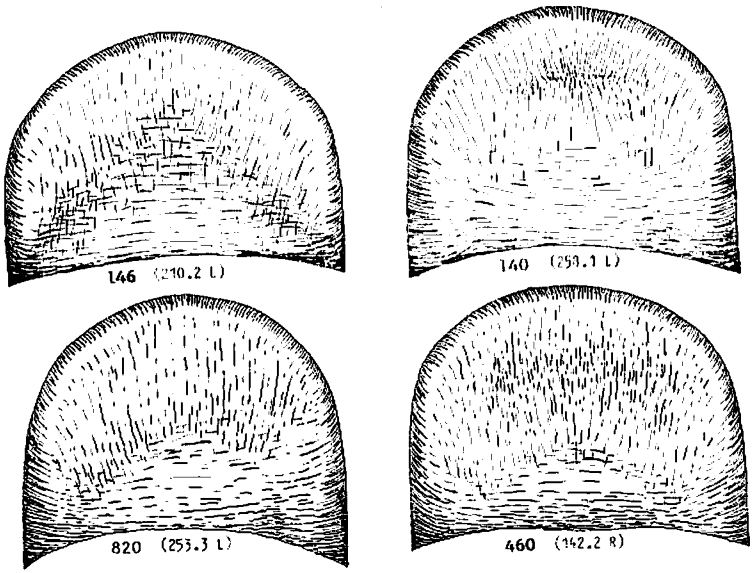


Figure A.2 Females (left) with their young (right) after separation

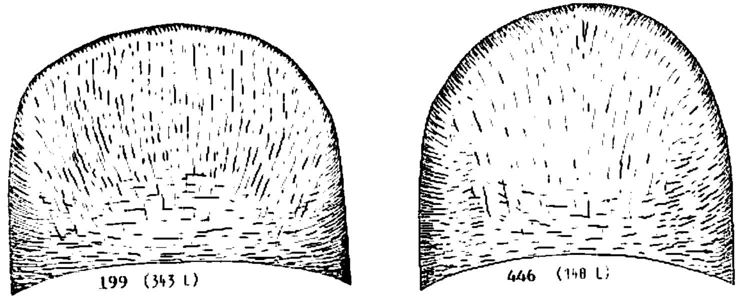


Unassociated young, born during the study

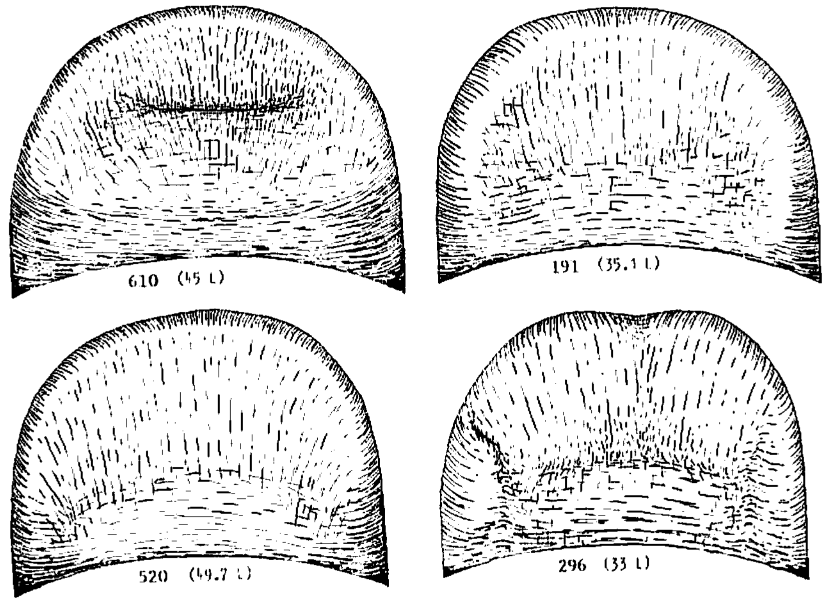


Sub-adults, born before the study

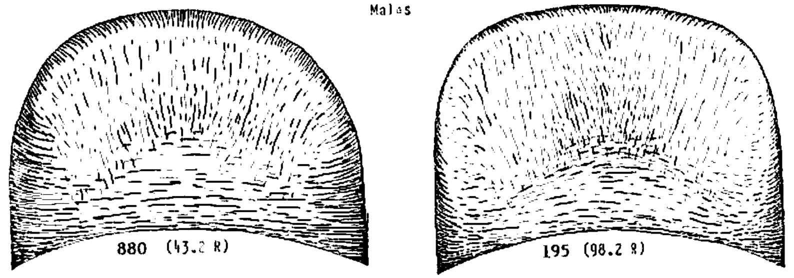
Figure A.3



Sub-adults, born before the study

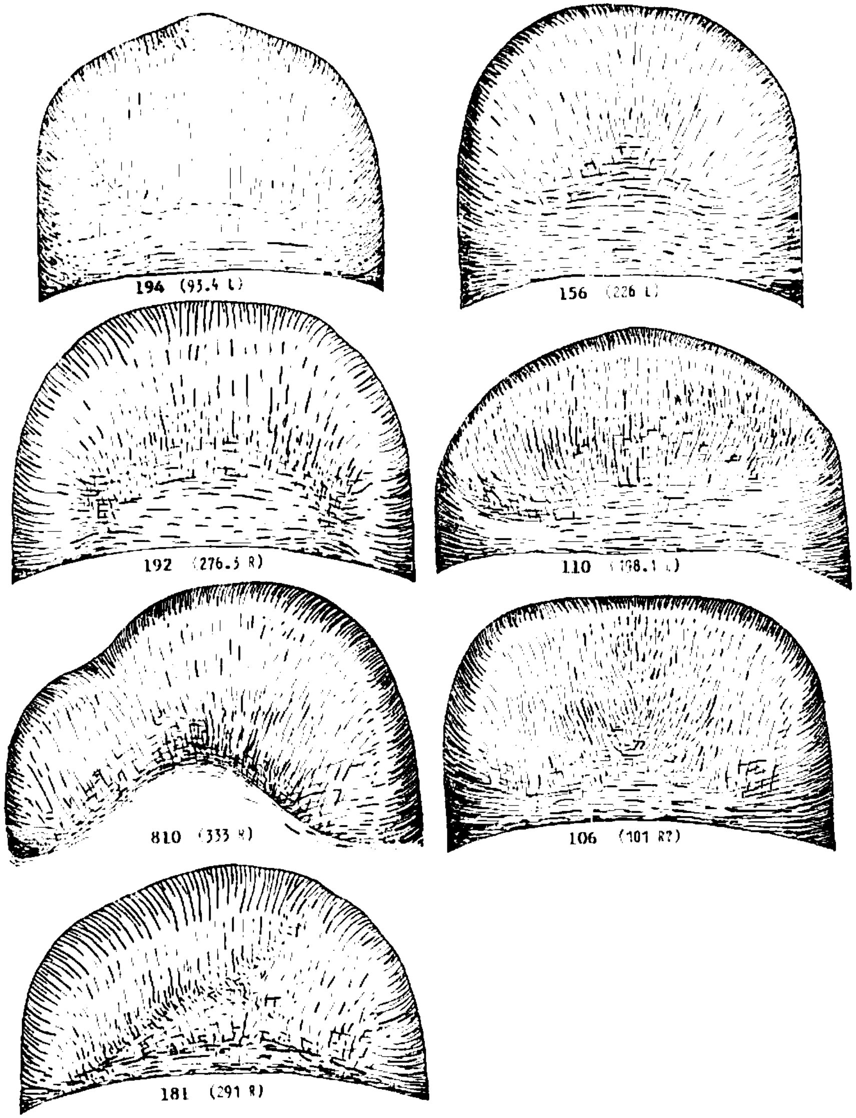


Males



Other adults

Figure A.4



Other adults

Figure A.5

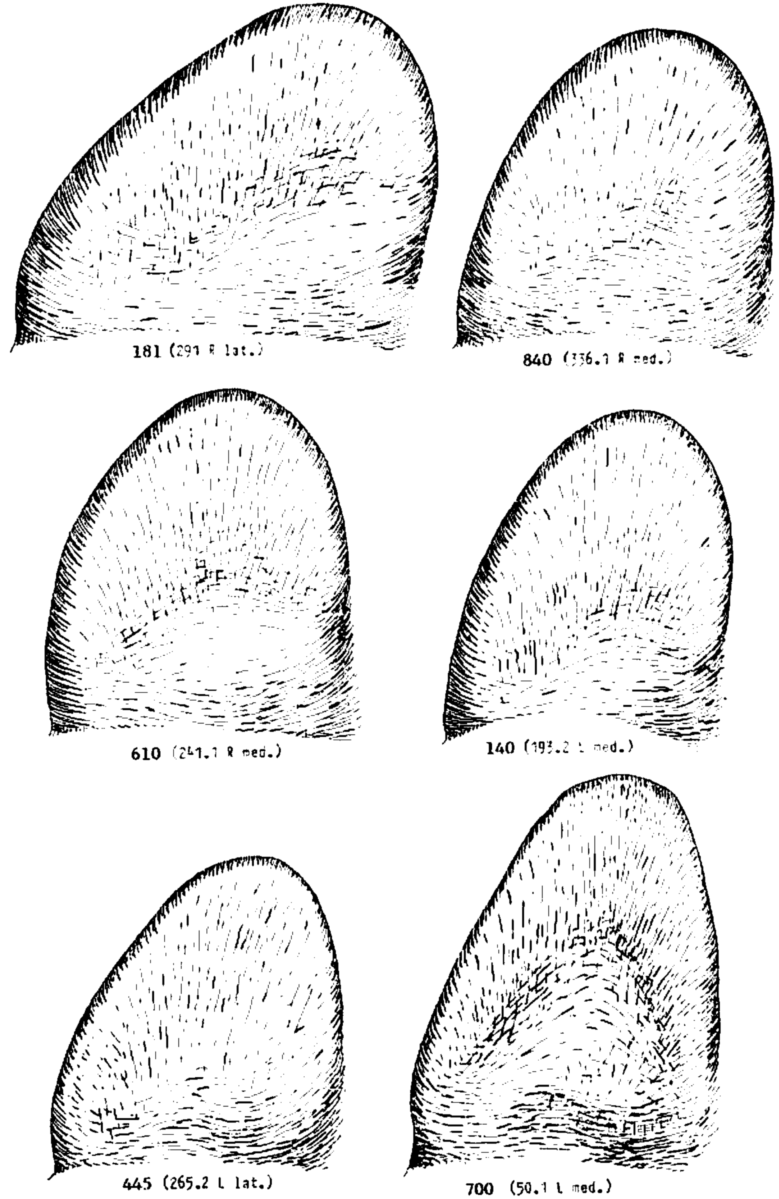


Figure A.6

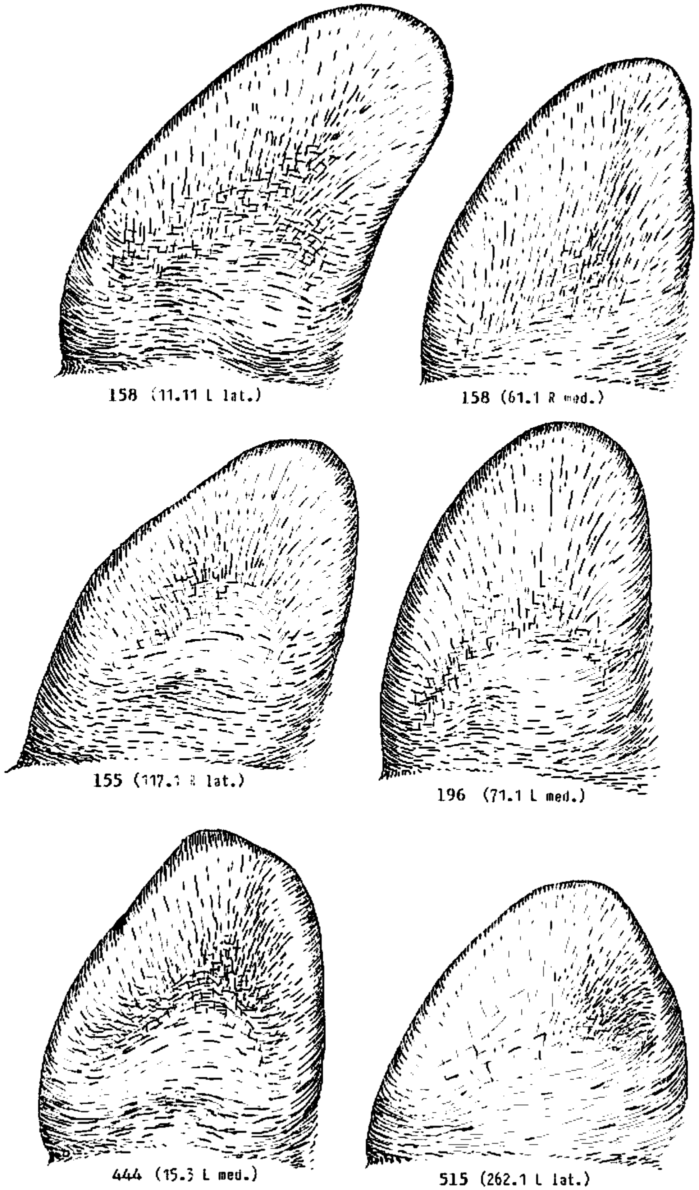


Figure A.7

APPENDIX B: Present status of the Sumatran rhinoceros

The Sumatran rhinoceros is generally regarded as one of the most threatened mammals in this world. It has disappeared from most of its former range and the surviving animals are scattered over a number of isolated areas (see figure 1.1). The reasons for its dramatic decline are ruthless persecution for the valuable horn and other marketable parts, and the loss of most of the animal's natural habitat to the expanding human populations. Poaching and loss of habitat are continuing and the Sumatran rhino is not far from extinction.

There is certainly not much reason for optimism for the future, but the overall picture is not so gloomy as is often depicted in conservation literature. The remaining populations are indeed widely scattered, but a few are probably much larger than is thought at present, and with adequate protection these populations could safeguard the survival of the species at least for the immediate future. With some goodwill on the side of the authorities in the countries that harbour the remaining rhino populations these animals can be effectively protected and in several areas there is good hope that the present populations will survive in the long term.

The recent estimates for the world population of Sumatran rhinos are very low. In the latest edition of the IUCN - Red Data Book (1976) the estimated total population is 89 - 158. Borner (1979) estimates the world population to lie between 100 and 160 individuals, while Flynn & Abdullah (1983) expect the total number to be less than 300. Virtually no recent information has been received of the animal's status in Burma and Thailand, but more information is available for Malaysia, Sumatra and Borneo, and the figures for these parts of the rhino's range need reviewing.

B.1 - The situation in Sumatra

Outside Gunung Leuser there are a number of areas where rhinos are known to exist. The whole island was surveyed by Markus Borner, between 1973 and 1975 and the results summarised in his thesis published in 1979. Detailed accounts of his survey can be found in his progress reports for project 884, submitted to World Wildlife Fund (see references). More recently several areas on Sumatra have been visited by scientists working for WWF or for the UNDP/FAO National Parks Development Project, whose reports contain several interesting observations on the occurrence of rhino.

Rhinos occur, or may occur, in 7 or 8 different areas on Sumatra. These areas are shown in figure 1.1. Below the status of each area will be reviewed, beginning with the three strongholds of the rhino, in the reserves of Gunung Leuser, Kerinci-Seblat and Barisan Selatan. In an area as large as the island of Sumatra, and where access to many places is still limited, it is very likely that there will be other areas where rhinos survive but we cannot expect to find more large populations as in Leuser and Kerinci. The lowlands of Sumatra are now rapidly being cleared for logging, agriculture and resettlement, and soon there will be very little natural habitat left for rhinos outside the central mountain chain, the Bukit Barisan. But even there clearance is progressing and without adequate protective measures the rhino will soon disappear altogether.

Gunung Leuser National Park.

The Gunung Leuser National Park (In Indonesia the term National park has no legal status, and exists only in ministerial decrees) forms the major stronghold of the Sumatran rhino. The number of surviving rhinos is much higher there than in any other area in Indonesia and elsewhere (with the possible exception of the Kerinci-Seblat area), and the field studies that have been carried out since 1973 have made this population the best known.

The distribution of the rhino is well-known (see figure 2.1). The main rhino stronghold is in the western half of the park, and covers an area of about 1000 sq km but rhinos can also be found, elsewhere in the reserve, but at much lower density - at Bengkong, Kapi, Langkat. In the eastern half of the reserve, which was extensively surveyed by Borner, rhino density is very low apart from in the central part of the Kapi plateau. On a survey in 1981 numerous signs of rhino were reported south and west of Gunung Kapi (pers. comm. C.G.G. van Beek and J. Wind).

