A Field Study of the Sumatran Rhinoceros

Dicerorhinus sumatrensis

Fischer 1814

Ecology and Behaviour Conservation Situation in Sumatra

INAUGURAL-DISSERTATION

zur Erlangung der Würde eines Doktors der Philosophie
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Dekan

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INTRODUCTION

1. Aims and Organisation of Project

The main objectives of the Sumatran-Rhino-Project were to investigate the distribution of the species in Sumatra, to estimate the size of the local rhino populations and to study the life conditions and survival chances of the rhinos. A further objective was the study of the ecology and behaviour of the species in order to provide the scientific background necessary for the development of a program devoted to the conservation of the rhino (photo 1).

The project has been carried out as IUCN/WWF Joint Project 884, financed by World Wildlife Fund International.* The scientific research has been carried out under the guidance of Prof.R.Schenkel, University of Basel, Chairman of IUCN/SSC Asian Rhino Specialist Group. Field work started in December 1972 and lasted until October 1975.

2. Areas Surveyed and Local Rhino Populations Studied

In 1973 the Gunung Leuser and Langkat reserves in the provinces of North Sumatra and Aceh were thoroughly surveyed. During this time, an area in the upper Mamas basin in the center of the

* In 1969 R. and L.Schenkel wrote an alarming report based on a survey trip to central Sumatra and to the Leuser reserve in northern Sumatra (province of Aceh) and sent it to IUCN/WWF and competent authorities of the central and local government. IUCN/WWF and the Indonesian Government agreed to take steps to start a rhino conservation program with special regards to Leuser. In 1970 F.Kurt, on mission by IUCN/WWF and the Indonesian Government, made a more extensive survey of the Leuser reserve. His report provided the basis on which Project 884 was planned and started.

Gunung Leuser reserve was selected for a more intensive study of the ecology and behaviour of the rhino. During 1974/75 21 survey areas outside the Gunung Leuser reserve, situated all over Sumatra, were visited (Fig.13, Tab.4, p.37-39).

3. Methods

3.1. Methods for general survey

Large parts of the Island of Sumatra, especially in the Barisan mountain ridge, are not mapped and remain unexplored. In selecting the survey areas, some recent literature on the distribution of the Sumatran rhino could be used (Talbot 1960, Skafte 1961, Milton 1964, Schenkel 1969 and Kurt 1970). In addition countless interviews were made all over Sumatra with officials from the Nature Conservation Department, the Forestry Department, police and army, with geologists, hunters, villagers and farmers. Survey flights were carried out in the Aceh, North Sumatra and Riau provinces.

For general orientation I used the "USAF Operational Navigation Chart" ONC-L-10 and ONC-M-10. For some areas I was able to use more detailed maps, obtained from the Dinas Kehutanan (Forestry Department) and the Dinas Perlindungan Alam (Nature Conservation Department). In the lowlands of Riau I used the aeronautical charts of P.T.Caltex Pacific Indonesia and in the unmapped Leuser area in Aceh the "Uncontrolled Mosaic Side Looking Radar Map" of P.T.Aceh Minerals (Newmont PTY). None of these maps was detailed or accurate, and correct orientation was often a matter of chance. The only accurate map available was for the Langkat reserve in North Sumatra (Mobil Oil S.E.Asia: Topo-Hydro, 1:100'000, 3N-97E / 3N-98E).

Usually the rhino areas were remote and difficult to reach. I approached the survey areas as closely as possible with a WWF Toyota Landcruiser. When I could go no further by vehicle,

I hired five to eight carriers with the help of the head of the local village. We usually set out into the forest on foot with a supply of rice for two to three weeks, and proceeded much in the manner of the local hunters and ratan collectors.

In the swampy lowlands of central Sumatra as well as in the steep mountains of the Barisan mountain range, the rain forest is not easy to penetrate. In cutting through it, we sometimes managed to cover only one or two kilometer in one day. Whenever it was possible, we followed rivers, streams and animal trails, even if it meant large detours.

During the surveys I covered about 45'000 km by Jeep and timber truck, 800 km by dugout and motorboat, 6000 km by plane, over 1200 km by helicopter and about 3000 km by foot. A total of 450 days were spent on expeditions, i.e. walking and camping in the forest.

My photo equipment and my tape recorder were packed with Silikagel in a waterproof aluminium box. (CANON F1/two bodies/lenses: 28 mm, 50 mm, 200 mm/flash. Colorfilm: EKTACHROME Highspeed and KODACHROME 64, black and white film: Kodak/Ilford. Tape: SANYO, Midget Memo.)

I used a THOMMEN altimeter and a RECTA compass.

3.2. Methods for the study of ecology and behaviour

3.2.1. The study area in the Gunung Leuser reserve

The Gunung Leuser reserve sensu stricto is situated in the province of Aceh between 3 and 4 degrees North and 97 and 98 degrees East. It covers an area of 416'500 ha and is approximately 150 km long and 50 km wide. The Bukit Barisan, the mountain range of Sumatra transverses the reserve from NNW to SSE. In the North and West the ridge rises to an altitude of over 3000 m a.s.l. (G.Leuser 3466 m, G.Kemiri 3314 m), in the East it descends to the Alas valley and in the South to the lowlands of the Singkil area (Fig.1).

Lowland forest can be found along the Alas river and in the Bengkong river area. The Mukab and the Mamas river areas are covered mainly with submontane forest. Most of the northern and the central part is damp moss forest. Natural belangs (treeless areas) can be found on the peaks of the higher mountains. Natural secondary growth occurs on landslide areas and along rivers. Man-made secondary growth can only be found on the periphery of the reserve.

Parallel to the Kluet and the Alas rivers, a rift valley separates two mountain ranges. This valley is drained by four rivers of the Alas system and one tributary of the Kluet river. For somewhat more than half of its length, the valley-bottom is situated below an altitude of 1500 m a.s.l. A rich mammal fauna can be found in this region (Fig.2).

Seven expeditions with a duration of 10 to 28 days each were carried out all over the Gunung Leuser reserve before deciding on a study area. As evidence of rhinos was abundant in the Mamas basin and the area could be reached by foot in only two to three days, I decided to establish my study area in the southern part of the Mamas basin (Fig.3).

The study area is situated 3°18' N / 97°40' E. It covers an area of about 250 square kilometers and includes part of the drainage area of the Mamas river and the main tributaries of the Kompas and Silukluk rivers (Fig.4). The highest elevation is found on the west side (Gunung Medan, 2200 m a.s.l.). This western ridge forms the watershed between the Mamas and the Kluet rivers. The eastern ridge, the watershed between Mamas and Alas rivers, reaches altitudes up to 1800 m a.s.l. Between these ridges is the Mamas basin, a flat valley, about 10 km wide. The south-eastern end of the Mamas basin is the relatively flat watershed to the Silukluk river. A long ridge, running from east to west,

Fig.1: Gunung Leuser Reserve

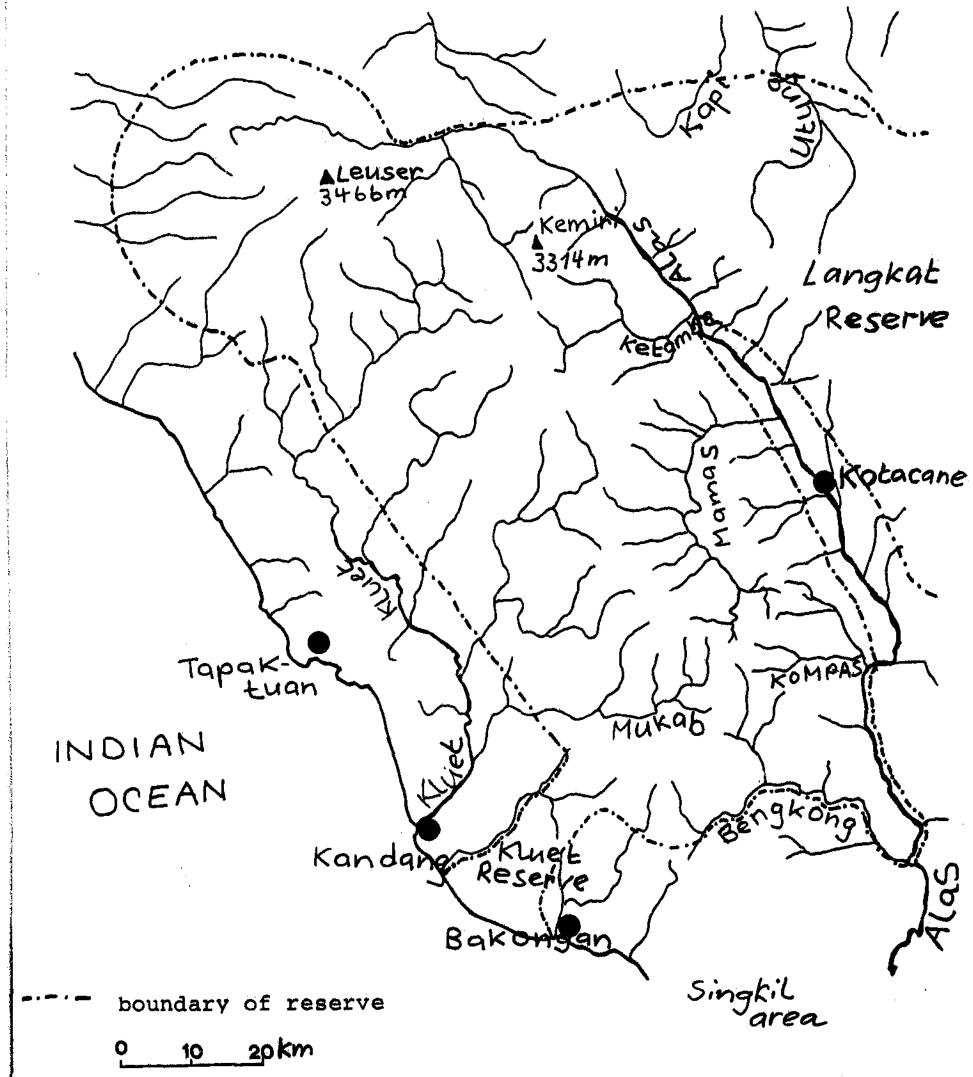
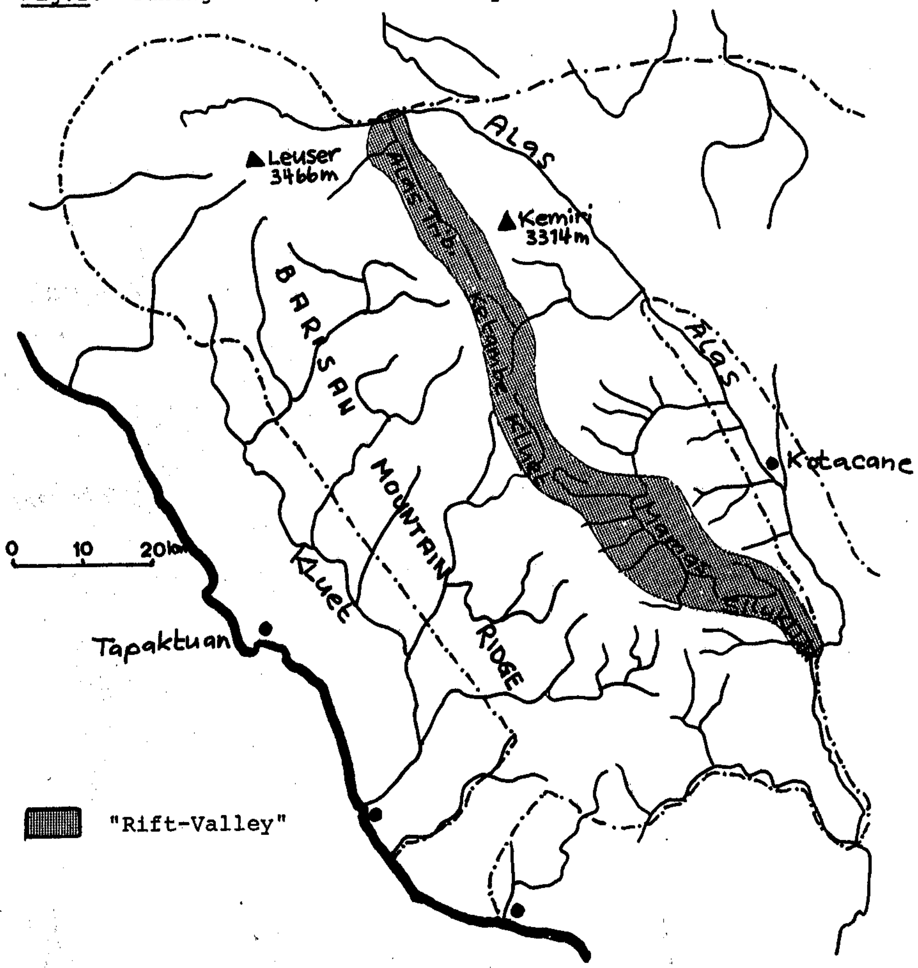


Fig.2: Gunung Leuser, "Rift-Valley"



"Rift-Valley": elevation and vegetation of valley floor transsect north-south (own data)

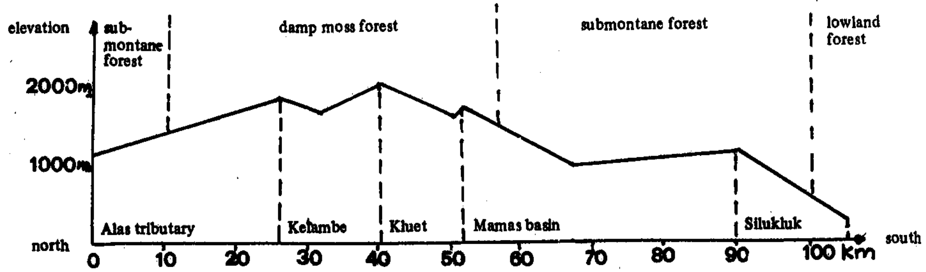
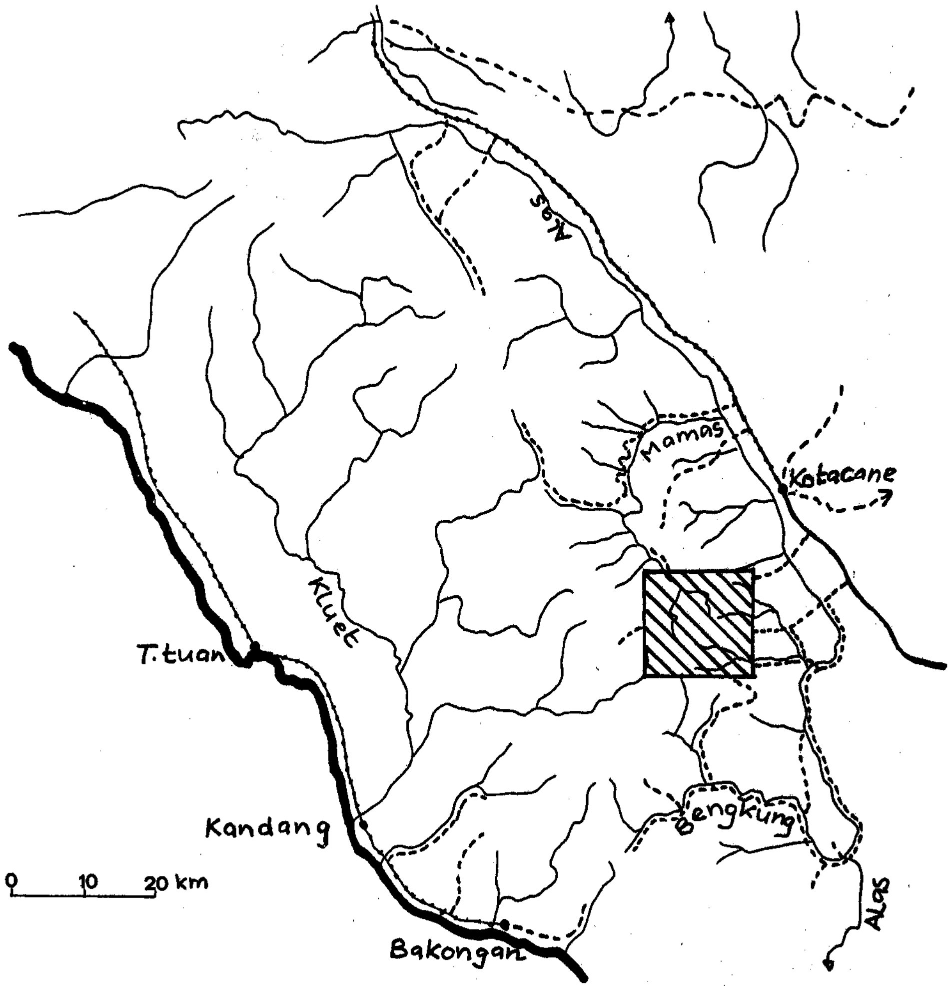


Fig.3: Gunung Leuser Reserve, Study Area and Expedition Routes



study area (approx. 250 km^2)

expedition routes

gravel roads

hard surface road

Fig.4: Study Area, Relief
Uncontrolled mosaic side looking radar map (for Newmont PTY)
all elevations own data

the Silukluk ridge separates the Mamas and the Silukluk rivers from the Kompas river. With the exception of the south-eastern Mamas basin the area is mountainous and steep (Fig.5).

Most of the area is covered with primary submontane forest. Damp moss forest can be found on the higher areas mainly in the western part.

Besides the rhino the following large mammals were found to live in the study area: Elephas maximus, Cervus unicolor, Muntiacus muntjak, Capricornis sumatrensis, Sus scrofa, Panthera tigris sumatrensis, Neofelis nebulosa, Felis temminckii, Helarctos malayanus, Cuon alpinus, Pongo pygmaeus.

Base camps were established at Sungei Pinus, Tempat Medan and Sungei Ikan Kaleng. The base camp at Sungei Pinus could be reached from Lawe SiGalagala (the nearest village) in two to three days (Fig.6).

From the beginning of 1973 to the end of 1975, expeditions with a duration of three to five weeks were made to the study area about every three or four months.

3.2.2. Direct observation and track analysis

Direct observation of the Sumatran rhino was nearly impossible. First, the density of the rhino population is extremely low and the animals are widely scattered over the area. Second, the visibility in the rain forest is reduced to some 20 meters or less and the flight distance of the rhino and other large mammals is usually much greater. Encounters with large, ground living animals were therefore extremely rare. By baiting natural salt licks with additional salt and by building well camouflaged tree-hides nearby I tried to make some direct observations of the rhinos. Although I stayed day and night in treehides - once for three weeks, twice for two weeks - the results were disappointing. To minimize disturbance, I had my base camp three walking hours from the treehide and got a food supply of cold rice and

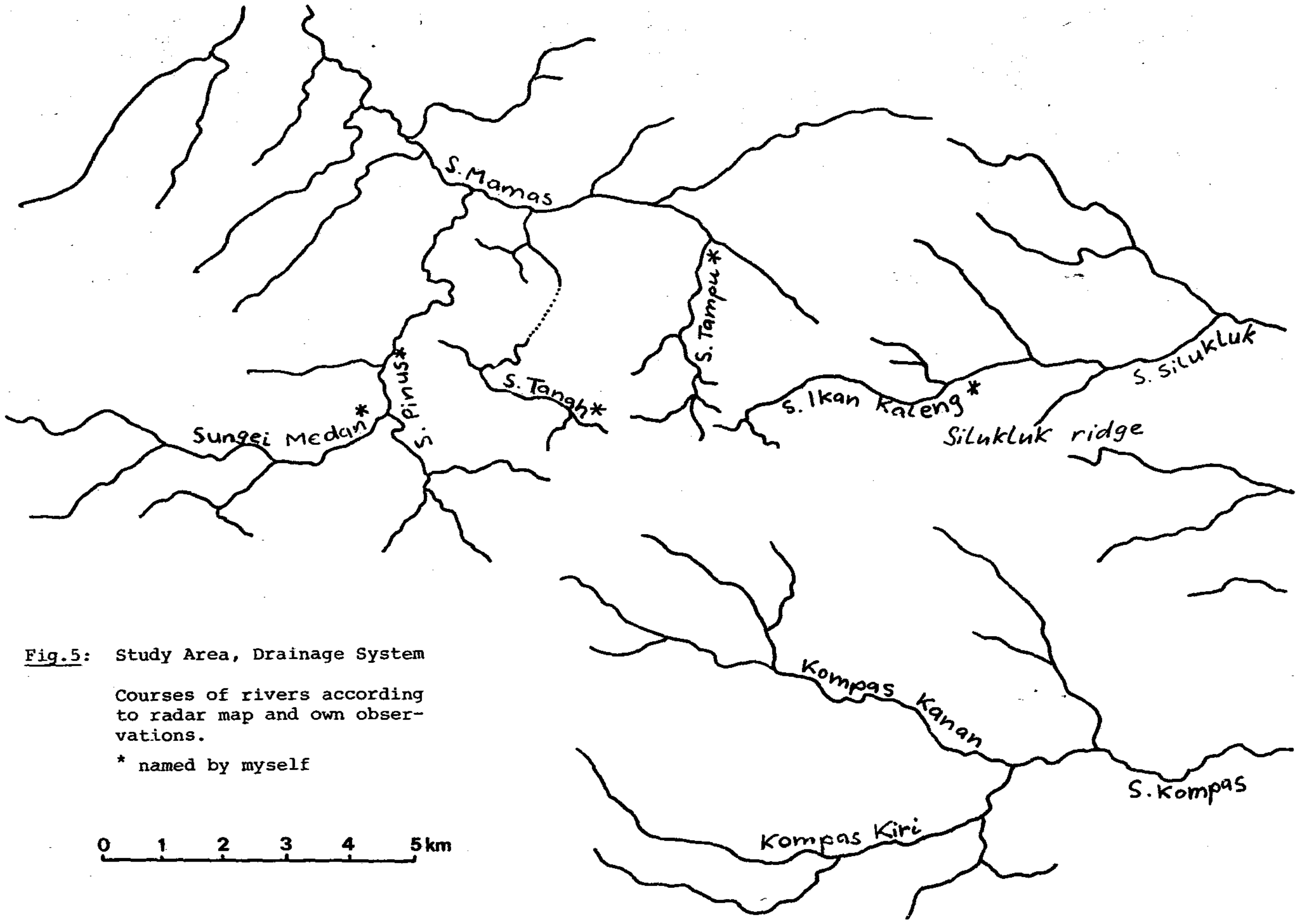


Fig.5: Study Area, Drainage System

Courses of rivers according to radar map and own observations.

* named by myself

0 1 2 3 4 5km

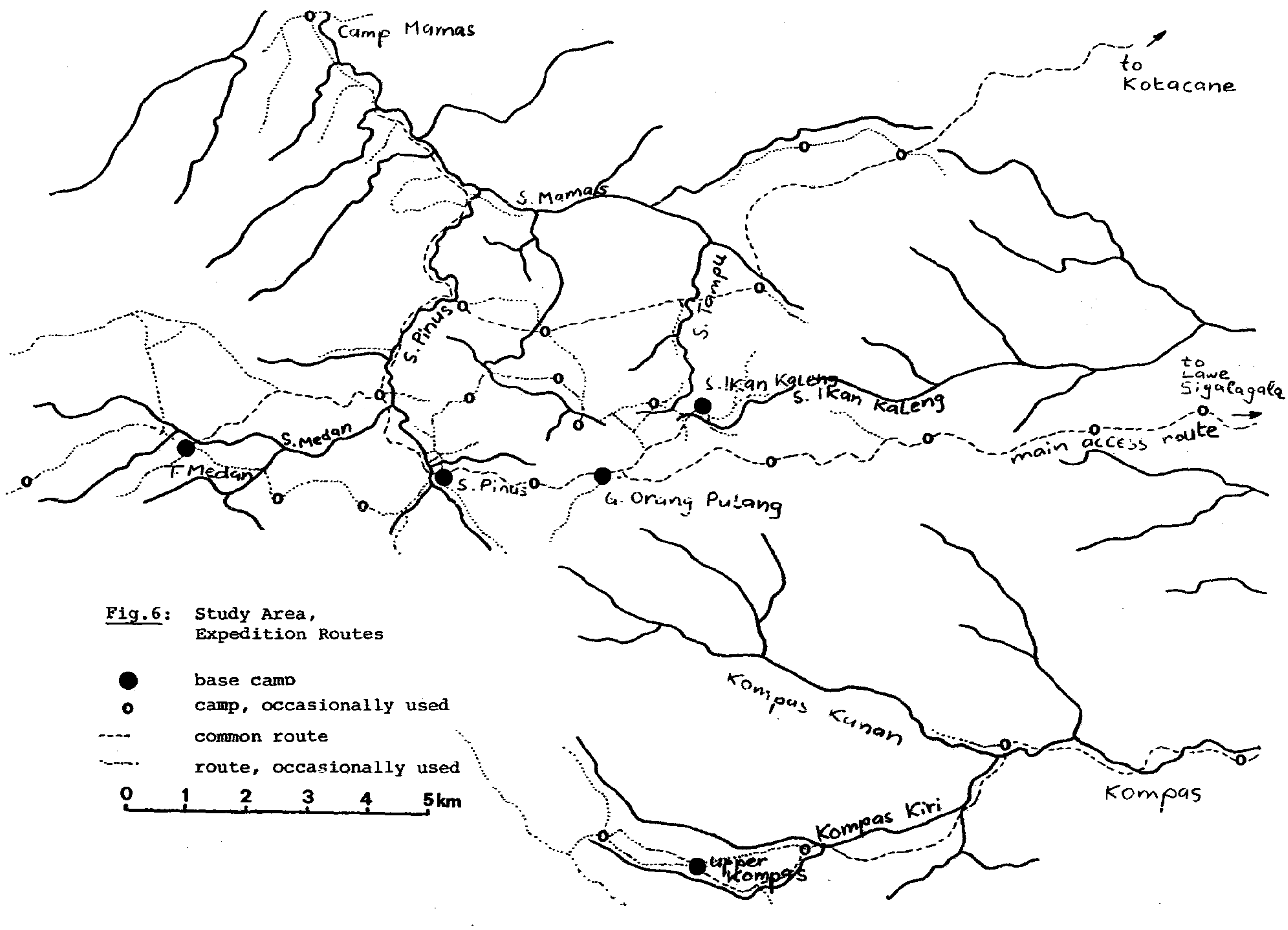


Fig.6: Study Area, Expedition Routes

● base camp
o camp, occasionally used
---- common route
.... route, occasionally used

0 1 2 3 4 5km

dried fish only every third day. Despite these precautions I never saw a rhino from a treehide.

As the Sumatran rhino is so critically endangered that every individual is important for the survival of the species, a technique such as radio-telemetry, which involves capturing and tranquillizing of the animal was out of question. Even if the difficulties of capturing them could be surmounted, the risk to the life of the animal would be too great.

The study therefore had to be concentrated on the various tracks and traces the rhinos left in the forest. Whenever a fresh rhino track was found, I followed it as far as possible. Every mark that had definitely been left by a rhino was carefully registered and analyzed. Foot prints, feeding marks, broken and twisted saplings, faeces and urine, wallows and trails and many other signs were carefully interpreted with regard to ecology and behaviour. These methods are described in more detail in the respective sections.

PART I: SURVEY ON DISTRIBUTION AND NUMBERS

1. Ecosystem and Rhino Population of Sumatra in Former and in Recent Times

1.1. Topography, climate and original vegetation of Sumatra

Sumatra is the fifth largest island of the world. It is about 1700 km long, reaches a width of nearly 400 km and covers an area of about 434'000 km^2. The Barisan mountain range, with numerous volcanoes, extends along the west coast for nearly the whole length of the island, descending eastwards to large alluvial lowlands. The Barisan mountains reach their highest peaks in the central and northern part. (Gunung Kerinci, 3778 m a.s.l. and Gunung Leuser, 3466 m a.s.l.) Owing to the proximity of the mountains to the west coast, the western rivers usually run through steep valleys and have a short lower course. The eastern rivers run through the large alluvial plains and have a long flat lower course (Fig.7).

Rainfall is abundant throughout the year. There is no specific dry season, even the driest months receive around thirty centimeters of rain. In western Sumatra, the annual rainfall amounts to 480 cm (Bünning 1956), in North Sumatra to 550 cm (Bohorok, own data) (Fig.8).

The mean annual temperature for the lowlands in Sumatra is about 26° Celsius. The mean monthly temperature varies only about two degrees throughout the year (West Sumatra).

With increasing altitude the temperature decreases by 0.5 to 0.6° C per 100 m. Lake Toba, with an elevation of 1143 m a.s.l., has a mean annual temperature of 20.9° Celsius. In my study area in the Gunung Leuser reserve at an elevation of 1200 to 2000 m a.s.l., the mean annual temperature lies between 16 and 19 degrees Celsius.