The area around Gunung Kapi where rhino are abundant is fairly small, not more than about 300 sq km; in the surrounding areas only a few scattered individuals were found during earlier surveys. The high density area probably extends into the rarely visited upper Lesten valley, where locals report important saltlicks. This area is of great importance because it is the only place in the eastern part of Gunung Leuser where the rhinos seem to survive at a 'normal' density. The expanding human population will soon split the reserve in two along the Alas valley, and then migration of rhinos between the east and western parts of the reserve will be impossible. The Gunung Kapi area could then function as a breeding nucleus for restocking the eastern part of the reserve, where the rhino has suffered most heavily from poaching.

Borner estimated a total of between 22 and 45 rhinos for the whole of Gunung Leuser, but this is certainly an underestimate (see chapter 10.1). In the study area in the upper Mamas alone 39 individuals could be recognised and in the five years of the study 12 calves were born. For the Mamas a density of about 14 rhinos per 100 sq km was calculated. The Mamas is clearly a good area for rhino, and it could be that the rhino density elsewhere in the reserve is less. The Mamas is the lowest and least dissected part of the animal's range, and has a number of important saltlicks. Saltlicks are also present elsewhere in the Leuser complex and rhino hunters who accompanied a geological expedition into the most rugged and inaccessible part of the reserve by helicopter speak of an unusual abundancy of tracks there. There is therefore no reason to regard the Mamas as an exceptional area and it is reasonable to take a figure of 10 rhinos per 100 sq km for the whole reserve.

This would put the minimum number of rhino in the western and eastern parts together at 130 animals, in 1300 sq km, about 15 % of the total area of Leuser. Including the few rhinos found elsewhere and for the possibility that the overall density might well be as high as it is in the Mamas, the best estimate for the surviving population of Gunung Leuser is between 130 and 200 individuals.

Kerinci-Seblat National Park.

The (proposed) national park Kerinci-Seblat covers a large section (about 15 000 sq km) of the Bukit Barisan range in central Sumatra, between the towns of Padang and Bengkulu. The area is a mosaic of forest-, nature-, game- and hunting-reserves, which was provisionally declared a national park in 1982. In general the legal status of this area is much weaker than that of Gunung Leuser, and the management infrastructure is poorly developed. In several parts there is heavy pressure from the human population, and without proper action the reserve will be fragmented in the near future.

Borner surveyed the Kerinci-Seblat area in 1974 and found evidence of rhino in several places. In the area of Danau Tucu (or Tujuh) tracks and faeces of rhino were found and Borner describes the area as "a rhino region comparable to the Gunung Leusor area. Many rhino trails can be found. However, most of them are overgrown, indicating that the rhino population is very small and at the edge of extinction."

Near Lempur, on a plateau southeast of Lake Kerinci, Borner found wallows, indistinct trails and fresh tracks of at least three different rhinos, including a cow and calf pair. Borner writes that "the region surveyed is probably only the periphery of the rhino area. I suspect the core area to be situated in the mountain ridge to the east."

In the Sungei Seblat area, northwest of Muara Aman, fresh tracks were found. Borner writes that he "found fresh rhino tracks in the middle part of Sungei Seblat, north of Air Putih. They were about one day old and very large. The width of the hindfoot was between 25 and 26 cm, which is the largest rhino track I have ever found. I found no evidence of trails, feeding marks or wallows, and I think that I penetrated only the periphery of the rhino area."

Borner estimated a total of 15 - 20 animals for Kerinchi-Seblat and concluded "that there is a remnant population of rhinos, which is surviving in the mountainous area at the boundaries of Jambi- and Bengkulu-Provinces. A small corridor is leading further north to Gunung Tucu and probably Gunung Kerinci." (Borner, 1974)

In recent years rhino have been reported from a few other places. In 1979 fresh rhino tracks were reported about 2 km from the road from Muara Labuh to Sungei Penuh, in the Kebupaten Pesisir Selatan (Gunung Bonkat). The tracks were reported to be very abundant (Suharto Djojosudharmo, 1979).

In 1980 fresh tracks were found in an area south of Lempur in the Tebat Pelapo or Tebat Selapo area. The tracks were found in an abandoned resettlement area. They were about 1 day old and measured 25.5 cm. In 1983 a rhino was killed there (pers. comm. R.Y. Bangun Mulya). In the same report it is mentioned that a team from Bandung searching for gas sources found fresh rhino tracks near Gunung Sumbung (or Sumbing) (de Wulf & MacKinnon, 1980).