Fig.7: Relief Map of Sumatra

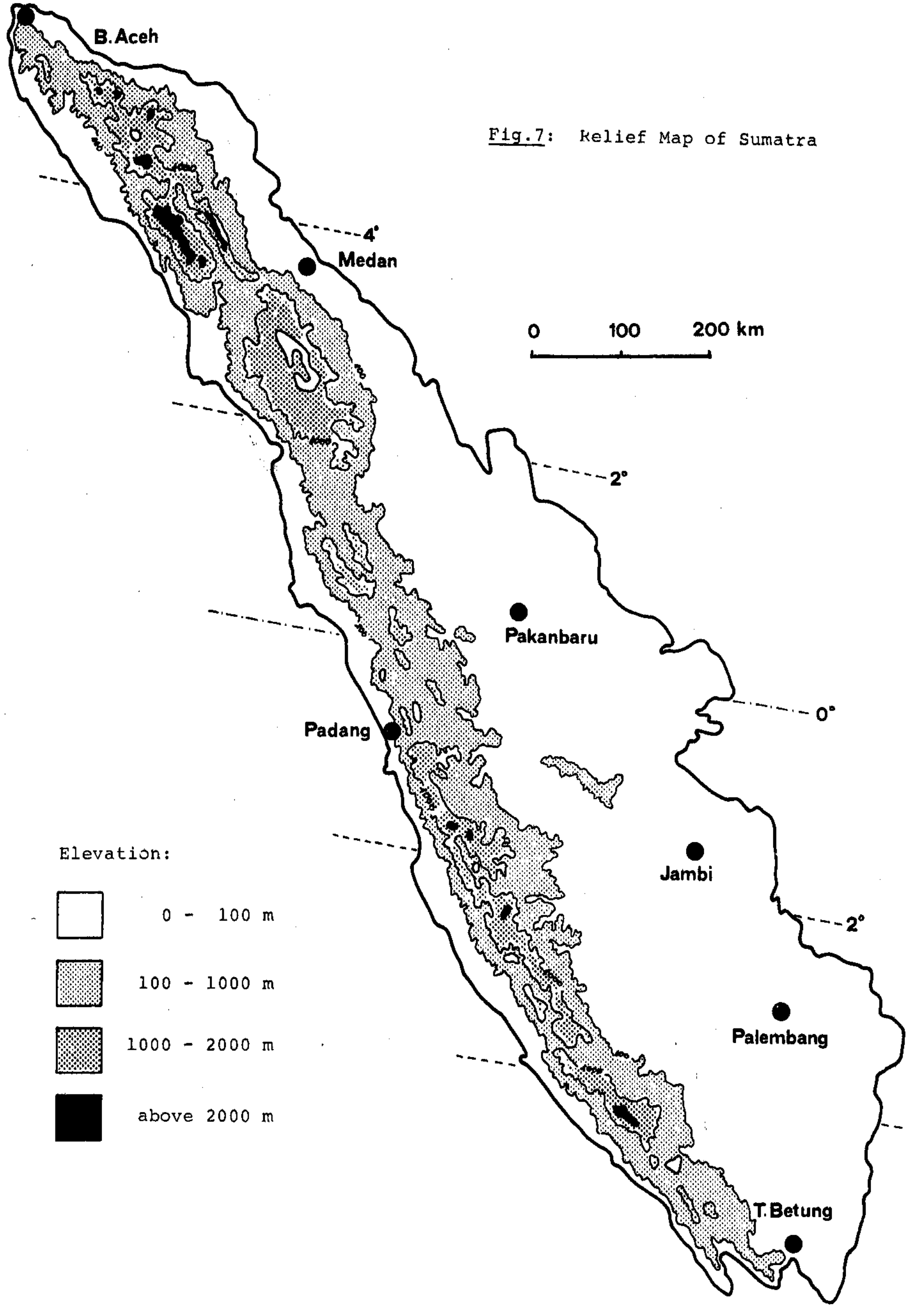
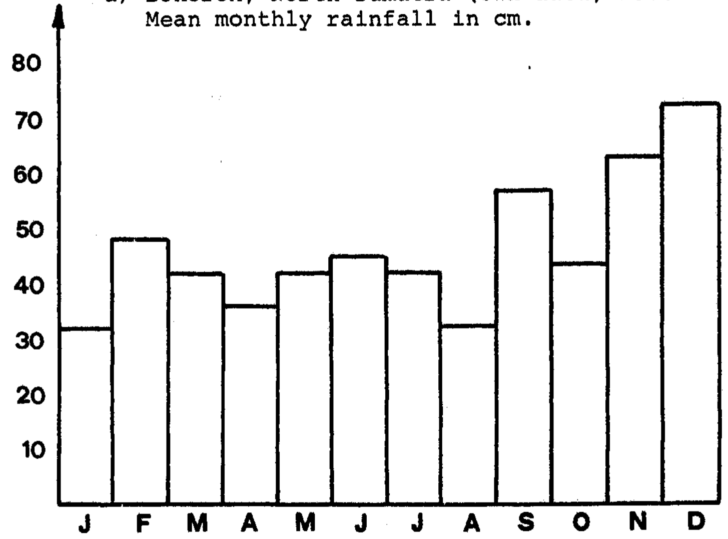
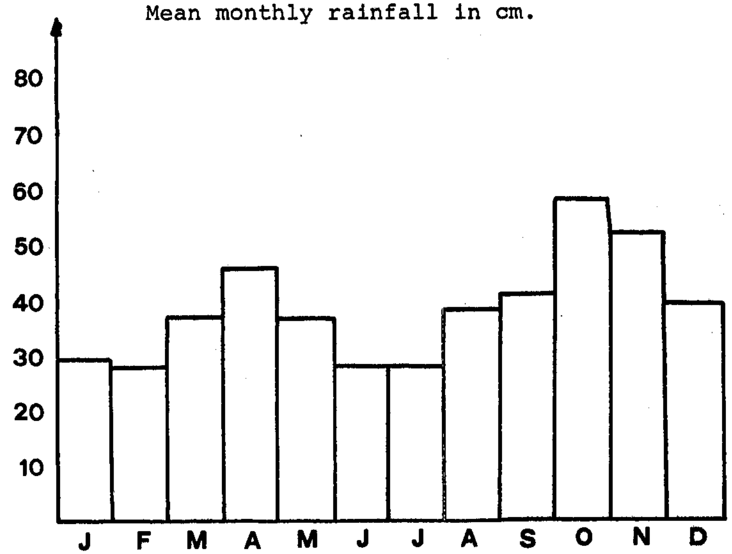


Fig.8: Monthly Rainfall

a) Bohorok, North Sumatra (own data, 1973-1975)
Mean monthly rainfall in cm.



b) West Sumatra (Bünning 1956)
Mean monthly rainfall in cm.



Depending on soil, water, topography, altitude, climatic conditions, etc. different forest types occur. It is useful to differentiate five original forest types - namely the mangrove forest, the swamp forest, the lowland forest, the hill and submontane forest and the damp moss forest (Bünning 1956, Engler 1964, Forestry in Indonesia 1972, IUCN 1973, Withmore 1975). These forest types are described on Fig.9 and Tab.1. With the exception of the treeless areas on top of the mountains and secondary growth on landslides and along rivers, these forests originally covered the whole Island of Sumatra.

1.2. Original situation of the rhino

In former times both the Sumatran Rhinoceros (Dicerorhinus sumatrensis), hereafter called "rhino", and the Javan Rhinoceros (Rhinoceros sondaicus) occurred in Sumatra. Van Strien (1974) reports some 50 locations where the Sumatran rhino had formerly been spotted. Groves (1967) cites six locality records for the Javan rhino. The last confirmed occurence of the Javan rhino in Sumatra was documented by Hazewinkel (1933).

It seems that between the two sympatric rhino species a certain specialization to different ecological niches took place. This "ecological displacement" (Groves 1967) will be discussed in 1.2.8.

According to previous reports, the population density of the Sumatran rhino was always very low, and the individuals were thinly scattered over large areas (Groves 1967).

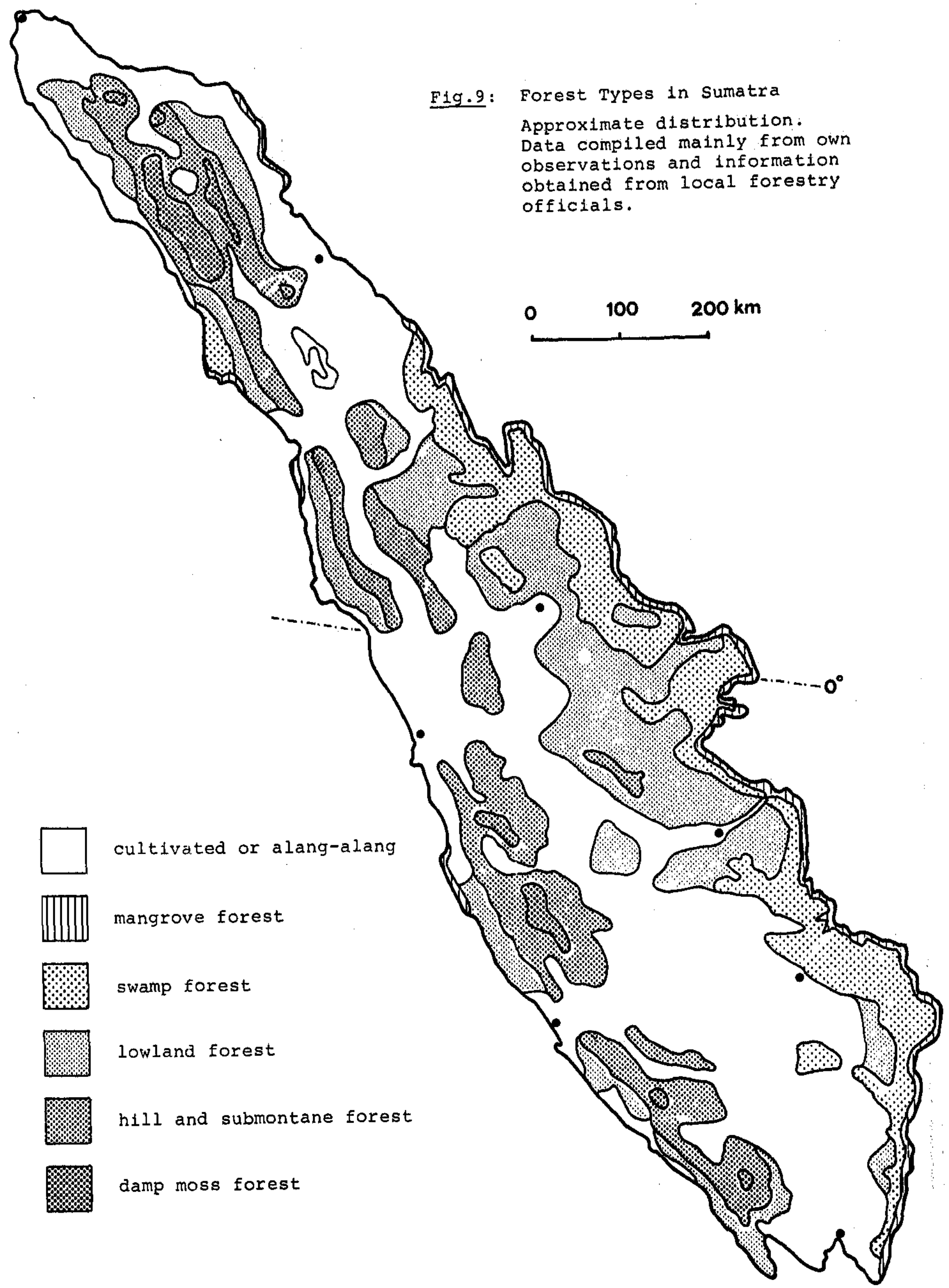


Fig.9: Forest Types in Sumatra
Approximate distribution. Data compiled mainly from own observations and information obtained from local forestry officials.

Tab.1: Rain-Forest Types in Sumatra

Type	Elevation	Characteristics	Typical Plant Species	Location in Sumatra
Mangrove Forest	sea-level	In tidal regions,ground covered with salt- or brackish water. Stiltroots and pneumatophores.Canopy not closed. Trees 20-30 m high. No epiphytes.Less than 50 different tree species.	Nypa fruticans (Palmae) Rhizophora sp (Rhizophoraceae) Sonneratia sp (Sonneratiaceae) Avicennia sp (Verbenaceae)	Mainly along Sumatra's east coast. Around the Singkil area on the west coast.
Swamp Forest	a few meters above sea-level	Standing fresh water or moist ground. Complex tangled root system with stiltroots and pneumatophores. Canopy not closed. Trees 20-30 m high. Epiphytes and climbers occuring. More tree species than in mangrove forest.	Pandanus sp (Pandanaceae) Acrostichum aureum (Plypodiaceae)	In the large alluvial plains of eastern Sumatra. Near Singkil in the West.
Lowland Forest	below 500 m	No standing water. Trees up to 50-60 m high. Different canopies. Only little light reaches the ground. Sparse undergrowth. Buttress roots. Abundance of tree species. Epiphytes and climbers are frequent. Very thin humus layer.	Dipterocarpus sp (Dipterocarpaceae) Shorea sp (Dipterocarpaceae) Dryobalanops sp (do) Eusideroxylon sp (Lauraceae) Ficus sp (Moraceae) Asplenium nidus (Polypodiaceae)	In the lowlands of central and southern Sumatra. All around the Bukit Barisan range.
Hill- and Submontane Forest	500-1500 m	Fewer tree species than in lowland forest. Trees 20-40m high. Leaves smaller than in lowland.Epiphytes and climbers abundant. More undergrowth than in lowland. Considerable humus layer.	Calamus sp (Palmae) Pandanus sp (Pandanaceae) Bambusa sp (Gramineae)	From north to south in the lower parts of the Barisan mountain range.
Damp-Moss-Forest	above 1500 m	Trees up to 20m high. Canopy not closed. Most of the time covered with clouds and mist. Relative humidity always close to 100%. Thick humus layer. Ground covered with a thick cushion of moss and fern.Fewer tree species than in lowland forest. Dense undergrowth, mainly consisting of saplings and fern. Abundance of epiphytes.	Pinus merkusii (Pinaceae) lichen, moss, fern	Northern and central regions of the Barisan mountain ridge.

Data compiled from:
Bünning 1956, Engler 1964, Forestry in Indonesia 1972, IUCN occ.paper No.5/1973, Whitmore 1975 and own observations.

1.3. The changing situation

1.3.1. Habitat transformation caused by man

Today enormous irreversible changes of the ecosystem are taking place all over the island.

The present human population of Sumatra numbers 15.7 million people. Population densities over 100 people/km^2 can be found around Medan (North Sumatra province) and Padang (West Sumatra province) while population densities of 20 to 100 people/km^2 are to be found throughout North Sumatra province, along the coastline in the Aceh province and in large parts of the provinces of South Sumatra and Lampong. About half of the island's area has a population density of less than two people/km^2.

Only about half of the island of Sumatra is still covered with forest. Most of these forests, especially in the lowlands are under timber exploitation or granted to timber companies. Valuable timber is occurring on Sumatra, meranti (Shorea sp), keruing (Dipterocarpus sp), ramin (Gonystylus sp) to name a few. The eastern lowlands are flat and the many large rivers can be used for lografting. Therefore mechanical logging is concentrated here.