Game guards reported rhino from the Rawas Ulu Lakiton area, near Lebuk Linggau (pers. comm. Widodo Sukahadi), and from the Air Simpang Seblat and Hulu Melam (de Wulf, 1979?). In the Management plan for the proposed national park the number of rhino is estimated as "at least 15, but it is quite possible that as many as 100 could still survive". (de Wulf, Djoko Supomo & Kurnia Rauf, 1981).

In 1983 and 1984 Raleigh A. Blouch surveyed several areas in southern Sumatra and found tracks of rhino in several parts of Kerinci-Seblat. Most signs were found along an old trail leading from Lempur in the Kerinci enclave to Muko Muko on the coast of Bengkulu. Tracks of several different rhinos and cow and calf pairs were reported there. Along the southern edge of the park, between Tapus and Lubuklinggau an old wallow was found but no recent evidence of rhino. In 1982 a rhino was killed in a village west of lake Kerinchi. Another dead rhino was reported in the same year from near Lebong Tandai (Blouch, 1984).

Figure B.1 shows the locations of the rhino reports. The northern population is pobably already isolated from the southern population, where there is still a vast area of undisturbed and unexplored forest. Most of the interior of the reserve has never been surveyed and it is most

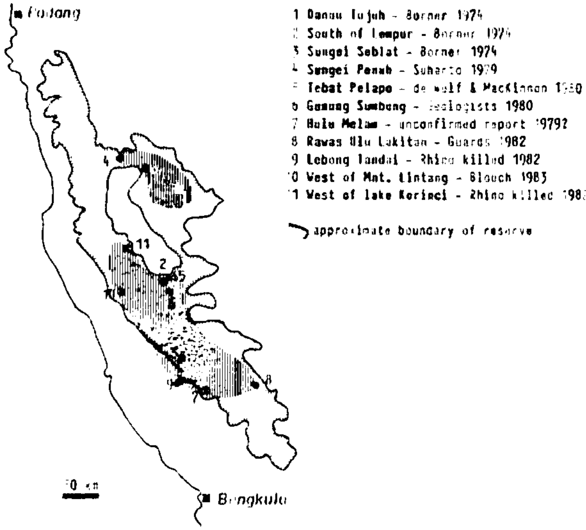


Figure B.1 - The proposed Kerinci-Seblat National Park with the locations of recent rhino records and the inferred distribution of rhinos

likely that the places where rhino are reported, the fringes of the reserve, are the perimeter of a continuous distribution covering most of the reserve. The total rhino distribution in Kerinci-Seblat may correspond to the shaded area in figure B.1, covering about 1000 sq km in the north and about 4000 sq km in the southern part of the reserve.

It appears that the rhino area in Kerinci-Seblat is even larger than that in Gunung Leuser. Several reports speak of abundant tracks and compare the area to Gunung Leuser, and there is no reason to expect the density to be substantially different from that in Leuser. In that case there may be as many as 500 animals in the Kerinci-Seblat area. But in view of the fact that large parts of the reserve have never been thoroughly surveyed a safe figure could be 250 - 500 animals.

Barisan Selatan Game Reserve.

The Barisan Selatan reserve (also called Sumatra Selatan I, Sumsel I or SS I), covers the most southern part of the Bukit Barisan range. The reserve is much smaller (about 3600 sq km) than Leuser or Kerinci and it is under heavy pressure from the rapidly expanding human population. The areas legal status is comparatively good, but the management structures have only been developed in recent years and are still inadequate. The reserve will soon be fragmented if the encroacnments cannot be stopped.

Borner surveyed the area in February and March 1975. In the southern part of the reserve he found no evidence of rhinos, but locals reported a sighting in 1974 at the Wai Kedjadian and tracks in 1972, west of the Kedjadian river. In the central part of the reserve tracks were found in two places - in the area of Wai Siran and between the mountain range south of Liwa and the Handaring river. A rhino was reported to be killed east of Liwa in 1974. Borner concluded that "well maintained rhino trails and feeding marks indicate that a small resident rest-population of rhinos is still surviving in the northern (sic) part of the Sumatra Selatan I reserve." He estimated the total number of rhinos at 2 - 5 (Borner, 1975). The area where Borner found the tracks is in the central part of the reserve as it is designated now, and the large part of the reserve north of Danau Ranau has apparently never been surveyed in recent years.

In 1981 tracks were found in the southern part of the reserve near Way Paya, and in 1982 tracks were reported from Wai Belambangan, and a rhino was sighted at Bukit Penotoh (pers. comm. Widodo Sukahadi). In the management plan for the reserve it is stated that "the status of the Sumatran rhino in Barisan Selatan is not clear... In the past there must have been a

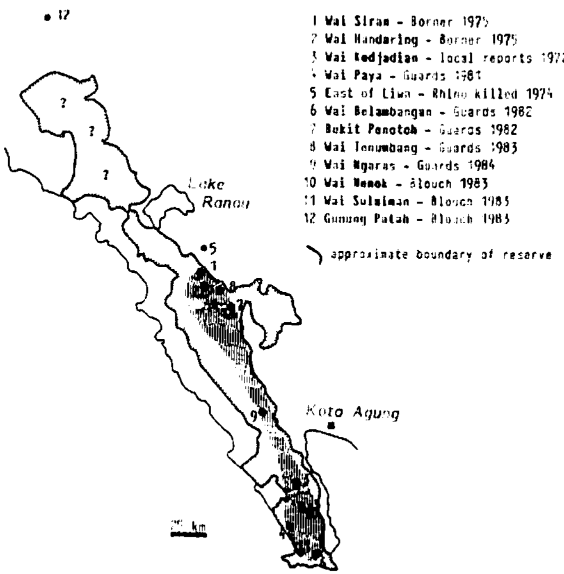


Figure B.2 - The proposed Barisan Selatan National Park with the locations of recent rhino records and the inferred distribution of rhinos

good-sized population of rhino in Barisan Selatan, however scattered, as these are solitary animals. The rapidly dwindling primary forest of the reserve makes the survival of the rhino very doubtful." (de Wulf, Djoko Supomo & Kurnia Rauf, 1981).

In 1983 Blouch found evidence of the occurence of rhino in Barisan Selatan. In the southern tip a track was found near the Way Nenok cave in the headwaters of the Paya river. Game guards reported a track further south near Way Sulaiman. In the central part of the reserve abundant signs of rhino were found about 10 km south of Way Laga in the headwaters of the Tenumbang river. In 1984 game guards found a rhino track in the upper Ngaras river, where the park is only few kilometres wide (Blouch, 1984).

Rhinos survive in two areas of the reserve, and probably still have a continuous distribution throughout the southern half of the park. They may also still occur in the north. The total area, shaded in figure B.2, is relatively small, not much more than 700 sq km and the number of surviving rhinos cannot be very high. A reasonable guess appears to be between 25 and 60 animals left in Barisan Selatan.

Gunung Patah Protection Forest

This is an isolated block of forest, about 700 sq km, on the border between the provinces of Sumatra Selatan and Bengkulu. It is classified as protection forest, but it receives little actual protection. In 1983 rhino tracks were found there for the first time by Blouch. Several signs of rhino were encountered at the edge of the undisturbed forest, a few kilometres south of the village of Tebat Benawa. Rhinos were reported to be common in this area some time ago and the extent of this population should be further investigated (Blouch, 1984).

Berbak Nature Reserve.

Berbak nature reserve on the east coast of Sumatra is often mentioned as one of the places where the Sumatran rhino still survives. When Borner visited the reserve in November 1974, he found no evidence of rhino. Villagers reported tracks in the vicinity of Simpang Kubu

(Borner, 1974). At B. jering and Cemara in the southeastern corner of the reserve very fresh rhino tracks were reported in 1976. The tracks were large (26.5 cm width and distance between forefoot – forefoot 180 cm) and it was suggested that they were probably made by the Javan rhino (Rhinoceros sondaicus) (Wind, 1976).

When the area was surveyed for the preparation of a management plan no evidence of rhino was found, and the rhino was presumed to be extinct in the Berbak reserve (de Wulf, 1982). In 1983 three graduate students from the Department of Nature Conservation at Wageningen University surveyed most of the reserve, and they also failed to find any evidence of rhino (Silvius, Simons & Verheugt, 1984). In 1983 Blouch surveyed the eastern part of the reserve, south of the Hitam Laut river without finding any evidence of rhino and the game guards' reports are also negative. Therefore is seems that the rhino is indeed extinct in the Berbak reserve, at least in the eastern half. A few might survive in the western half, which is seldom visited.

Torgamba.

The Torgamba area lies on the border between the provinces of Sumatra Utara and Riau, southeast of Rantoprapat. Borner surveyed this area in December 1973, and he found fresh and old tracks about two day-trips north of the Asahan basecamp. In 1975 again tracks were reported by Laurie and McDougall, east of the Asahan basecamp, close to the provincial border (Borner, 1979). Borner estimated 1 to 5 animals for the Torgamba area.

In 1977 a small population of Sumatran rhino was reported in the area between the Rokan and Borumun rivers in Riau. No details are given and it is most likely that reference is made to the Torgamba reports (Seidensticker, 1977).

The area was a forest reserve, but a large part has been converted to oilpalm plantation and the rest is a logging concession. The logging company is expected to receive permission to clearcut and there seems to be no hope for the survival of the rhino (pers. comm. K.S. Depari, 1982). In 1984 Blouch found rhino tracks in the area. As the area is cleared for plantations there seems no hope for survival of the rhino (pers. comm. R.A. Blouch).

Gunung Abongabong and Lesten-Lukup.

In the province of Aceh, north of the Gunung Leuser National Park, there are still large areas of undisturbed and unexplored forest. In the course of the present study many reports from villagers were received about the occurrence of rhino in the mountain areas north of Gunung Leuser. It seems certain that rhino do exist there, but there is no information about the range and size of the populations. Sizeable populations may still occur in the remote areas around Gunung Abongabong and the villages of Lesten and Lukup.

B.2 - The situation in Borneo

The Sumatran rhinoceros of Borneo is considered to be distinct from that of Sumatra and the mainland. The teeth are relatively small, the skull is slightly different in proportions, and the animal is believed to be smaller. It is described as a separate subspecies - harrissoni Groves, 1965.

The situation for the rhino in Borneo is much more serious than it is in Sumatra. The rhino has vanished from most of the island, and there are virtually no populations left in reserves. The more rapid decline on Borneo can be attributed to the greater hunting skills of the Bornean island people. Most tribes are living in and from the forest, while the tribes in Sumatra are more agriculturists than hunters.

In a recent review of the status of the rhino in Borneo (Rookmaaker, 1977) the author concludes that the animal's present status "can only be guessed since practically no reports later than 1945 are known. A few wandering individuals, or tiny remnant populations, may still occur in the ulus of the Mahakam, Kayan and Bahua rivers, and in northern Kalimantan Timur. More detailed information does not exist."