Timber extraction has increased enormously during the last decade. Up to 1967, logging activities in Indonesia were restricted to the Island of Java (mostly teak) and the mangrove forests of Sumatra. Most of the timber was used within the country itself and about 593'000 m^3 were exported. Due to a sharp increase in the demand for wood on the domestic and foreign markets, the production of lumber increased rapidly. In 1973 an estimated 15'500'000 m^3 were exported mainly as logs, and 3 to 4'000'000 m^3 were consumed by the local market (Forestry in Indonesia 1972, Hutan Kita 1972).

Several large oil companies are working in Sumatra's lowlands. The main oil centres are found on the east coast of Aceh and in the provinces of Riau and South Sumatra (Fig.10). Oil drilling

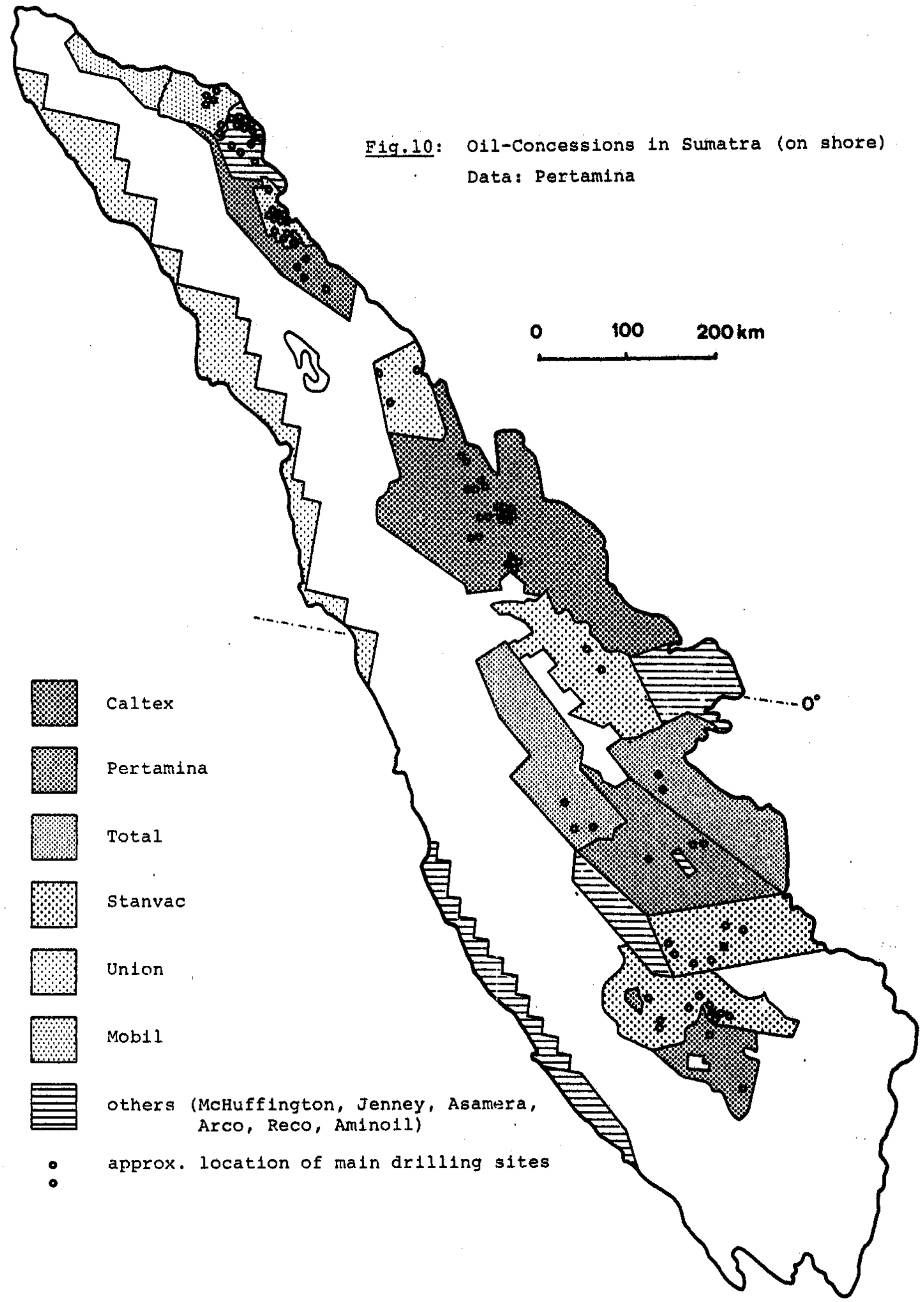


Fig.10: Oil-Concessions in Sumatra (on shore)
Data: Pertamina

itself is restricted to rather small areas, but the activities connected with oil exploration and exploitation are fatal to the lowland forest and its wildlife. A dense network of lanes for seismic studies is cut through the forest. Large roads are built to the new oil wells, thus opening the remotest wilderness to timber concessions and shifting cultivation.

Making use of the access roads built by oil- and timber-companies, local farmers are undertaking cultivation projects in areas which were formerly completely inaccessible. Large forest areas are cleared every year. The trees cut down for shifting cultivation purposes are not used but burnt on the spot. The newly cleared area can be cultivated for a few years only, since the rains wash away the thin layer of fertile humus. The resulting "Alang-Alang" (Imperata cylindrica) grassland is not suitable for either wildlife or domestic stock and is difficult to reclaim for cultivation.

Shifting cultivation has brought fatal consequences to large areas in Sumatra. Roughly one fourth of the island has been turned into unproductive, barren alang-alang grass prairies and shrub country (Fig.11).

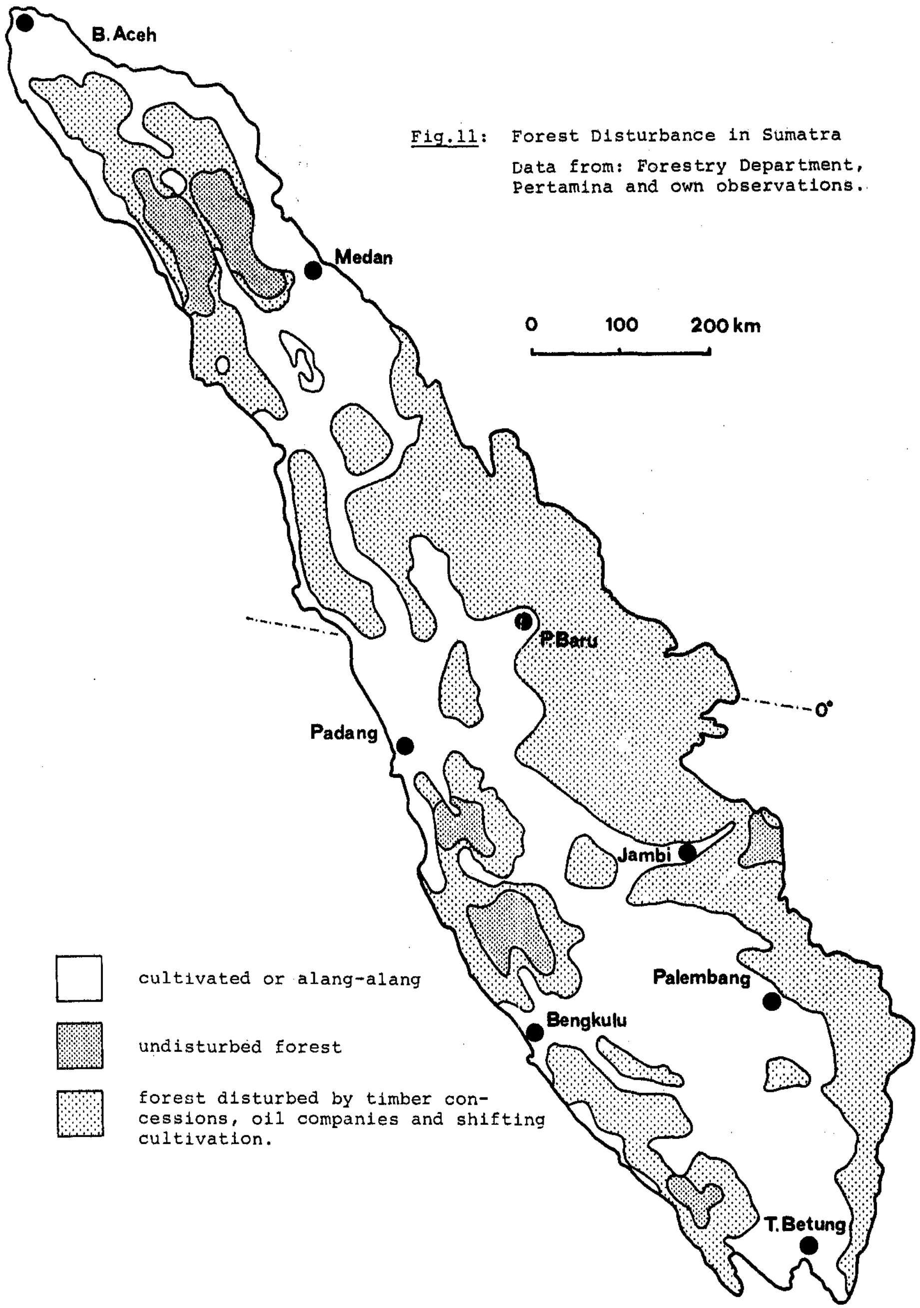
Sumatra has had large rubber plantations for decades, and even today forests are being cleared to plant new rubber and oil palm plantations.

Several reserves have been established throughout Sumatra and the Indonesian government is willing to set aside more forest areas to preserve Sumatra's wildlife. The reserves are under the administration of the Indonesian Nature Conservation Department, Dinas Perlindungan dan Pengawetan Alam (PPA). (Fig.12, Tab.2)

1.3.2. The decline of the rhino

Two conditions are principally responsible for the decline of the rhino. The first is the destruction of the original habitat by man, as described in the previous chapter. The second, per-

Fig.11: Forest Disturbance in Sumatra
Data from: Forestry Department, Pertamina and own observations.



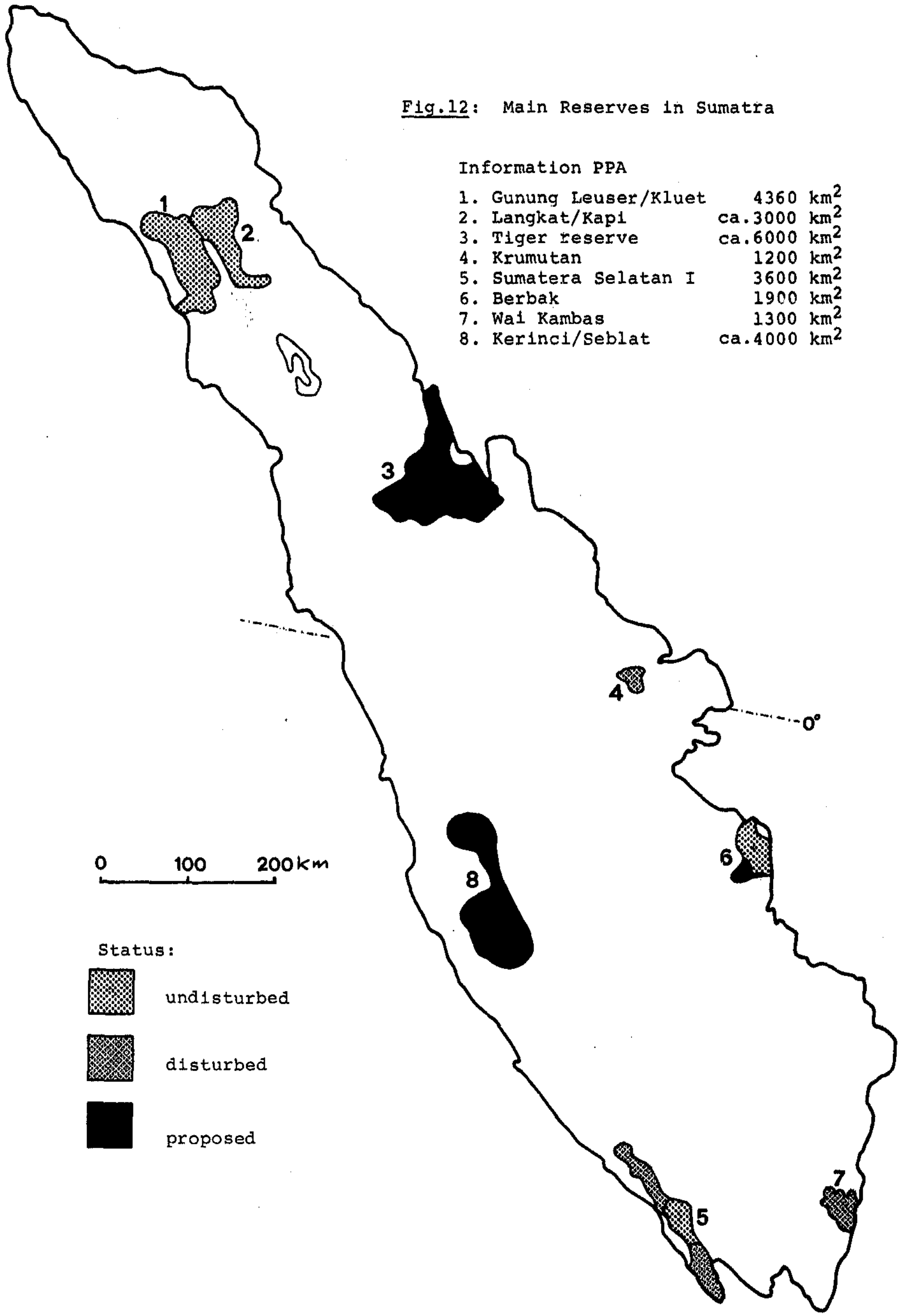


Fig.12: Main Reserves in Sumatra

Information PPA

1. Gunung Leuser/Kluet 4360 km^2
2. Langkat/Kapi ca.3000 km^2
3. Tiger reserve ca.6000 km^2
4. Krumutan 1200 km^2
5. Sumatera Selatan I 3600 km^2
6. Berbak 1900 km^2
7. Wai Kambas 1300 km^2
8. Kerinci/Seblat ca.4000 km^2

Tab.2: Land Use in Sumatra

(from: Forestry in Indonesia, 1972)

	km^2	percentage of total land area
1. total land area without surrounding islands	434'000	100%
2. forest acreage	284'200	66%
3. agriculture acreage	45'485	10%
4. state acreage (plantations)	4'456	1%
5. unproductive (alang-alang and shrub) and unknown usage	99'859	23%

haps not less important condition, is the illegal hunting of the rhino.

In colonial times, rhinos were sometimes killed by so-called "sport hunters", but nowadays illegal hunting is carried out by professional poachers.