The last reliable report of rhino in the Indonesian part of Borneo, dates from 1976, when two sets of tracks were reported from the Banumuda area, north of the Kutai Game reserve (van der Zon, 1977). In 1980 a survey was made in this area to establish the animal's presence, but no signs of rhino were found. It was concluded that there is no viable rhino population in the Banumuda nor has there been any in the recent past, and that the reported tracks were most likely made by a stray animal driven out of its original range by logging disturbance. In and around the Banumuda area there were thousands of people in the field for logging and gas surveys but rhino signs were apparently never seen (van Strien, 1980).

Elsewhere a few rhinos may survive in some parts of the central mountain chain, but so far this has not been confirmed. The Bukit Raya area was surveyed in 1976, but no evidence of rhino could be found and the local villagers believed that no rhino were left in that area (van der Zon, 1977). In 1981 a survey was made of the upper Kayan and upper Mentarang (in the northwest corner of East Kalimantan, bordering Sabah and Sarawak), but again no signs of rhino were seen and the local villagers believed that no rhino remained and that the animal's disappearance was due to heavy hunting by their fathers generation (Blower, Wirawan & Watling, 1981).

In 1975 a rhino hoof and faeces were confiscated by game guards near Nunukan, close to the Sabah border. The rhino was reported killed by Dayak Punun villagers (pers. comm. Widodo Sukahadi). In 1978 one or two rhinos were reported to have survived in the Muara Teweh area (Darpon Dirap, in letter 21 March 1978. UNDP/FAO files in Bogor). In June 1982 reports appeared in the Indonesian press that in West Kalimantan, in the village of Belatung (apparently upper Kapuas) a herd of 20 tri-horned (sic) rhinoceroses were seen.

There are persistent rumours that hunters from northern Sarawak regularly cross the border with Indonesia to hunt rhino there, and that each year several are killed (pers. comm. K. Proud and J.R. MacKinnon). In 1981 or 1982 a rhino hunter was apparently caught by the Sarawak border patrols and the remains of the rhino were confiscated.

These reports indicate that there might be rhinos left in some forgotten corners of this vast island. If the rumours are true there might be a few rhinos left somewhere along the Kalimantan-Sarawak border, probably in the upper Kayan or upper Mahakan. This needs further confirmation, but the chances that a viable population can be found in the Indonesian part of Borneo are extremely slim. The rhino is probably not extinct but very rare.

In Sarawak the rhino has not been recorded for many years and is almost certainly extinct, but in Sabah the situation seems better. In recent years large parts of Sabah have been thoroughly surveyed and it appears that there are more rhinos left than was expected. There is a breeding population, estimated at about 20 animals, in the Silabukan and Lumerau forest reserves. There are rhinos in several of the areas being opened up or due to be opened up for agricultural development and in the extensive, continuous block of forest reserves in south/south-eastern Sabah. In total there are at least 15 rhinos in Sabah, and the actual number is more likely to be around 30 (Andau & Payne, 1982).

The reason that the rhino has survived in southeast Sabah, while it has been virtually exterminated elsewhere in Borneo, is probably because of the absence of real hunting tribes in this area. Only in recent years have groups of hunters moved into this area creating a serious threat to the few surviving rhinos (pers. comm. J. Payne). Recently a part of the known range of the rhino has been protected (Tabin wildlife reserve), but the rhinos cannot be effectively protected against hunters because of lack of staff (pers. comm. P.M. Andau).

B.3 - The situation in Malaysia

As in Sumatra and to a lesser extent Borneo, the situation for the rhino in Malaysia is not so hopeless as was previously thought. In 1972 the Red Data Book still gave an estimate of 10 to 30 rhino for west Malaysia, while the most recent estimate is between 50 and 75 (Flynn & Abdullah, 1984). This is not due to in increase in numbers of the rhino (on the contrary the population probably declined), but to a better knowledge of the species' distribution.

Throughout the country rhino occur in 13 different areas, but in only two areas, Endau-Rompin and Taman Negara, are the estimates of significant size. In Taman Negara 8 to 12 animals are estimated, from reports over a large part of this 4343 sq km reserve (Flynn & Abdullah, 1984). Although the density of rhino appears to be very low everywhere in the park, the estimate may be too conservative for an area of this size.

The Endau-Rompin area is the best studied area, and currently 20 to 25 animals are estimated to survive in 1600 sq km. The central part of the reserve - about 400 sq km - has a higher density of 1 rhino per 40 sq km, calculated from track counts (Flynn & Abdullah, 1983). Using the same data, but calculating the area of the census over a strip of 1 km instead of 2 km (as is recommended in this study) gives an estimate of a total of 30 to 40 rhinos instead of 20 to 25 (see chapter 10.1). Most of the remaining rhino habitat is now protected (pers. comm. Mohd. Khan).

The third largest rhino population in Malaysia is the Sungei Dusun reserve. For many years it was believed that three rhinos were living there. Now the figure is put at between 4 to 6, again because the area is now better surveyed. It seems to be the rule that in areas where there are rhino left, the numbers tend to rise the better the area is surveyed. Since many of the other rhino locations in Malaysia are only poorly known and surveyed, there is good hope that the present estimates there are also too low.

B.4 - The situation in other countries

There is virtually no reliable recent information about the status of the rhino in the rest of its range, in Thailand, Burma and Indochina. Most existing reports date from 10 or more years ago and many of the areas in which rhino may survive are in regions that are plagued by various kinds of political unrest and where the nature conservation agencies have little or no access. It is of little use to mention all the areas believed to harbour rhino some ten or more years ago, since no recent information is available. Surveys of these areas should be a priority as soon as practical.

B.5 - Summary of the present status of the Sumatran rhino.

<u>Sumatra</u> (Summary of B.1)

Kerinci-Seblat	Probably the largest contiguous population. Imperfectly known, but estimated at between 250 and 500 individuals.
Gunung Leuser	The best known population. Estimated at between 130 and 200.
Barisan Selatan	Rhino survive in the southern half of the reserve. Imperfectly known. Estimated at between 25 and 60 individuals.
Gunung Patah	Rhino surviving but numbers unknown
Gunung Abong-abong	Unknown. Rhino surviving in unknown numbers.
Lesten - Lukup	Unknown. Rhino surviving in unknown numbers.
Torgamba	Unknown. A few surviving, but habitat threatened
Berbak	Last report 1976, now probably extinct.
Total Sumatra	400 to 750 rhinos surviving in reserves and an unknown number in two or three other locations.

<u>Borneo</u> (Summary of B.2)

Sarawak	Extinct many years ago.
Kalimantan	Extinct over most of the area. Probably some surviving in the Kalimantan-Sabah border area and scattered remnants here and there. Possibly a larger number on the Kalimantan-Sarawak border.
Sabah	15 to 30 individuals, mainly in the Silabukan area and in southeast Sabah.
Total Kalimantan	One viable population in the east of Sabah and possibly some in the centre of the island. Insignificant remnants elsewhere. Extinct over most of the area.

<u>Malaysia</u> (From Flynn & Abdullah, 1984 and Khairiah Mohd Shariff, 1983)

Endau-Rompin	Probably the largest population in Malaysia. Estimated at between 20 and 25, but could very well be more.
Taman Negara	Second largest population. Estimated 8 to 12, but might be more. Imperfectly known.
Sungei Dusun	Small population. 4 to 6 individuals. See also: Mohd Zuber bin Mohd Zain, 1983.
Mersing coast (Tenggaroh)	At least two left in an isolated patch of forest. One trapped in 1983 (pers. comm. Mohd Khan)
Gunung Belumut	Latest report 1980. Small surviving population. Imperfectly known. Estimated 2 - 3.
Bukit Gebok	Latest report 1980. One or two animals in a small isolated patch of forest, that has since been cleared. Probably extinct now.
Sungei Lepar	Latest report 1979. Unknown, 3 to 5 may survive.
Ulu Selama	Latest report 1983. Unknown, 3 to 5 may survive.
Kuala Balah	Latest report 1977. Unknown, 3 to 4 may survive.
Sungai Depak	Latest report 1976. Unknown, 3 to 5 may survive.
Ulu Belum	Latest report 1972. Unknown, 3 to 5 may survive.
Krau Reserve	Latest report 1963. Unknown, probably extinct now.
Kedah Border	Entirely unknown. A few might survive.

<u>Thailand</u> (From McNeely & Laurie, 1977)

Phu Khio	Latest report 1976. Unknown. McNeely & Laurie found tracks at four different places in four days in the field. This indicates that a few animals survive.
Khao Soi Dao	Latest report 1974. Species uncertain. Unknown.
Surat Tani province	Unconfirmed reports.
Thai-Burma border	Some may survive (pers. comm. Pong Leng-Ee, 1979).

Burma (From U Tun Yin, 1980)

Shwe-u-daung game sanctuary	Probably extinct
Tumanthi game sanctuary	4 may survive
Lassai tract	6-7 may survive

Indochina (From Rookmaaker, 1980)

The presence of the Sumatran rhino in the Indochinese region cannot be confirmed and the few animals that might survive (e.g. south Laos and Vietnam) are most likely Javan rhinos Rhinoceros sondaicus.

APPENDIX C: Rhino poaching in the Gunung Leuser reserve

Hunting of rhinoceros is a traditional trade in north Sumatra, usually carried out by a small number of people, called "pawang badak", who lead a group of rhino hunters and who have a certain status and esteem in the local community. Many pawangs are from the Gayo tribe, natives of the mountainous interior of Aceh, but men from other tribes, Alas, Batak, Aceh etc. are also involved. It appears that all pawangs from the area north of Gunung Leuser are supervised by the pawang from Kampong Porang, near Blankedjeren. Without his permission and blessings another pawang should not go out to hunt, but it is not clear how strictly this is maintained.

Rhino hunting has occurred everywhere around Gunung Leuser and eliminated rhinos from all areas within two or three days walking distance from human settlements. In the border areas of the park one can still see old abandoned trails and wallows, but it is clear that they have not been used for a good many years. In the Alas valley the rhino disappeared from the lower slopes probably before 1960. Elsewhere as on the highlands near mount Leuser, they disappeared before 1930.

Old traps and camp sites of rhino hunters can be found on the borders of the reserve, reminders of the days when rhino used to roam over most of the reserve. At the time of the present study the rhino was already confined to the remote interior of the reserve, where it was believed that the rhino poachers had not yet penetrated. It was a surprise therefore when on the first expedition to the Mamas new rhino traps were found, showing that the poachers had already found their way into the last stronghold of the Sumatran rhino in Gunung Leuser. Here only the events in the Mamas will be described. For other information on rhino hunting around Gunung Leuser, see Borner (1979) and Kurt (1970).

Soon after the party was dropped by helicopter on the first expedition, in a small natural opening in the forest cover halfway along the upper Mamas river, fresh human tracks were found. The next day a camp site was discovered, where later camp Pawang was constructed, and on July 17, 1975, a series of rhino traps was found on a ridge west of this camp site.

The traps, of the spear-fall type, were built over a rhino trail on a ridge. Seven traps were made on a line over about 1.5 km, each 50 to 400 metres apart. At the time of the find six spears had already dropped, and only one trap was still intact. Four had missed and the spear was stuck in the ground, but from two traps the spear was missing, which means that a rhino may have been hit. Probably one rhino ran into two traps, but no dead animal could be found. The spear does not kill the animal immediately, but it will die within a few kilometres from the place where it was hit. No time was available to make a search for the corpse, which can take several days. It is said that rhino hunters only recover about half of the animals that are wounded.

Figure C.1 shows the construction of the trap. The whole construction is hung from a horizontal pole, tied with rattan between two trees at the sides of the game trail, some 8 to 10 metres above the ground. A small pole, with a few cross-bars, are tied to the stems of these trees, to facilitate the construction of the trap. The main part of the trap, the weight, is cut from a straight trunk, some 15 cm in diameter and 230 to 300 centimetres long. On one end a hole is made for the hanging cord, on the other end a notch is made to attach the spear.

The spear is almost one metre long and made from a hard type of wood (sometimes bamboo is used). The spear is pointed very sharp and smooth. It is tied with a few thin strips of rattan to the notch on the weight, precisely in the centre of the log. The hanging cord is made of a few twined rattans, about 40 cm long, with a 25 cm long wooden peg on the end. The end of the cord is hung over the horizontal beam, with the peg pointing downwards. Peg and cord are held together by a rattan ring, connected to the trigger thread.

The trigger thread, a long thin rattan, is stretched over the game trail, about 30 cm above the ground. It is attached to two sticks left and right of the game trail. The trigger thread is guided upward through rattan rings. When an animal disturbs the trigger thread the ring is pulled from the peg on the hanging cord and the whole construction drops down, driving the spear into the rhino's back.

On the second expedition another series of traps, made by the same group of poachers, was found on a ridge west of the Mamas river. At this place there were 9 traps, all already out of order. The poachers were soon known to the park management and together with the local police they managed to apprehend one of them red-handed, carrying 26 kilograms of rhino bones out of the reserve. A member of the park management had posed as trader in rhino products and persuaded the man to go into the reserve and collect bones of the rhinos that had been killed previously. The leader of the group, a pawang from kampong Porang near Blangkedjeren, was not caught but he died shortly afterwards while hiding in a remote village. The captured poacher was prosecuted and jailed for about 7 months.

He informed the park management that the first traps in the Mamas where built in July 1974 and another series was made in April 1975. It is not completely clear how many rhinos were killed during this period, but horns from at least three rhinos were sold to Chinese in

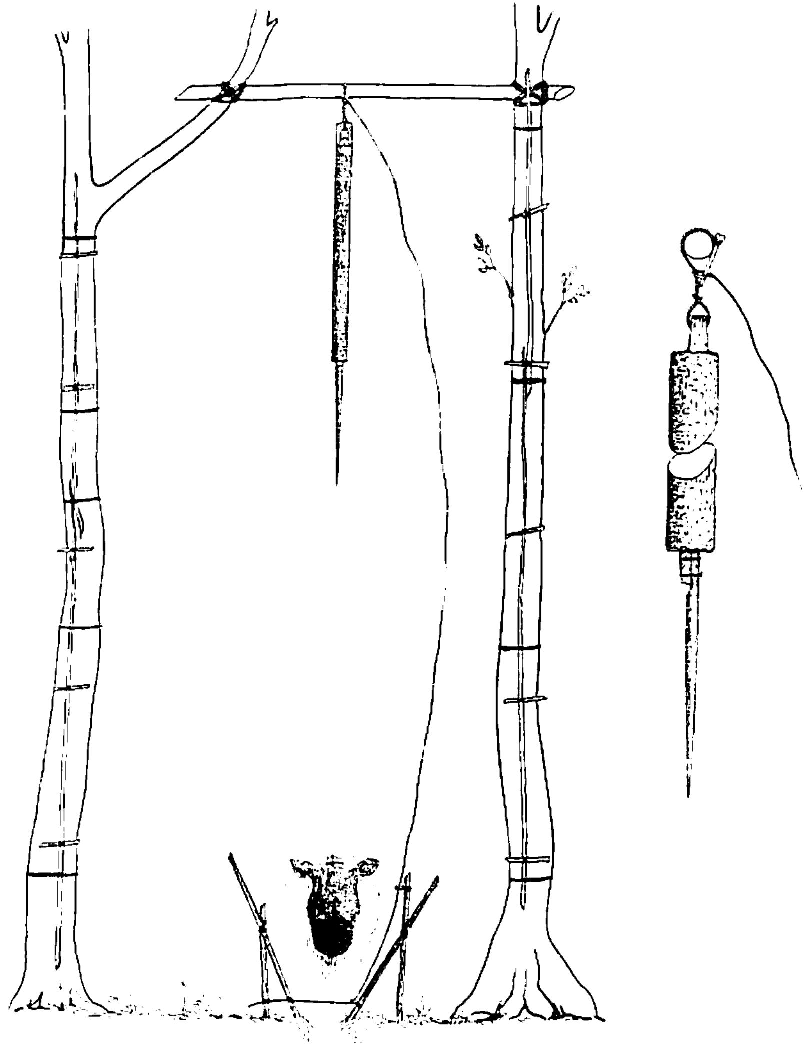


Figure C.1 - The construction of the spear traps used in the Gunung Leuser area

Medan. The poacher probably did not reveal everything he knew and it appeared that at least 4 and probably up to 6 rhinos were killed in the Mamas between July 1974 and July 1975. From the killed rhinos the horns and hoofs were sold (for about 40 000 Rp (US$ 90.-) per 100 grams or more. The teeth were also taken and given to relatives and local officials. The corpses were buried and the poacher was caught with one of those skeletons.

The poacher's success clearly demonstrates the efficiency of these type of traps. When 4 to 6 rhinos can be caught by just one group of hunters in one year, it is not difficult to imagine what will happen if these activities continue in the upper Mamas. If poaching continues within a few years there will be no rhino left in the Mamas and rhinos will disappear completely from Gunung Leuser.

In March 1976 more evidence of rhino poachers was discovered in the Mamas. This time the people had entered from the Kompas river area, the best known entrance route. They had placed snares, anchored to a piece of log, in the deep trails leading to the important saltlicks at Sungei Pinus. They also used an old treehide as a shooting-platform. From the platform they had stretched a signal thread to the saltlick and apparently also had a strong searchlight.

The snares were made from thin wire cable, with a loop of about 60 cm diameter, and were tied to a pole about 150 cm long, anchored behind a few small trees. The snares were positioned in the very deep and narrow trails to the saltlick, held in position with a few pegs in the sides of the trail. Apparently no rhino was shot or trapped in the snares and all snares were destroyed. The poachers were never caught and there is a strong suspicion that someone from the local police or army was involved.

After that no more attempts were made to trap rhino in the Mamas during the course of the study. It was widely known that the area was under regular surveillance and that there was a certain risk of being caught. Later some pitfalls were discovered in the Kompas area, south of the Mamas, by a patrol of park guards. This is an unusual method of trapping rhino in north Sumatra and probably outsiders were involved. At that time a pair of rhinos originating from Sumatra was offered by an animal dealer in Singapore and there could very well be a connection.

During the fieldwork it became clear that the interior of the reserve is far from being completely unvisited. At various places, all over the Mamas, marks were found on tree trunks, that were clearly much older than those left by the 1973 geological survey, and it was clear that small groups of people had been over most of the area. Since no more rhino traps were found people probably visited the area for other reasons than rhino hunting. During the study several groups of men entered the Mamas, but usually they were connected with one of the numerous mineral surveys, of which the park staff were never informed.

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PLATES

Figure I - A young female Sumatran rhino in Melaka Zoo, Malaysia. This animal was caught in 1984 by plantation workers after it had strayed from the Sungei Dusun reserve, north of Kuala Lumpur. The animal is now kept by the Department of Wildlife and National Parks.

Figure II - The mountains west of camp Pawang (🡇), seen from the eastern ridge. The Mamas flows from left to right at the foot of the mountain and to the right of the mountain the valley of the Sungei Niko is seen. The patrol network extends to the top of this mountain (2124 m).

Figure III - The Upper Mamas valley near camp Central (🡇) seen from the eastern ridge. The Mamas flows from left to right, approximately in the middle of the photograph. In the right upper corner the valley of the Sungei Badak is seen.

Figure IV - The Upper Mamas valley is relatively flat compared to the rest of Gunung Leuser National Park. Here the upper reaches of the Sungei Bohorok in the Serbolangit range are seen. This type of landscape is typical for most of Gunung Leuser.

Figure III

Figure IV

Figure I

Figure II

Figure V - *Landfalls are common in the steeper parts of Gunung Leuser. The rhinos feed on the young regrowth on places where the canopy has been broken by land- or treefalls.*

Figure VI - *The Mamas river about halfway between camp Pawang and camp Central. During periods of heavy rainfall the water can rise one and a half metres or more and crossing can be difficult.*

Figure VII - *Camp uning in the northern extension of the study area. The Mamas is fairly wide here and deep and during periods of heavy rainfall this camp could not be reached.*

Figure VIII - *Camp Aceh. In the centre the kitchen and to the right the raised sleeping platform is seen.*

Figure VII

Figure VIII

Figure V

Figure VI

Figure IX - *A fresh rhino track in a marshy area.*

Figure X - Camp Central

Figure XI - Sub-montane forest at about 1600 metres. There are no very big trees but a great number of saplings and small trees. The people are sitting along a rhino trail.

Figure XII- A rhino trail in the lower parts of the Upper Mamas. The forest is very dense here, but the rhino trails are usually wide and open and can easily be followed.

Figure IX

Figure X

Figure XI

Figure XII

Figure XIII - *A rhino trail in low scrub, as is found on the highest ridges in the study area. The rhinos never feed in this scrub and they apparently only use these trails when moving to another side of the mountain.*

Figure XIV - *A tunnel-like rhino trail in moss-forest. Above about 1800 metres there is mist for most of the days and the soil and treetrunks are thickly covered with moss.*

Figure XIII

Figure XIV

Figure XV - A rhino wallow at the bottom of a slope. With the horn the rhinos dig in the higher soil and a vertical wall is formed.

Figure XVI - Traces of the rhino's horn on the wall of a wallow.

Figure XVII - A sapling broken by a rhino along a trail.