Since all parts of the rhinoceros body and even its excretions are believed to have strong magical and medical power, rhino products from horn to dung fetch high prices. Therefore the animals are hunted ruthlessly by local hunters. It is a well known Chinese belief that the rhino horn has strong power as an aphrodisiac. Most rhino horns are sold to Chinese in- and outside of Sumatra. The local people of Sumatra use small pieces of horn as amulets. In carrying a small piece of horn, often mounted in a silver ring, they believe to be immune to the evil powers of the practitioners of black magic who live throughout the island. According to this belief it is impossible to poison the owner of a piece of rhino horn, because cups with poisoned drinks or dishes with poisoned food will break. Small pieces of horn are also used in the treatment of all kinds of poisonous bites or stings. It is believed that a piece of rhino horn pressed on a snake bite can extract the venom. Similar power is attributed to nails and teeth but they are believed to be less powerful than the horns. Dried rhino meat is used as a medicine for diarrhoea, leprosy and tuberculosis. "Rhino-Oil" is still widely used for skin diseases. To produce this oil, the skull of a rhino is placed in a container full of coconut oil along with other magic ingredients like serow horns, strangely formed plants, etc. After a few weeks this oil is sold in small bottles. The rhino's shoulder-blade is used to make cigarette holders that are believed to have magical powers. Even dung is dried and used as medicine, either fried in coconut oil or boiled in water. (All information from Husin, former rhino hunter in Aceh.)

Due to the extremely high prices paid for all kinds of rhino products, there is still a great deal of incentive for native hunters to kill the animals, despite strict conservation laws. Under the leadership of a "Pawang", small groups of three to five poachers penetrate the remotest wilderness to set up their traps.

In Sumatra I found three different kinds of rhino traps. The type most commonly used in the Gunung Leuser area in Aceh is the spear trap. A heavy pole about 3 m in length and 15 cm in diameter is attached to a horizontal log approximately 10 meter above a well maintained rhino trail. A spear of hardwood, bamboo or iron is loosely fixed to the heavy pole. The spear itself has a length of 80 to 100 cm. When a rhino walks along the trail, it releases a trigger mechanism, the heavy pole falls down and drives the spear deep into the rhino's back. Only very rarely is the rhino killed on the spot. Usually it is still able to run away. I once found the tracks of a speared rhino which indicated that the animal had run in wild circles, rubbing its back against tree trunks and shrubs, thus trying to get the spear out of its back. As the spear had entered cleanly, little blood had been shed. I could follow the tracks for about 1 km. However it was not possible to find the animal itself. The rhino must have run at least a few km before it died of internal injuries. According to local hunters, less than half of the rhinos speared can be found. I discovered old and new spear traps in six different places in the rhino range of the Gunung Leuser reserve (specifically in: upper Kompas, ridge west of Kotacane, Gunung Pawang Husin, Mamas river, Sungei Pinus and Tempat Medan). (photos 2 and 3)

Pit fall traps were found in the Kompas area of the Gunung Leuser reserve and in the Kerinci area of the province of Jambi. All of them were small. The hole was 180 to 220 cm long and 60 to 90 cm wide. The pits were about 150 to 250 cm deep and normally the walls converged slightly toward the bottom. The openings of the pit falls are kept small to prevent the rhino from moving, once it has fallen into the pit. Sometimes hard wooden spears are placed at the bottom of the pitfall.

In Kerinci a third type of trap is used. A tree is felled at an angle of 90° to a rhino path. A fence is erected along the tree trunk on both sides of the trail. A small passage is left open, forcing the rhino to cross the trunk at this opening. Two or three pointed knifes, which have been sharpened on both sides are fixed to the log at this point of passage. The knifes are covered with grease and the whole trap is camouflaged with dead leaves. The trap functions when the knifes rip open the belly of a passing animal. This kind of trap is often used to supplement a spear trap.

I have no positive proof, that rhinos were actually killed with the "knife"-trap. At least some animals were caught with pit fall traps. According to the rhino hunter Husin, one animal in the Kompas area could free itself by tramping down the walls of the pit.

The spear traps are the most harmful to the rhino population. According to Pawang Husin only about 50% of the animals killed in this manner can be located. Therefore, at least two animals die for each pair of horns which reaches the market. Once set, the spear traps remain in working condition for three to six months. Since the hunters are primarily interested in the horns, they inspect the traps in intervals of several months only. Because seven or more traps are built in one area and because they stay in working condition for several months, the effect on the local rhino population is severe. According to the evidence I found, at least three rhinos were killed with spear traps in the Gunung Leuser reserve from 1973 to 1975.

It is nearly impossible to hunt rhinos with a rifle. No professional hunter carries a gun. But on the occasional encounters between rhino and police or army people the rhino may be shot. In the Wai Kambas reserve a rhino was shot in 1961, and

in 1973 another was killed in northern Bengkulu (Tab.3).

1.3.3. Recent reports on the presence of rhinos in Sumatra

Since 1940 reports on the presence of rhinos have come only from three areas in Sumatra. The rhino population in the Gunung Leuser reserve was confirmed by Milton (1964), Schenkel and Schenkel (1969), Kurt (1970) and Rijksen (1972). Hooijer (1946), Skafte (1961) and Anderson (1961) reported a rhino population in central Sumatra, in the province of Riau. Neither Milton (1963), nor Schenkel and Schenkel (1969) found evidence of the survival of this population in Riau. The third area where rhinos were reportedly seen, was the South Sumatra Nature Reserve I (Talbot 1960).

An estimate of the size of the surviving rhino population in these areas was given as follows: For Aceh and North Sumatra, Burton (1963) estimated 20 individuals, Milton (1964) 30 to 50, and Kurt (1970) 27 to 68. Ryhiner and Skafte captured 10 rhinos in Riau (Anderson 1961) and estimated the number of rhinos near the Siak river to be 40 to 60 animals (in Grzimek 1960). Talbot (1960) found rhino tracks at five different places of the South Sumatra I reserve, but gives no estimation of numbers.

2. Results of Survey: Distribution and Estimation of Numbers

2.1. Results concerning distribution

2.1.1. Survey areas

On the basis of previous surveys, local information, map- and aerial-surveys, I selected 21 areas outside the Gunung Leuser/ Langkat reserve for investigation and carried out expeditions in each of these areas in order to search for evidence of the rhino. Information about these survey areas is presented in Tab.4 and Fig.13.

Tab.3: Confirmed Rhino Hunting in Sumatra in the Last 20 Years

1956	Sungei Tjimpur (upper Rokan River), 2 animals killed by villagers. Teeth still in possession of villagers.
1950-60	Kerinci/Seblat, 3 animals killed by professional rhino hunter, Pawang Bahir. Some bones are still in his possession.
1961	Wai Kambas reserve, Lampung, 1 animal shot, report from PPA (Nature Conservation Department).
1960-70	Gunung Leuser reserve, Bengkong river and Kompas river, 4 animals killed by professional rhino hunter Pawang Husin.
1960-70	Gunung Leuser reserve, Gunung Pawang Husin, Mamas basin, 3 animals killed by professional rhino hunters Aman Slimbing and Pawang Husin.
1969	Siak river, Riau, 10 animals captured by Ryhiner and Skafte.
1973	Gunung Leuser reserve, upper Mamas, 1 animal speared, but not found, by professional rhino hunter Rabil.
1973-75	Gunung Leuser reserve, Mamas basin, 1 animal killed and at least one more speared but not found, by unknown professional rhino hunter.

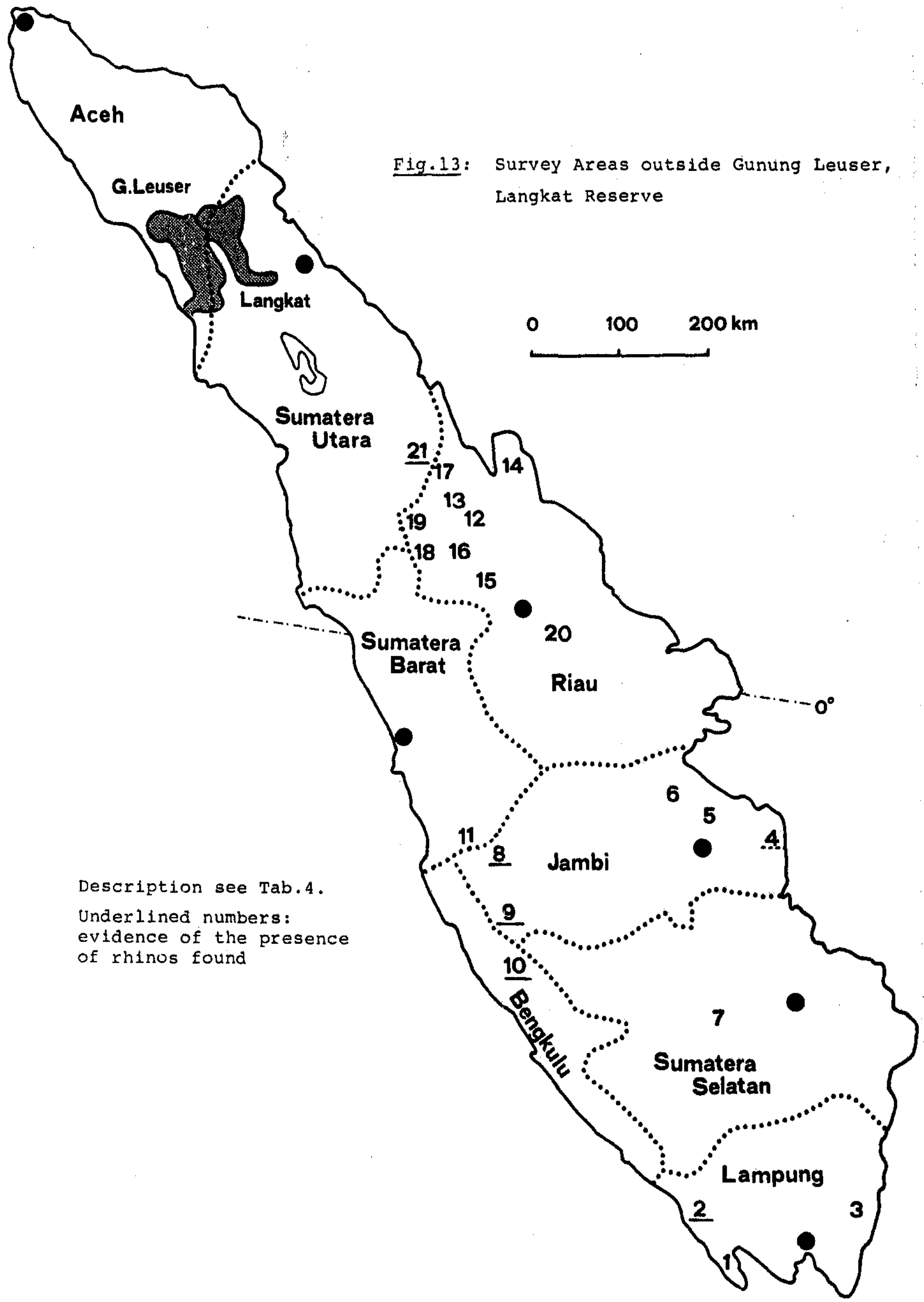


Fig.13: Survey Areas outside Gunung Leuser, Langkat Reserve

Description see Tab.4.

Underlined numbers: evidence of the presence of rhinos found

Tab.4: Survey Areas outside Gunung Leuser/Langkat Reserve

Survey area	Location	Forest type	Altitude	Previous information on rhino	Approx. length of field survey	Evidence of rhino found by myself
1. Sumatera Selatan I Wai-Kedjadian	5°40'S/104°30'E	second. lowland and hill forest	0- 700 m	Talbot (1960) + local inf.	1 week	-
2. Sumatera Selatan I Liwa	5°05'S/104°10'E	primary hill- and sub-montane forest	500-1200 m	Talbot (1960) + local inf.	1 week	+
3. Wai Kambas reserve	5°S/105°40'E	second. lowland forest and alang-alang	0- 50 m	inf. PPA, one rhino shot in 1961	1 week	-
4. Berbak reserve	1°20'S/104°20'E	prim. mangrove, fresh-water swamp and lowland forest	0- 20 m	inf. PPA, Forestry Department	3 weeks	-
5. Napal	1°10'S/103°20'E	prim. and second. swamp and lowland forest	0- 50 m	no inf.	3 days	-
6. Total Base Camp	approx. 15 km east of Napal	prim. and second. swamp and lowland forest	0- 50 m	no inf.	3 days	-
7. Pendopo, Lahat and other areas in Sumatera Selatan		mostly alang-alang with patches of swamp and low-land forest	0- 100 m	Hoogerwerf (1936), Groeneveldt (1938), Carpenter (1938)	1 week	-
8. Danau Gunung Tucu	1°40'S/101°25'E	damp moss forest (primary)	1500-2960 m	no inf.	1 week	+
9. Lempur	2°15'S/101°35'E	prim. submontane and damp moss forest	700-3000 m	local inf.	2 weeks	+
10. Sungei Seblat	2°55'S/102°05'E	prim. submontane and damp moss forest	600-2000 m	Groeneveldt (1938), inf. PPA	2 weeks	+
11. Gunung Kerinci	1°40'S/101°15'E	prim. damp moss forest and belang	1600-4150 m	local inf.	3 days	-
12. Balam field	1°41'N/100°40'E	second. lowland forest	0- 50 m	local inf., rhino skull from ca. 1950	3 days	-
13. Rimba Djaya	1°41'N/100°36'E	second. lowland forest	0- 100 m	local inf.	3 days	-
14. Sungei Buluhala	1°55'N/101°15'E	prim. swamp forest	0- 10 m	local inf.	1 week	-
15. Libo/Mindal field	1°N/101°10'E	prim. and second. swamp and lowland forest	0- 50 m	local inf.	3 days	-
16. Rangau field	1°14'N/100°57'E	prim. and second. swamp forest	0- 50 m	local inf.	2 days	-
17. Purple 14	1°56'N/100°32'E	prim. and second. swamp forest	0- 50 m	local inf.	1 week	-
18. Udjung Batu/ Bukit Tongu	0°45'N/100°30'E	prim. and second. lowland forest	50- 400 m	inf. Schenkel (1969) local inf.	1 week	-
19. Sungei Tjimpur/ Tandjung Medan	0°40'N/100°25'E	prim. and second. lowland forest	50- 400 m	inf. PPA, one rhino shot in 1956	1 week	- (old signs still visible)
20. Sungei Sail	0°30'N/101°30'E	second. lowland forest, shifting cultivation	0- 50 m	inf. Skafte, Ryhiner, Anderson (1961)	2 days	-
21. Torgamba	1°45'N/100°20'E	prim. and second. swamp and lowland forest	0- 50 m	local inf., PPA	2 weeks	+

2.1.2. Areas with evidence of rhino occurrence

I found positive proof of the presence of the rhino in five areas in Sumatra: the Gunung Leuser reserve sensu stricto (province of Aceh), the Langkat reserve (provinces of Aceh and North Sumatra), Torgamba (provinces of North Sumatra and Riau), Kerinci/Seblat (provinces of Jambi and Bengkulu) and the Sumatera Selatan I reserve (province of Lampung). (Fig.14)

A brief description of these areas is given in the following passages. The Gunung Leuser reserve, where my study area was located, is described in greater detail in Introduction, section 3.2.1.

A) Gunung Leuser Reserve s.str.

Location: Between 3° and 3°50' N / 97°10' and 97°55' E. In the province of Aceh. It covers an area of 4165 km^2 and is approximately 150 km long and 50 km wide.

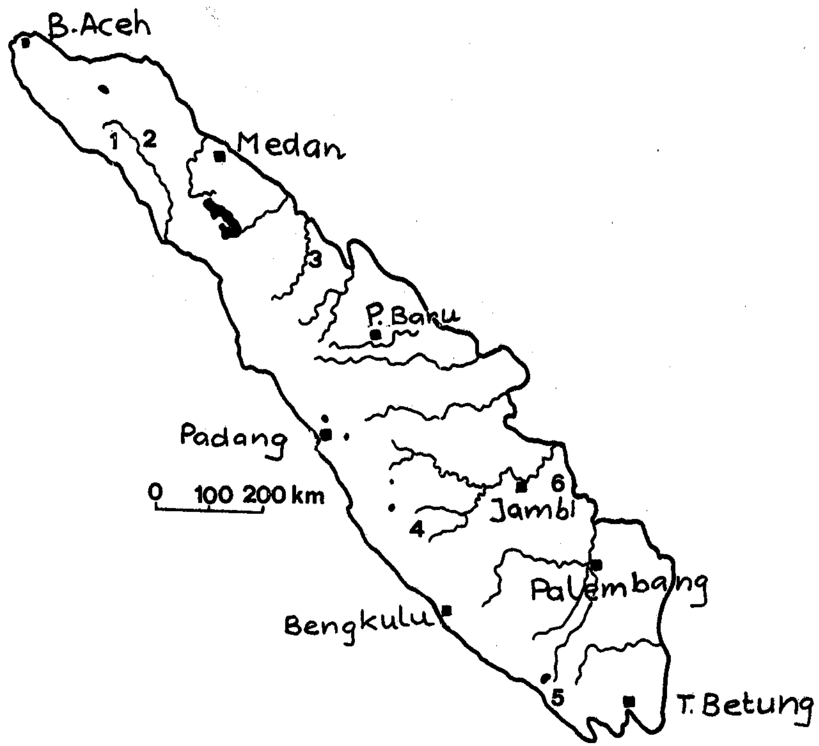
Topography: The Bukit Barisan, Sumatra's largest mountain ridge, crosses the reserve from north to south. In the north and west, the ridge rises to an altitude of over 3000 m a.s.l. In the east it descends to the Alas valley and in the south to the lowlands of the Singkil area.

Vegetation: Primary freshwater swamp forest can be found in the Kluet area, primary lowland forest in the south and east and primary submontane and damp moss forest in the centre of the reserve.

Disturbance: Shifting cultivation activities are occuring on the periphery. Fishing and hunting are common, even deep inside the reserve.

Rhino: It seems that a few years ago the rhinos still occurred in suitable areas all over the Gunung Leuser reserve and its surroundings. They are now restricted to the undisturbed core area of the

Fig.14: Today's Rhino Areas in Sumatra



1. Gunung Leuser reserve
2. Langkat reserve
3. Torgamba
4. Kerinci/Seblat
5. Sumatera Selatan I reserve
6. Berbak reserve

reserve. This central part is situated between 1000 and 3000 m a.s.l. It includes the upper Kompas area, the Mamas river basin and the upper Kluet river (Fig.15).

B) Langkat Reserve

Location: Between 3°20' and 4° N / 97°40' and 98°05' E. In the provinces of North Sumatra and Aceh. It covers an area of about 2000 km^2.

Topography: A large part of the reserve to the east is hilly lowland. In the west and north, a steep mountain-chain rises up to an altitude of 3000 m a.s.l. (Gunung Bandahara). About two thirds of the reserve are below 1500 m a.s.l.

Vegetation: Primary lowland and hill forest covers the eastern part, submontane and damp moss forest the western and northern parts of the reserve.

Disturbance: Shifting cultivation and logging activities occur on the eastern and western peripheries.

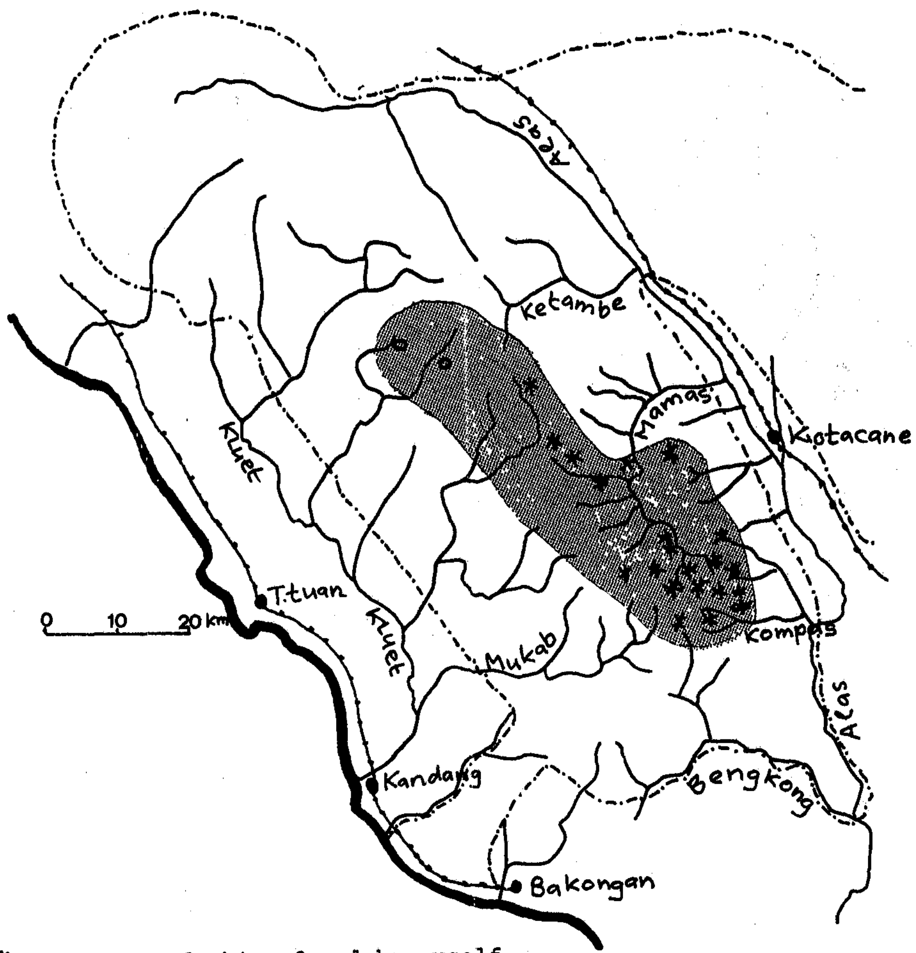
Rhino: A small rhino population still survives in the core area of the reserve, on the eastern slopes of Gunung Bandahara, Gunung Perkinson and Gunung Bidul. The rhinos venture as far south as the Landak river and as far north as the Kapi volcano (Fig.16).

C) Torgamba

Location: app. 1°45' N / 100°20 E. The Torgamba forest is situated east of the Barumun river at the boundary of the provinces of North Sumatra and Riau.

Topography: The area is flat or hilly lowland with its highest elevation around 150 m a.s.l.

Fig.15: Gunung Leuser, Rhino Area



* evidence of rhino found by myself
o evidence of rhino found by Helmkampf
rhino area (approx. 1000 km^2)

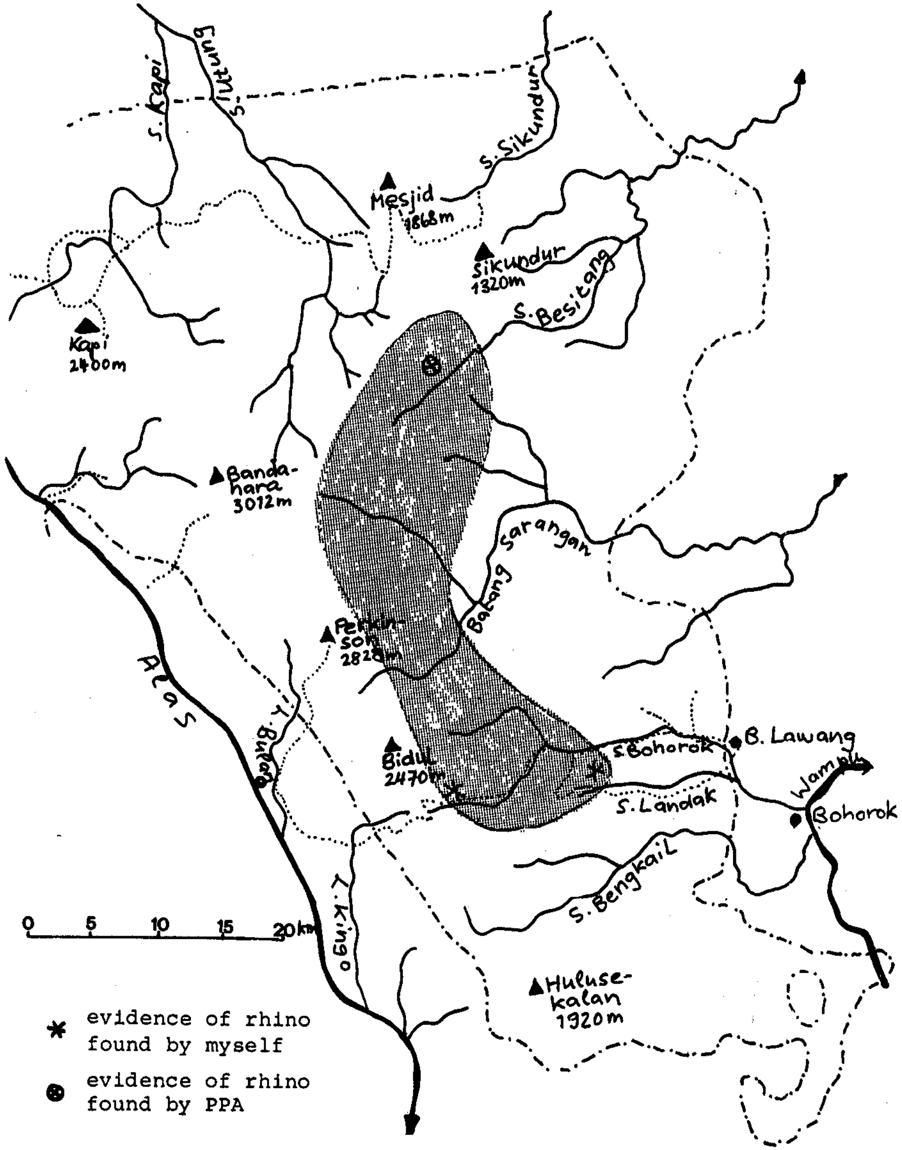
boundary of reserve
road
(expedition routes and topography see Introduction)

Fig.16: Langkat Reserve, Rhino Area

conjectured rhino area (approx. 400 km^2)

reserve boundary

expedition routes



Vegetation: The original vegetation is primary lowland forest with patches of primary freshwater swamp forest. Due to logging activities the vegetation has changed considerably and secondary growth is abundant.

Disturbance: The whole area is granted to timber concessions. A net of truck roads and exploration lanes covers the region. Shifting cultivation is taking over the area near the river Barumun. Hunting and animal capturing is common.

Rhino: I found rhino tracks in an area of primary forest north and east of the "Asahan"-base camp. The range of the small surviving population of rhinos is limited in the north and east by swamp forest and in the south and west by timber concessions. Thus the rhino range is rapidly shrinking (Fig.17).

D) Kerinci / Seblat

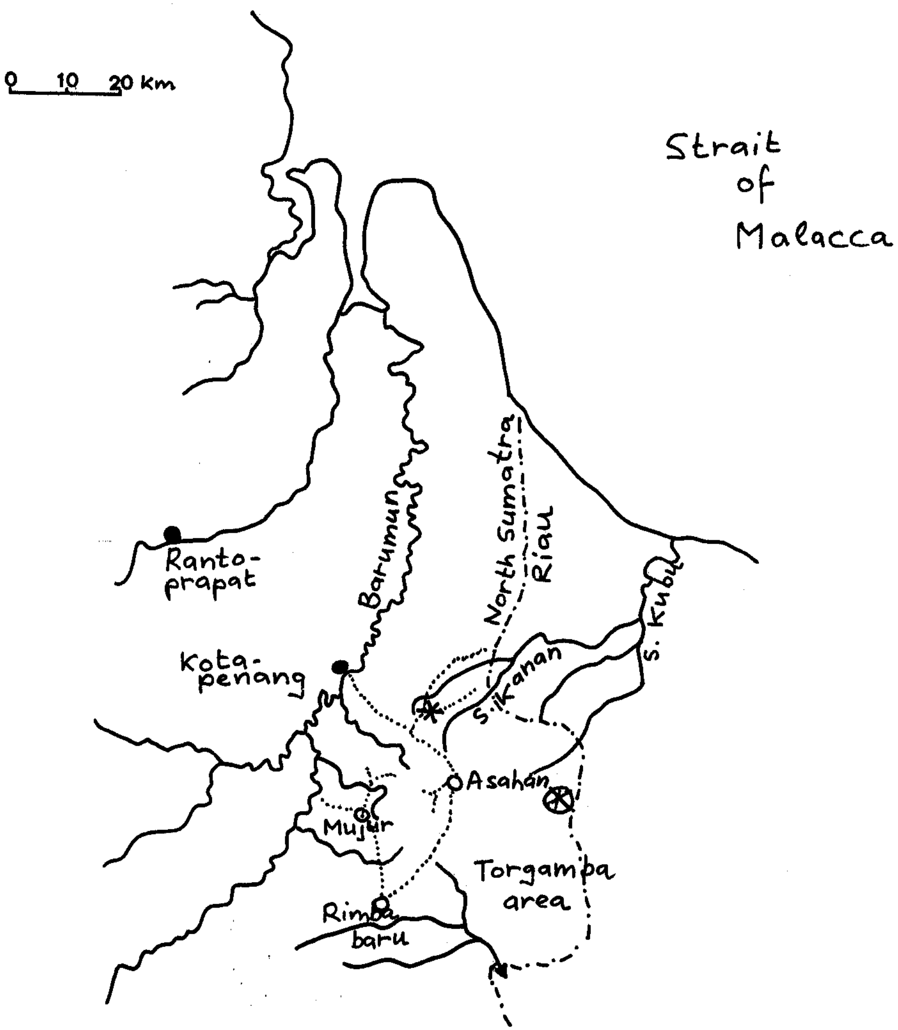
In the Kerinci/Seblat area I found rhino tracks in three regions. As the forest cover between these regions is still intact, the rhinos might be in contact with each other and could belong to the same population (Fig.18 and 19).