Figure XVIII - A rhino scratch mark along a trail. With the hindfeet the soil, often with faeces, is kicked into the vegetation. Broken saplings, scratch marks and urine sprayed over the vegetation are usually only found along the large rhino trails and they obviously function as a visual and olfactory sign of the animal's presence.

Figure XVII

Figure XVIII

Figure XV

Figure XVI

Figure XIX - Part of the plastercast collection in the storage boxes.

Figure XX - Part of the reference collection of plastercasts. From each individual rhino the few best casts were placed on racks for easy reference and comparison.

Figure XIX

Figure XX

SAMENVATTING

Titel: De Sumatraanse neushoorn - Dicerorhinus sumatrensis (Fischer, 1814) - in het Nationale Park Gunung Leuser, Sumatra, Indonesië; Verspreiding, levenswijze en bescherming.

De Sumatraanse neushoorn is een der diersoorten die wel het meest te lijden heeft van de ongebreidelde groei van de wereldbevolking en van de daarmee gepaard gaande vernietiging van de natuurlijke levensgemeenschappen. Daarnaast is de neushoorn van ouds her fel bejaagd voor de waardevolle hoorn. Eens kwam de Sumatraanse neushoorn voor over een groot gedeelte van Zuid-oost Azië, van de voet van de Himalaja in Bhutan tot Borneo en Sumatra. Tegenwoordig is de soort uitgeroeid in het grootste deel van dit gebied en nog slechts hier en daar zijn er kleine aantallen te vinden, allen in de meest afgelegen streken.

De Sumatraanse neushoorn is de kleinste van de 5 bestaande neushoorn soorten, en ook de minst bekende. Het dier is al lang zeldzaam en leeft in moeilijk toegankelijk gebied, hetgeen het doen van onderzoek aan deze soort niet eenvoudig maakt. Dit onderzoek werd dan ook niet alleen uit wetenschappelijke belangstelling opgezet, maar ook met het oog op natuurbeschermings aspecten. Door een betere kennis van de verspreiding en levenswijze van de neushoorn kan de bescherming en het beheer van de laatste overgebleven populaties beter worden opgezet en uitgevoerd. Verder is de Sumatraanse neushoorn de grootste planteneter, die uitsluitend in het dichte tropische regenwoud leeft, waardoor de soort een gids-functie vervult bij het instellen van reservaten. Het voorkomen van de Sumatraanse neushoorn geeft aan dat het gebied relatief ongestoord is en een reservaat dat een voldoend grote populatie neushoorns kan herbergen moet ook geschikt worden geacht voor de andere, kleinere, planteneters.

Door de zeldzaamheid en de schuwheid van de neushoorn en door het moeilijke en zeer dicht begroeide terrein is rechtstreekse waarneming van de neushoorn vrijwel uitgesloten. Daarom moest het onderzoek voornamelijk gericht worden op het bestuderen van sporen en andere tekens, welke in het terrein worden aangetroffen. Een van de eerste opgaven bij dit onderzoek was het ontwikkelen van een methode waardoor de afzonderlijke neushoorns aan hun voetsporen te herkennen zijn, zodat de bewegingen van de dieren in de ruimte en de tijd kunnen worden gevolgd.

Het onderzoek werd uitgevoerd in het Nationale Park Gunung Leuser, een bijna een miljoen hectare groot reservaat in de bergen van noord Sumatra. Door stroperij is ook hier de stand van de neushoorn sterk aangetast, maar in het moeilijk toegankelijke centrale bergland zouden naar schatting nog enkele tientallen neushoorns voorkomen. Daarom werd daar een studie-gebied gekozen, en wel in het dal van de boven Mamas. Dit is een tamelijk breed hoogland-dal, gelegen op ongeveer 1200 meter boven zeeniveau en omringd door bergen van 1800 to 2100 meter hoog.

Het hele studie-gebied is begroeid met dicht bos, met uitzondering van een paar kleine moerassige stukjes en van enkele bergtoppen. In het dal liggen een aantal warme bronnen, waar neushoorns en andere dieren het mineraal-houdende water komen drinken. Deze plaatsen worden zoutlikken genoemd. Het gebied wordt doorkruist met wildpaden, langs de grotere rivieren en over de bergruggen. Van deze paden werd ongeveer 150 kilometer in kaart gebracht en als patrouille route gebruikt. Vanuit 6 permanente kampen werd het gehele studie-gebied, dat ongeveer 180 vierkante kilometer beslaat, enkele malen per jaar doorkruist op zoek naar neushoorn sporen.

Voor het bestuderen van de neushoorn sporen werd gebruik gemaakt van gipsafgietsels van de voetafdrukken. In het algemeen werden van ieder spoor twee afgietsels van de linker en twee van de rechter achterpoot gemaakt (de achterpoten worden normaal op de afdruk van de voorpoot gezet). Later werden de afgietsels stuk voor stuk op plankjes gemonteerd. Gedurende de studie werden van 371 verschillende sporen gipsafgietsels gemaakt.

Door vergelijking van de grootte, vorm en stand van de voet en van de drie hoeven, konden een aantal verschillende dieren individueel worden herkend. Bij het vergelijken van de gipsafgietsels werd ook gebruik gemaakt van stereofoto's en van tekeningen van de omtrek van de voet en de hoeven. Verder werden van ieder afgietsel 5 maten genomen.

Hoewel er vele, vaak zeer karakteristieke, verschillen tussen de afgietsels te zien zijn, is het verre van eenvoudig alle afgietsels met zekerheid te identificeren. Vaak zijn de afgietsels van een minder goede kwaliteit en zijn niet alle kenmerken duidelijk te zien, maar ook de grondsoort, de helling en de richting en snelheid van voortbewegen beinvloeden de vorm van de voetafdruk. Verder bleken er in de loop van de tijd duidelijke veranderingen in de vorm van de hoeven op te kunnen treden.

Nadat de hele collectie afgietsels vele malen was doorgewerkt konden er 39 verschillende neushoorns worden herkend. Acht dieren bleken wijfjes te zijn omdat ze gedurende de studie samen met de sporen van een jong werden gevonden, 4 dieren waren waarschijnlijk mannetjes omdat ze gedurende minstens drie jaren nooit met een jong werden gevonden. Van de ander 9 volwassen dieren kon het geslacht niet met zekerheid worden vastgsteld. Gedurende de studie zijn er 12 jongen geboren en verder werden er nog 6 andere onvolwassen dieren gevonden.

Van een paar jonge neushoorns werden regelmatig sporen gevonden en daaruit kon een groeikurve van de voet worden samengesteld, waardoor het mogelijk is de leeftijd van andere, minder vaak gevonden, jongen te schatten. Er werden geen duidelijke verschillen gevonden tussen de voetafdrukken van mannetjes en die van wijfjes. De voet van een mannetje is waarschijnlijk gemiddeld wat groter en wijfjes lijken vaker een onregelmatige of asymmetrische voet te hebben.

Uit de verspreidingskaarten van de verschillende neushoorns kan de ruimtelijke verdeling van de individuen worden bestudeerd. Verder kan aan de hand van het aantal verse sporen, in relatie tot de tijd die is verstreken sinds de laatste regenbui, worden berekend hoe vaak een neushoorn een bepaalde plaats bezoekt.

De wijfjes tonen een opvallend verspreidingspatroon. In het studie-gebied bleken de wijfjes neushoorns slechts om de drie of vier jaar een jong te krijgen, dat gedurende anderhalf jaar bij het wijfje blijft. Wijfjes met jongen houden zich op in de omgeving van de zoutlik en trekken rond in een gebied van 10 tot 15 vierkante kilometer. Gemiddeld eens in de drie weken gaan ze naar de zoutlik.

Als het jong zelfstandig wordt blijft het in dit gebied, maar het wijfje trekt zich terug op grotere afstand van de zoutlik. Zonder kalf worden de wijfjes slechts zelden gevonden, meestal in de hoger gelegen gedeelten aan de rand van het studie-gebied of op weg naar een zoutlik. In deze periode trekken ze waarschijnlijk rond in een relatief klein gebied, 10 vierkante kilometer of minder, en gemiddeld wordt eens per zes weken een bezoek gebracht aan de zoutlik. Het lijkt er op dat de gebieden waar de wijfjes zonder jongen zich ophouden duidelijk van elkaar zijn gescheiden. Daarentegen kunnen er twee of drie wijfjes met een jong zich ophouden in hetzelfde gebied nabij een zoutlik.

Een jonge Sumatraanse neushoorn houdt zich aanvankelijk op in een relatief klein gebied, waar het ook met de moeder heeft rondgezworven. Waarschijnlijk trekken jonge neushoorns soms voor enige tijd gezamenlijk op. Geleidelijk worden ook aangrenzende gebieden bezocht en breidt het woongebied zich uit tot 20 of 25 vierkante kilometer. Dan worden deze individuen nog slechts met onregelmatige tussenpozen in het studie-gebied aangetroffen, hetgeen er op wijst dat ze waarschijnlijk een zwervend bestaan leiden en vaak ver van hun oorspronkelijke gebied afdwalen.

De woongebieden van de mannetjes neushoorns zijn, net als die van de wijfjes, vrij regelmatig verdeeld over het gebied, maar de individuele woongebieden overlappen elkaar voor een groot gedeelte. Het gebied waarin een mannetje rond trekt is relatief groot, 25 tot 30 vierkante kilometer en soms nog wel meer. Gemiddeld bezoeken mannetjes eens in de twee maanden een zoutlik, maar sommige mannetjes bezoeken deze veel vaker en soms gaan ze ook naar andere zoutlikken.

Volwassen neushoorns worden vrijwel uitsluitend alleen aangetroffen. Slechts in een geval werden er sporen gevonden van twee dieren, een mannetje en een van de jongere dieren, die enige tijd samen optrokken. Dit wijst er op dat de geslachten slechts voor een korte periode samen komen voor de voortplanting.

De dichtheid van de neushoorns in het studie-gebied kon worden berekend aan de hand van het verspreidingspatroon van de individuen. Er blijken ongeveer 13 of 14 dieren per 100 vierkante kilometer voor te komen in de boven Mamas. Gebaseerd op deze cijfers kan de totale populatie van de neushoorn in Gunung Leuser geschat worden op 130 tot 200 dieren.

Alle neushoorns in het studie-gebied bezoeken van tijd tot tijd een van de zoutlikken en drinken van het mineraal-rijke water. Omdat de meeste dieren slechts met tussenpozen van een maand of langer een zoutlik bezoeken, is het waarschijnlijk dat het daarbij niet alleen om de, relatief geringe hoeveelheid, mineralen gaat. Het lijkt er op dat de zoutlikken ook als ontmoetingsplaats functioneren. Sommige mannetjes gaan veel vaker naar een zoutlik en ze zwerven dan enige tijd rond in de omgeving, hetgeen de indruk wekt dat ze de omgeving afzoeken naar andere sporen, misschien van een wijfje dat daar eerder was.