Kerinci/Seblat: Gunung Tucu

Location: 1°40' S / 101°25' E.
Danau Gunung Tucu is situated just east of Gunung Kerinci, Sumatra's highest mountain. It belongs to the province of Jambi.

Topography: The area is covered by very steep mountains. The peak of the Gunung Tucu volcano reaches 2960 m a.s.l. The lake in the old crater is situated at an altitude of 2170 m a.s.l.

Fig.17: Torgamba, Rhino Area



* evidence of rhino found by myself

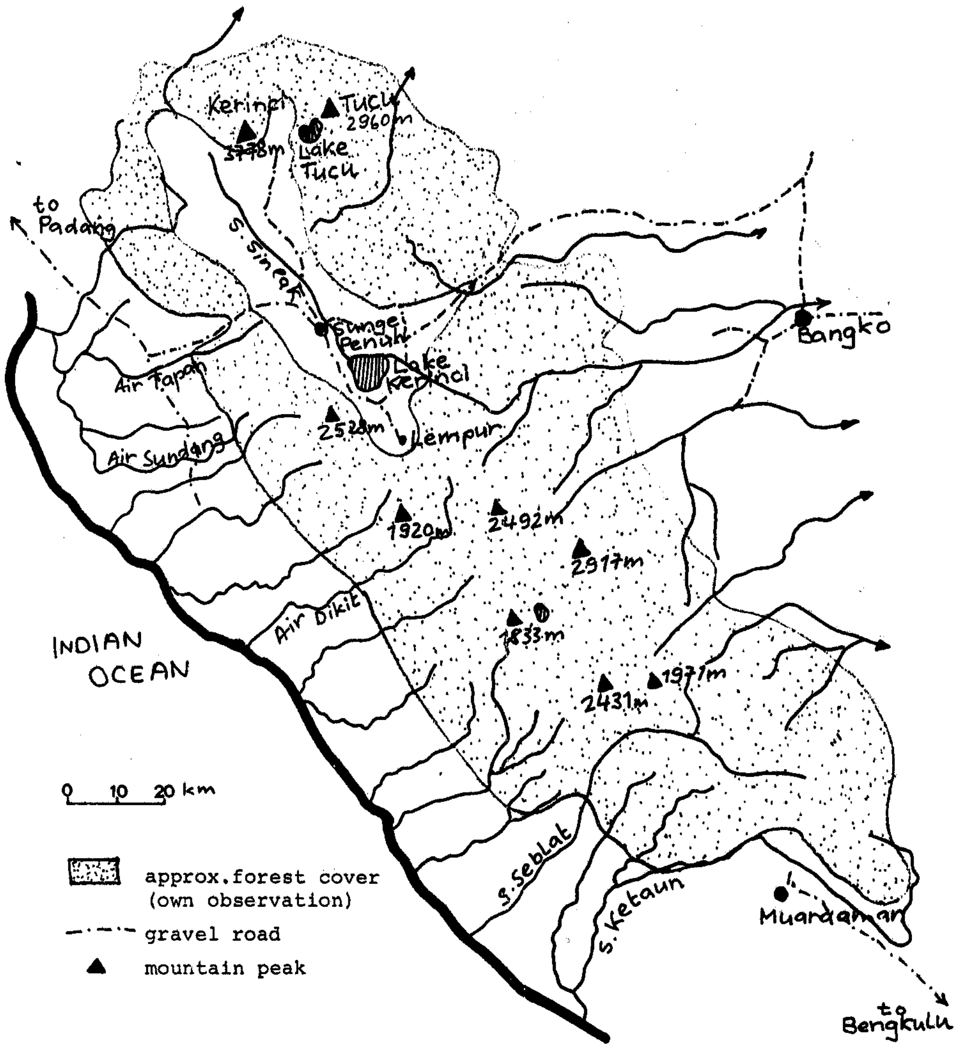
⊛ evidence of rhino found by Laurie/McDougall

expedition routes

province boundary

o timber concession camp

Fig.18: Kerinci/Seblat, Relief and Forest Cover

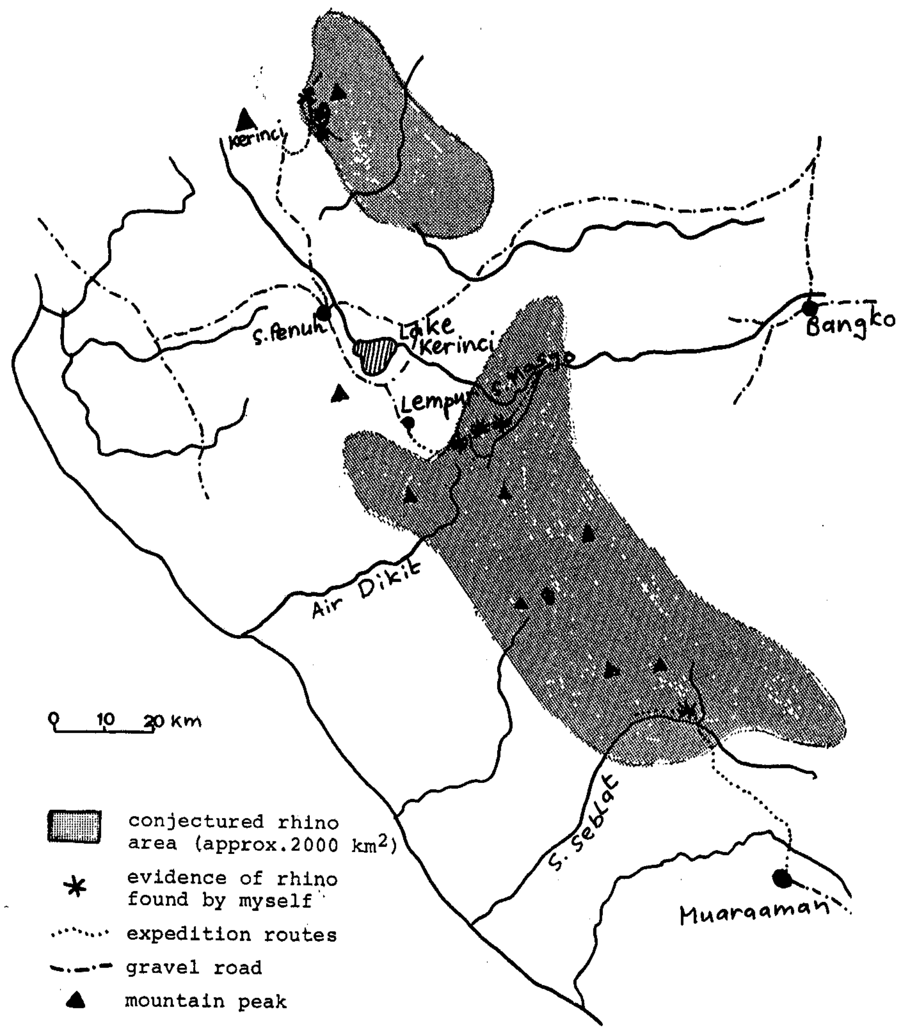


approx. forest cover (own observation)

gravel road

▲ mountain peak

Fig.19: Kerinci/Seblat, Rhino Area



Vegetation: Undisturbed primary submontane forest can be found in the lower areas, damp moss forest in higher altitudes and "belangs" (areas without forest) at the top of Gunung Tucu.

Disturbance: A small nature reserve was established in the area but as it lacks defined boundaries and adequate supervision, shifting cultivation is creeping up the west slopes of Gunung Tucu and villagers occasionally hunt serow.

Rhino: I found evidence of rhinos on the ridge around lake Tucu. Many of the trails were overgrown, an indication that the remnant population is of limited size (Fig.19).

Kerinci/Seblat: Lempur

Location: $2^{\circ}15'$ S / $101^{\circ}35'$ E.
The area is situated south-east of the lake Kerinci in the province of Jambi.

Topography: High, steep mountain area reaching up to 3000 m a.s.l. in the west. A relatively flat, hilly plateau between 700 and 1000 m a.s.l. extends to the east.

Vegetation: Mainly primary submontane forest with an abundance of bamboo and in higher regions, damp moss forest.

Disturbance: The heavy pressure from the human population of the Kerinci valley and the Bangko area is contributing to the expansion of shifting cultivation activities. Hunting is frequent. Old rhino traps indicate previous rhino hunting.

Rhino: I found evidence of several rhinos on the relatively flat plateau south of Sungei Masgo (Fig.19).

Kerinci/Seblat: Sungei Seblat

Location: 2°55' S / 102°05' E.
Sungei Seblat is situated app. 70 km south-east of the survey area "Lempur", north-west of the town of Muaraaman in the province of Bengkulu.

Topography: With the exception of the relatively wide upper Seblat valley, the area is steep and difficult to penetrate. Mountain peeks reach an altitude over 2000 m a.s.l.

Vegetation: Primary submontane- and damp moss forest can be found.

Disturbance: Shifting cultivation activities and rice plantations reach far into the forest.

Rhino: I found evidence of the rhino in the central part of Sungei Seblat, north of Air Putih (Fig.19).

E) Sumatera Selatan I Reserve, Liwa

Location: 5°05' S / 104°10' E.
Liwa is situated in the northern part of the Sumatera Selatan I reserve in the province of Lampung.

Topography: The area is mountainous, with peaks over 1200 m a.s.l. The mountain ridge is highest on the eastern side of the reserve and slowly descends to the coastal plains in the west.

Vegetation: Due to timber concessions and shifting cultivation, only little primary forest is left in the south, whereas the northern parts are still covered by primary submontane forest.

Disturbance: In the southern part of Sumatera Selatan I reserve timber concessions, shifting cultivation and villages are abundant. The northern part is fairly

undisturbed. Hunting seems to be frequent.

Rhino: I found evidence of rhinos south of Liwa in the area of Wai Siran (1200 m a.s.l.) and the Handaring Kiri (500 m a.s.l.). (Fig.20)

F) Berbak Nature Reserve (Information from PPA)

Location: 1°20' S / 104°20' E.
The Berbak Nature reserve covers an area of 1900 km^2 and is situated south of the mouth of the river (Batang) Hari in the province of Jambi.

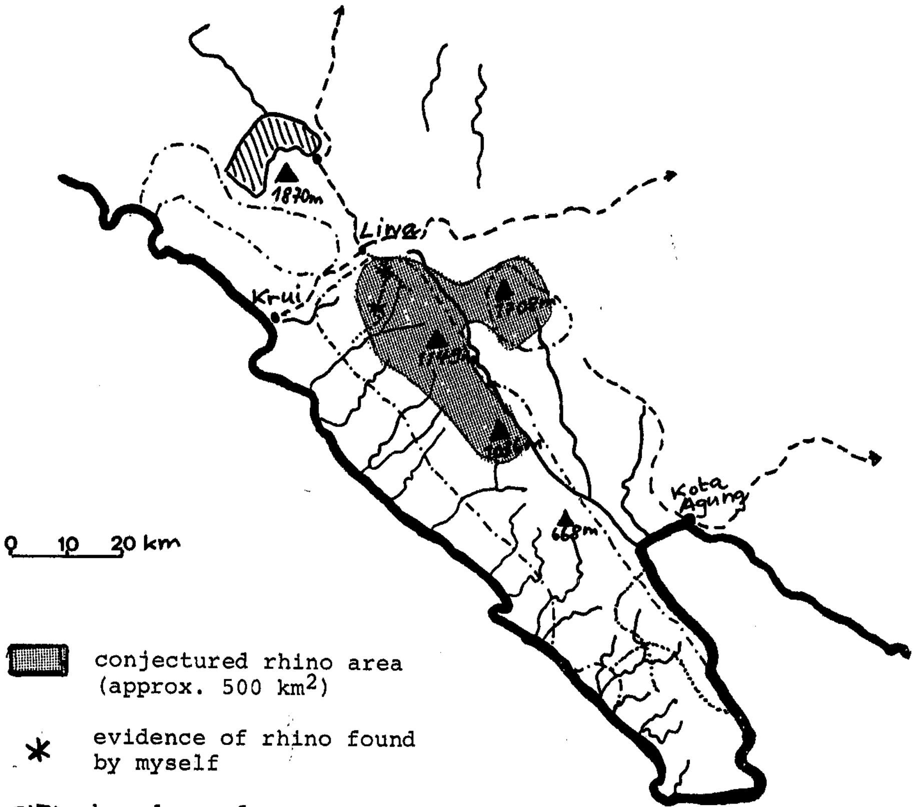
Topography: Swampy lowlands with a few scattered hills not higher than 20 m a.s.l. cover the area.

Vegetation: Primary mangrove and fresh water swamp forest, with patches of primary lowland forest is the typical vegetation.

Disturbance: Shifting cultivation resulting from planned and spontaneous transmigration projects is spreading along the coast and the river Hari. Fishermen, ratan collectors and hunters are penetrating far into the reserve.

Rhino: When I surveyed the area in November 1974 I found no evidence of the rhino. However Mr. Sutrisno Soewoko, the local Chief of PPA (Nature Conservation Department) informed me in 1976 that he had found rhino tracks in the south eastern part of the reserve (Sutrisno, pers.com.1976). (Fig.21)

Fig.20: Sumatera Selatan I Reserve, Rhino Area



conjectured rhino area (approx. 500 km^2)

* evidence of rhino found by myself

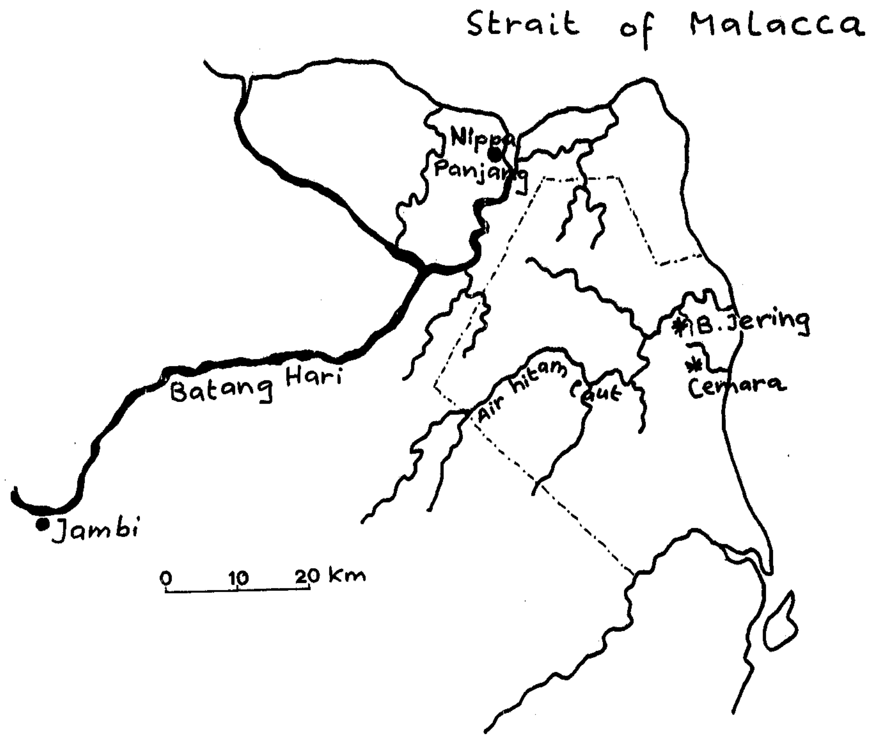
boundary of reserve

expedition routes

road

mountain peak

Fig.21: Berbak Reserve, Rhino Area



* evidence of rhino found by Sutrisno Soewoko (PPA) (February/March 1976)

boundary of reserve

2.1.3. Discussion

The rhino has disappeared from most of the areas where it was previously reported to have ranged (Tab.5, Fig.22). In fact, present rhino ranges cover only a fraction of their former area. For two of these areas, Torgamba and most of Kerinci/Seblat, no previous reports are available (Tab.6, Fig.22).