In de loop der jaren hebben de neushoorns, en de olifanten, een uitvoerig padenstelsel gemaakt over het hele gebied. Vooral langs de grotere rivieren en over de hoogste bergruggen zijn deze paden breed en open en ze vergemakkelijken het zich verplaatsen aanzienlijk, niet alleen voor neushoorns maar ook voor andere dieren en onderzoekers. Neushoorns volgen deze paden soms voor vele kilometers, vooral op weg naar een zoutlik. Verder lopen ze vaak min of meer langs de hoogtelijnen over de hellingen en ze lijken zich vooral te orienteren op de grote rivieren en op de bergruggen.

In het gehele gebied worden modderkuilen of zoelen aangetroffen, waarin de neushoorns zich regelmatig baden. Soms is het niet meer dan een ondiepe put in een drassige plaats, maar op andere plaatsen, vooral langs de grote paden, zijn er een aantal kuilen bijeen gemaakt, soms door veelvuldig gebruik diep uitgegraven in de helling. Andere dieren maken ook van deze zoelen gebruik, maar de neushoorn geeft er de karakteristieke vorm aan.

Langs de grotere paden maken de neushoorns soms opvallende tekens. Met de achterpoten wordt de grond open gekrabd, en vaak worden er op die plek ook een paar boompjes geknakt en wordt het geheel met faeces overdekt of met urine besproeid. Dergelijke tekens worden door beide geslachten en alle leeftijdsgroepen gemaakt, maar slechts zeer zelden door heel jonge dieren. De wat oudere jongen en sommige mannetjes maken relatief veel tekens, terwijl het knakken van boompjes voornamelijk door mannetjes lijkt te worden gedaan, mogelijk een teken van dominatie in een bepaald gebied. Verder zouden de tekens een territoriale betekenis kunnen hebben, waardoor een regelmatiger verspreiding van de dieren over het gebied wordt verkregen.

In het studie-gebied leven de neushoorns voornamelijk van de bladeren en zachte stengeldelen van kruiden en struiken, maar ook worden kleine boompjes omver gedrukt om er de bladeren vanaf te eten. Hoewel er een grote hoeveelheid voedsel beschikbaar is (de ondergroei in de gebergtebossen is zeer dicht) is de aangroei zeer traag en ook de voedingwaarde is gering. Dit verklaart waarschijnlijk de betrekkelijk lage dichtheid van de neushoorn en is mogelijk ook de reden voor de langzame voortplanting.

Neushoorn faeces is zeer karakteristiek, met een grote hoeveelheid kort-afgebeten stengeldelen. Vooral op de hogere bergruggen kan faeces een jaar of langer herkenbaar blijven. Er kon worden aangetoond dat de aanwezigheid van oude faeces de neushoorn tot een eigen bijdrage stimuleert en verder wordt er meestal wat faeces in het water gedeponeerd als een neushoorn een beekje of riviertje oversteekt.

In eerdere neushoorn studies werd meestal alleen gebruik gemaakt van de breedte van de voetafdrukken om de verschillende dieren te herkennen en een schatting van het aantal te maken. Door vergelijking met de resultaten van de identificatie met behulp van gipsafgietsels kon worden aangetoond dat met voetspoor-breedte alleen zelden betrouwbare resultaten te verkrijgen zijn. Evenwel door naast meten ook gipsafdrukken van de middelste hoeven te maken kan er wel een goede schatting van het aantal dieren in een gebied worden verkregen in een betrekkelijk korte periode.

De hele wereldpopulatie van Sumatraanse neushoorns telt waarschijnlijk minder dan 1000 stuks en deze zijn verspreid over een groot aantal verschillende gebieden. De meeste gebieden herbergen slechts een gering aantal dieren en de overlevingskansen voor dergelijke kleine geisoleerde populaties zijn gering. Er zijn echter nog enkele vrij grote populaties, met name op Sumatra in Gunung Leuser en Kerinci-Seblat, maar ook in Malaysia en Sabah. Door een goede bescherming kan het aantal neushoorns daar nog belangrijk toenemen en voor het voortbestaan van de soort zijn dit verreweg de belangrijkste gebieden.

Het is daarom van het grootste belang dat de bescherming van deze gebieden verder te verbeteren en de neushoorn stroperij daar aktief te bestrijden. Elders dient bezien te worden of de overgebleven neushoorn populaties nog voldoende levenskansen hebben en of het mogelijk is daar voldoende grote reservaten in te stellen om hen ook op de lange duur levensruimte te geven.

RINGKASAN

Judul: Badak Sumatera Dicerorhinus sumatrensis (Fischer, 1814) di Taman Nasional Gunung Leuser, Sumatera, Indonesia: Penyebaran, cara hidup dan perlindungan.

Badak Sumatera adalah salah satu diantara jenis-jenis satwa yang paling banyak menderita akibat ledakan populasi manusia yang tidak terkendali dan sejalan dengan itu penghancuran dari pada persekutuan-persekutuan hidup alami (biocoenose). Disamping itu badak sudah sejak lama banyak sekali diburu untuk mendapatkan culanya yang bernilai tinggi. Pada suatu ketika badak Sumatera terdapat disebahagian besar daerah Asia Tenggara dari kaki Gunung Himalaya di Bhutan sampai Kalimantan, Sabah dan Sumatera. Dewasa ini jenis tersebut telah punah disebahagian besar daerah tadi dan hanya disana sini masih terdapat dalam jumlah kecil, biasanya didaerah-daerah yang amat terpencil.

Badak Sumatera adalah terkecil dari 5 jenis yang masih ada dan juga yang paling sedikit pernah mengalami penelitian. Sudah lama binatang ini langka dan hidup didaerah yang sulit dikunjungi hal mana kurang menguntungkan bagi melakukan satu penelitian. Penelitian ini dilakukan tidak hanya karena ada minat ilmiah untuk itu tapi juga dipandang sangat penting ditinjau dari sudut perlindungan alam. Dengan pengetahuan yang lebih banyak tentang persebaran dan cara hidup dari pada badak, maka perlindungannya dan pengelolaan dari populasinya terakhir yang masih tinggal akan terselenggara lebih sempurna. Lagi pula badak Sumatera adalah pemakan tumbuhtumbuhan (herbivora) terbesar yang hidup melulu dihutan lebat tropis. Oleh karenanya jenis ini memiliki semacam fungsi pemandu dalam penghunjukan suaka-suaka alam didaerah ini. Satu suaka yang dapat mendukung satu populasi besar badak dapat dianggap juga sesuai bagi kehidupan pemakan tumbuh-tumbuhan kecil lainnya.

Karena kelangkaannya dibarengi sifat pengejut dari badak ditambah dengan topografi lapangan yang kurang menguntungkan, seraya mengandung tumbuhan sangat lebat tidak memungkinkan seseorang melihat langsung seekor badak sebagaimana telah terbukti dari penelitian-penelitian sebelumnya. Oleh sebab itu penelitian harus tertuju kepada usaha mempelajari jejak-jejak dan tanda-tanda lainnya yang dapat dijumpai di lapangan.

Satu dari sekian banyak persoalan pertama dalam penelitian ini ialah menumbuhkan satu cara (methode) yang memungkinkan pengenalan secara terpisah setiap ekor badak berdasarkan jejak-jejak kakinya sehingga semua gerak binatang itu baik dalam ruang maupun waktu dapat diikuti.

Penelitian dilakukan di Taman Nasional Gunung Leuser sebidang lapangan yang luasnya hampir sejuta hektare dipegunungan Sumatera bagian Utara. Disebabkan pemburuan-pemburuan gelap, maka juga disini populasi badak sudah sangat jarang, namun dibagian tengah dari suaka itu yang sukar dikunjungi, menurut taksiran masih ada beberapa puluh ekor. Oleh sebab itu disana telah dipilih sebidang lapangan studi/penelitian, yakni dilembah hulu Mamas, satu anak sungai dari Sungai Alas yang mengalir mengikuti panjang suaka alam.

Hulu Mamas berada kurang lebih 1200 meter dari pemukaan laut dan gunung-gunung sebelah menyebelah dari padanya mencapai ketinggian 1800 sampai 2100 meter. Seluruh daerah itu ditumbuhi hutan lebat, kecuali beberapa lahan rawa kecil dan satu dua puncak gunung. Sepanjang sungai terdapat beberapa mata air panas (lumpur garam) dimana badak dan binatang-binatang lainnya berdatangan untuk minum air yang mengandung mineral. Daerah tersebut diarungi dengan jalan satwa yang mengikuti sungai-sungai yang lebih besar dan punggung-punggung gunung. Dari jalan-jalan tersebut kurang lebih sepanjang 150 km telah dipetakan dan dipergunakan sebagai jalan patroli. Dari 6 perkemahan tetap seluruh daerah penelitian ini, seluas kurang lebih 180 km^2, beberapa kali dalam satu tahun diarungi dalam usaha mencari jejak-jejak badak.

Untuk mempelajarinya dipergunakan coran batu-tahu (plastercast) dari pada jejak-jejak kaki. Pada umumnya dari setiap jejak diambil dua coran dari kaki sebelah kiri dan dua dari kaki sebelah kanan bagian belakang (kedua-dua kaki belakang biasanya ditaruh diatas cetakan kedua-dua kaki depan). Kelak, semua coran batu-tahu keping per keping dilem diatas papan-papan kecil. Selama studi telah diperbuat 371 pelbagai coran batu-tahu dari jejak-jejak badak.

Dengan membandingkan besar, bentuk dan letak kaki dan ketiga-tiga kuku, dapat diketahui jumlah pelbagai binatang secara tersendiri. Waktu membandingkan coran-coran batu-tahu dipergunakan foto-foto stereo dan skets dari pad keliling kaki dan kuku-kuku. Selanjutnya diambil 5 ukuran dari setiap coran.

Biarpun ada banyak perbedaan, kerap kali sangat khas diantara semua coran, tidaklah begitu mudah untuk mengenal dengan pasti semua coran. Tidak jarang satu coran berkualitas rendah dan tidak semua ciri-ciri dapat dilihat dengan jelas, tapi juga jenis tanah, lereng dan arah dan kecepatan berjalan mempengaruhi bentuk dari pada bekas jejak kaki. Selanjutnya ternyata bahwa disepanyang masa bisa terjadi perobahan-perobahan jang jelas dalam kuku.

Setelah seluruh koleksi coran beberapa kali diolah dapat dikenali 39 ekor pelbagai badak. Dari 8 binatang dapat diketahui bahwa mereka adalah betina oleh karena selama penelitian berjalan mereka kelihatan bersama jejak seekor anak badak, 4 ekor diduga adalah jantan oleh sebab selama penelitian mereka dijumpai tanpa seekor anak. Dari 9 ekor binatang yang sudah dewasa jenis kelaminnya tidak dapat ditentukan. Selama penelitian ada 12 ekor anak badak lahir didaerah studi kami dan selanjutnya diketemukan lagi 6 ekor badak muda belia.

Dari sepasang anak badak dalam waktu teratur dijumpai jejaknya dan dari situ dapat disusun satu garis lengkung pertumbuhan bagi kaki badak Sumatera yang masih muda. Ini memungkinkan menaksir umur anak-anak badak lainnya yang jarang diketemukan. Tidak ada dijumpai perbedaan perbedaan yang jelas antara jejak jejak kaki jantan dan betina. Kaki dari pada seekor jantan muda agaknya rata-rata lebih besar dan betina muda kelihatan kerap kali memiliki jejak kaki tidak teratur atau asymetris (tidak sepadan).

Dari peta persebaran pelbagai badak dapat dipelajari pembagian ruang gerak dari pada setiap individu. Berdasarkan banyaknya jejak-jejak baru sehubungan dengan waktu yang telah silam sejak hujan deras terakhir, dapat dihitung berapa kali seekor badak mengunjungi satu tempat tertentu. Lebih-lebih badak betina memperlihatkan satu teladan yang menarik. Didaerah penelitian para badak betina hanya sekali dalam tiga atau empat tahun memperoleh seekor anak, yang akan tinggal bersama ibunya selama satu setengah tahun. Induk dan anak tinggal disekitar satu tempat garam jilatan seraya menjelajahi satu daerah seluas 10 sampai 15 kilometer persegi. Rata-rata sekali dalam tiga minggu mereka pergi ketempat garam jilatan.

Apabila si anak sesudah satu setengah tahun dapat berdiri sendiri ia tetap berada disekitar daerah tersebut, namun induknya menarik diri jauh dari tempat garam jilatan. Tanpa anak, badak betina jarang sekali diketemui, biasanya ia berada pada tempat-tempat yang letaknya lebih tinggi di pinggiran daerah penelitian. Dalam kurun waktu ini mereka berkelana agaknya disatu daerah yang relatip kecil, 10 kilometer persegi atau kurang dan rata-rata sekali dalam enam minggu mengunjungi tempat garam jilatan. Kelihatannya, daerah-daerah dimana betina mengembara tanpa anak jelas terpisah satu dari yang lain. Sekitar tempat-tempat garam jilatan dapat dijumpai dua atau tiga ekor betina dengan seekor anak dalam satu daerah.

Ditahun-tahun pertama dari pada kebebasannya seekor badak muda Sumatera menempati sebidang daerah yang relatip kecil, dimana ia berkelana bersama seekor betina. Ada kemungkinan anak-anak muda badak berkelana bersama-sama buat sementara waktu saja. Lambat laun daerah tempat tinggalnya meluas sampai 20 atau 25 km persegi. Lalu mereka dijumpai di daerah penelitian dengan selang tidak beraturan hal mana menunjukkan bahwa mereka mungkin hidup mengembara jauh dari tempat kediamannya semula.

Daerah-daerah yang dihuni oleh badak-badak jantan, serupa dengan yang dihuni oleh badak-badak betina, secara teratur terbagi diatas lapangan penelitian, daerah-daerah tinggal bersendirian sebagian besar tumpang tindih satu sama lain. Daerah tinggal seekor jantan relatip adalah luas, 30 km persegi atau kadang-kadang lebih. Rata-rata sekali dalam dua bulan badak-badak jantan mengunjungi tempat garam jilatan, tapi beberapa ekor diantaranya berkunjung lebih sering dan kadang-kadang mereka juga pergi ke tempat garam jilatan lainnya.

Badak-badak dewasa dijumpai hampir melulu sendirian, hanya sekali peristiwa diketemui jejak-jejak kaki dua binatang, seekor jantan dan seekor binatang muda agaknya sudah berumur yang pada satu waktu hidup bersama-sama. Ini menunjukkan bahwa badak-badak jantan dan betina hanya dalam kurun waktu yang sangat singkat berkumpul untuk melakukan persetubuhan.

Kepadatan populasi badak di daerah penelitian, berdasarkan contoh/teledan persebaran dari pada oknum-oknumnya (individu) diperkirakan kurang lebih 13 atau 14 binatang per 100 km persegi ataupun seekor badak dalam areal seluas 700 - 800 ha.

Semua badak didaerah penelitian dari waktu ke waktu mengunjungi tempat-tempat garam jilatan sambil minum air yang kaya akan mineral dan mungkin kadang-kadang juga makan sedikit lumpur.

Tetapi oleh karena kebanyakan binatang hanya dengan selang sebulan atau lebih mengunjungi tempat garam jilatan, bukan mustahil mereka lakukan itu melulu untuk mendapatkan mineral yang jumlahnya relatip sedikit. Kelihatannya tempat-tempat garam jilatan juga berperan sebagai tempat pertemuan. Ada jantan pergi sering kali ke tempat garam jilatan dan berkelana terus-menerus disekelilingnya. Ini menimbulkan kesan seolah-olah ia mencari jejak jejak kaki betina yang sebelumnya sudah pergi ketempat itu.

Selama bertahun-tahun badak dan gajah telah membikin jaringan jalan-jalan yang padat diseluruh daerah tersebut. Lebih-lebih sepanjang sungai-sungai besar dan lewat punggung gunung tertinggi jalan-jalan ini agak lebar dan terbuka. Ia tidak sedikit mempermudah mobilitas, bukan saja bagi badak tapi juga bagi jenis-jenis satwa lainnya dan para peneliti. Badak-badak mengikuti jalan-jalan tersebut kadang-kadang sejauh puluhan kilometer, terutama dalam perjalanan ketempat garam jilatan. Selanjutnya mereka berjalan kerap kali mengikuti garis-garis ketinggian (contour lines) lewat lereng gunung dan kelihatannya mereka memilih sungai-sungai besar dan punggung-punggung gunung sebagai titik orientasi. Lewat lintasan-lintasan dan dibeberapa tempat dalam hutan diketemukan panas dan lembah atau lobang-lobang lumpur, dimana badak-badak secara teratur datang untuk mandi. Kadang-kadang tempat mandi tersebut terdiri dari hanya satu lobang yang dangkal, tetapi ditempat-tempat lain ada sejumlah lobang dibikin berdekatan satu sama lain, ada kalanya dikorek dalam dilereng gunung. Ada juga jenis-jenis binatang lainnya yang memanfaatkan lobang-lobang tersebut, namun sang badaklah yang membuat bentuknya yang khas itu.

Lewat jalan-jalan/lintasan-lintasan yang agak besar badak-badak membikin tanda-tanda yang menyolok. Dengan kedua-dua kaki belakangnya tandah digarukaya dan sering ditempat itu ia rusakan beberapa pohon kecil dan menutupi keseluruhannya dengan kotoran (faeces) atau menyiramnya dengan air kencing (urine). Tanda-tanda yang serupa dibikin oleh jantan maupun betina dari semua golongan umur, tetapi jarang sekali oleh satwa-satwa yang masih sangat muda.

Anak badak yang agak lebih tua dan beberapa ekor jantan membikin relatip banyak tanda namun hanya badak-badak jantan saja yang merusak pohon-pohon kecil mungkin sebagai tanda penguasaan satu daerah tertentu. Mungkin juga tanda-tanda tersebut mempunyai arti teritorial, oleh sebab mana dapat diperoleh satu gambaran persebaran baik dari pada binatang-binatang itu didaerah berkenaan.

Didaerah penelitian badak hidup terutama dari daun-daun dan pucuk-pucuk tangkai lunak dari pada rumput-rumputan dan pohon-pohon kecil yang tumbang ditekan oleh badak. Biarpun banyak jumlah bahan makanan yang tersedia, tumbuhan bawah dihutan-hutan pegunungan biasanya sangat padat, namun proses pertambahan tumbuh berlangsung sangat lamban juga nilai makanannya sangat rendah. Barangkali inilah penyebab sedikitnya populasi badak disatu daerah dengan limpahan bahan makanan yang semu dan mungkin juga satu alasan bagi lambannya pembiakan dari pada badak.

Kotoran badak sangat khas dengan mengandung jumlah besar bagian-bagian tankai yang digigit pendek-pendek. Terutama di punggung-punggung gunung yang tinggi kotoran badak selama satu tahun atau lebih masih dapat dikenali. Kotoran sering dijumpai dianak-anak sungai atau sungai-sungai tempat penyeberangan badak juga dapat diketahui bahwa tumpukan-tumpukan kotoran lama itu merangsang seekor badak untuk "mengeluarkan" kotorannya pula.

Dalam penelitian badak terdahulu biasanya hanya lebar jejak-jejak kaki dipakai untuk mengenali pelbagai jenis binatang-binatang dan membuat taksiran jumlahnya. Dengan membandingkan hasil-hasil identifikasi melalui coran-coran batu tahu dapat ditunjukkan bahwa metode ini jarang memberikan hasil-hasil yang dapat dipercaya. Akan tetapi disamping mempergunakan ukuran-ukuran jejak-jejak kaki juga coran batu tahu dari pada kuku paling tengah dapat diperoleh taksiran yang baik dari jumlah satwa dalam waktu relatip singkat.

Populasi se dunia badak Sumatera barang kali kurang dari 1000 ekor dan ini berada di sejumlah pelbagai daerah (negara). Kebanyakan dari padanya dihuni hanya oleh beberapa ekor saja dan kesempatan untuk hidup terus serta membiak bagi populasi yang begitu kecil lagi pula dalam keadaan terpencil adalah minim. Di samping itu masih ada beberapa populasi yang agak besar, antara lain di Sumatera, di Suaka-Suaka yang besar/luas seperti Gunung Leuser dan Kerinci-Sebelat, tapi juga di Semenanjung Malaysia dan Sabah, Malaysia Timur. Dengan perlindungan/pengamanan yang baik dan mantep jumlah badak di sana masih bisa meningkat. Daerah-daerah tersebut diatas adalah merupakan lokasi-lokasi terpenting bagi usaha melestarikan jenis badak Sumatra oleh karena itu adalah sangat penting jika perbaikan sistim perlindungan/pengamanan di daerah-daerah ini tadi dapat terus ditingkatkan seraya memberanteras dengan tuntas perburuan-perburuan liar badak. Pada tempat-tempat lain perlu dilakukan peninjauan apakah populasi badak disana masih mempunyai cukup kesempatan untuk terus hidup atau kah mungkin dihunjuk suaka-suaka yang besar yang dalam jangka panjang dapat memberi ruang hidup yang cukup luas bagi mereka yang kini tergolong satwa langka.