With the exception of the area south of Liwa, the rhino has disappeared from the province of Lampung. Wai Kambas reserve and the southern part of Sumatera Selatan I reserve, where recent reports indicate the occurrence of the rhino, are being transformed by logging and shifting cultivation activities. No evidence of the presence of rhinos was found in these areas.

South Sumatra province is densely populated and most of the forest has been cut down. No rhinos survive in the remaining alang-alang areas.

In the provinces of Bengkulu and Jambi, human habitat changes are not yet as extensive as in other provinces. Evidence of the rhino was found in the large Kerinci/Seblat area.

In the vast lowlands of Riau, which were once described as "Rhino Country" (Skafte 1964), the rhinos have suffered their most dramatic set-back. Despite numerous reports of the existence of rhinos until about 15 years ago, the present survey showed that the rhinos have been exterminated in this province.

In the province of North Sumatra two small remnant populations were found in Langkat and Torgamba, but the rhino has vanished from most of the areas where it formerly ranged.

Even in the heavily forested province of Aceh, the range of the rhino has been drastically reduced. It has vanished from the periphery of the Gunung Leuser reserve. Today only two of 24 rhino areas indicated by Kurt and none of Rijksen's are situated in the present range of the rhino.

During the last twenty years the range of the rhino in Sumatra has been reduced in an alarming way and is still shrinking.

Tab.5: Areas, where the Rhino has Vanished Today

Place surveyed in which no evidence was found:	Previously reported by: (according to van Strien 1974)
Province of Lampung:	
Wai Kambas	Directorate Gen.of Forestry 1971
Southern part of Sumatera Selatan I reserve	Rappard 1936, Hoogerwerf 1936, Talbot 1960
Province of South Sumatra:	
Padang Besi	Müller and Schlegel 1944, Hooijer 1946
Benarat (Palembang)	Neumann 1885
Bukit Lumut	Hazewinkel 1933
Province of Bengkulu:	
Gunung Dempo	Hazewinkel 1933
Province of Riau:	
Indragiri	Neumann 1885, Schneider 1905
Simalambu range (Rokan)	Dammermann 1932
Pangkalan Kampar	Hooijer 1946
Sungei Sail (Siak)	Anderson 1961
Province of North Sumatra:	
Tandjung Morawa	Hooijer 1946
Serbang	Hagen 1890
Besitang/Batang Serangan	Otto 1903
Sungei Lepan	Otto 1903, Harper 1945
Dolok Saut	Hoogerwerf and vanSteenis 1936
Province of Aceh:	
Gunung Leuser, periphery	Kurt 1970, Rijksen 1972
Langsa	Ullrich 1955

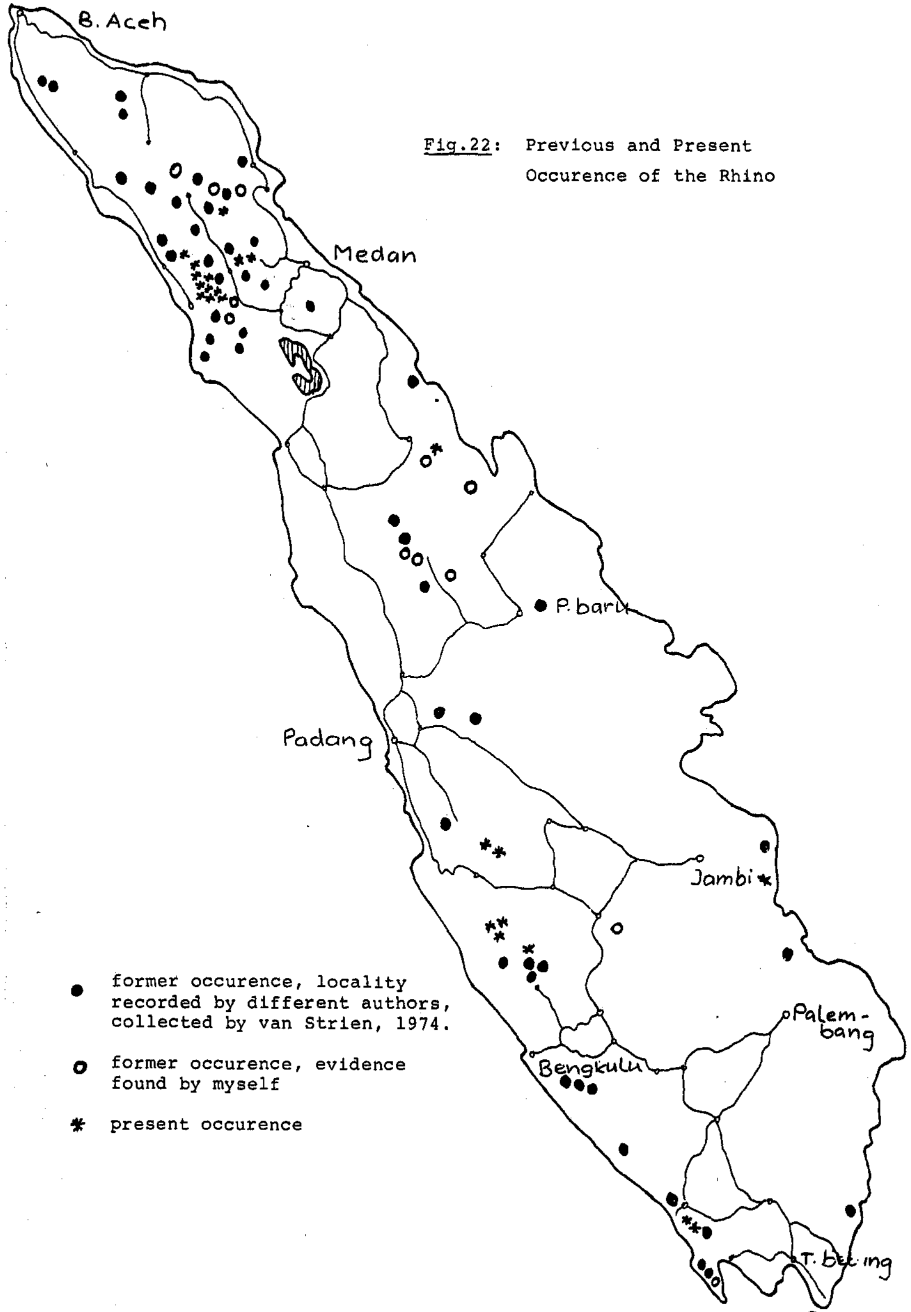


Fig.22: Previous and Present Occurence of the Rhino

● former occurence, locality recorded by different authors, collected by van Strien, 1974.

o former occurence, evidence found by myself

* present occurence

Tab.6: Former Reports on the Present Rhino Areas

Today's rhino ranges according to present survey:	Previous reports on these areas (according to van Strien 1974):
1. Gunung Leuser reserve	Neumann 1885, Hoogerwerf and vanSteenis 1936, Milton 1964, Schenkel and Schenkel 1969, Kurt 1970
2. Langkat reserve	Neumann 1885, Otto 1903, Schneider 1905, Miller 1942, Harper 1945
3. Torgamba	no report
4. Kerinci/Seblat	vanWaterschot van der Gracht 1928, Groenevelt 1938 no report on Gunung Tucu and Lempur
5. Sumatera Selatan I	Rappard 1936, Hoogerwerf 1936, Talbot 1960
6. Berbak reserve (conf.by PPA)	Endert 1936

2.2. Estimation of numbers

2.2.1. Estimation method developed for the rhino area in the Leuser reserve

In the Leuser area, the census method developed by Schenkel and Schenkel (1969b) for the Javan rhinos in Udjung Kulon, could not be applied for several reasons. The remoteness and vastness of the Leuser area made it impossible to survey the whole rhino area simultaneously with several teams. Unnecessary disturbance of the area had to be avoided and it was feared that if the local people involved in such a census received knowledge of the rhino areas, they would use that knowledge for poaching.

An estimation method was worked out for the study area in the Gunung Leuser reserve. Expeditions with a duration of three to five weeks were made to the study area about every three to four months from the beginning of 1973 to the end of 1975. During these expeditions I tried to visit regularly key areas of the study area such as Sungei Pinus, Tempat Medan and Sungei Ikan Kaleng, and record all fresh rhino tracks.

The hindfoot print usually overlaps the forefoot print, making measuring of the width of the forefoot more difficult. The maximum width of the hindfoot proved to be the most consistent measure and the estimation of population size was therefore mainly based on it. Whenever possible, the maximum width of the forefoot was also taken. In the study area, altogether 67 fresh tracks with over 1000 footprints were measured.

In order to distinguish the prints of different individuals, it was necessary to establish the following restrictions:

- Only fresh tracks, not older than two or three days were used for the census.
- The data were used only if it was possible to follow the track for at least a few hundred meters and thus to measure at least 10 clear hindfoot prints.

- Only prints on hard soil were measured.
- The field work in the study area lasted for more than two years. Therefore I had to take into account, that the size of prints, especially of young animals, would increase during this period.

In order to estimate the number of solitary rhinos it was assumed, that spoors (at least 10 prints measured each) had been made by different individuals, if the standard deviation of the maximum width of the hindfoot prints did not overlap. The difference between maximum fore- and hindfoot width gave an additional clue which could be used to distinguish individual rhinos (Fig.23). (photo 4)

For the estimation of the number of animals in pair bond, additional information was taken into consideration. Two examples are given:

Example 1: $calf_1$ 17.28 ± 0.96 $mother_1$ 20.0 ± 0.65 (pair III)
$calf_2$ 17.30 ± 0.46 $mother_2$ 21.9 ± 0.22 (pair II)

As $mother_1$ and $mother_2$ are definitely different animals, it was concluded, that despite the same measurements, $calf_1$ is a different animal than $calf_2$ (Fig.24).

Example 2: adult $animal_1$ 22.67 ± 0.58 with calf 19.0 ± 0.61
adult $animal_2$ 22.81 ± 0.65 without calf

Adult $animal_1$ has a calf and its track was found in April 1973 in the extreme northern part of the rhino range near the Kluet river. Adult $animal_2$ has no calf and its track was found in June 1973 in the extreme southern part of the rhino range, near the Kompas river. It was therefore concluded that adult $animal_1$ and adult $animal_2$ are, despite similar hindfoot measurements, two different animals.

In this manner, a minimum number of animals can be inferred for the study area. It must be kept in mind that all other population estimates are extrapolations and must therefore be viewed as cautious approximations.

Fig.23: Estimation of Population Size: Solitary Animals.

Spoors recorded in the study area. For each sample at least 10 clearly visible hindfoot prints on hard soil were measured.

Conclusions:

6 animals can be distinguished: the standard deviation of mean hindfoot width did not overlap and the forefoot was obviously different (arrows).

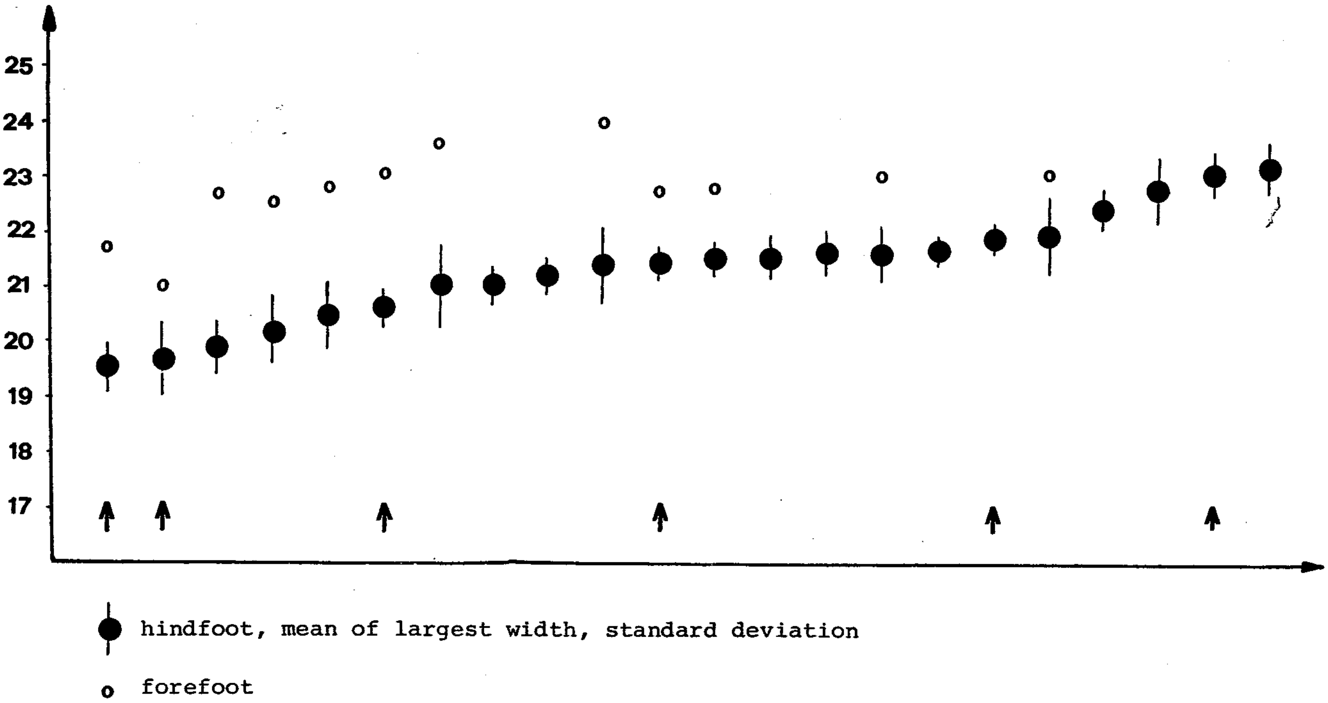
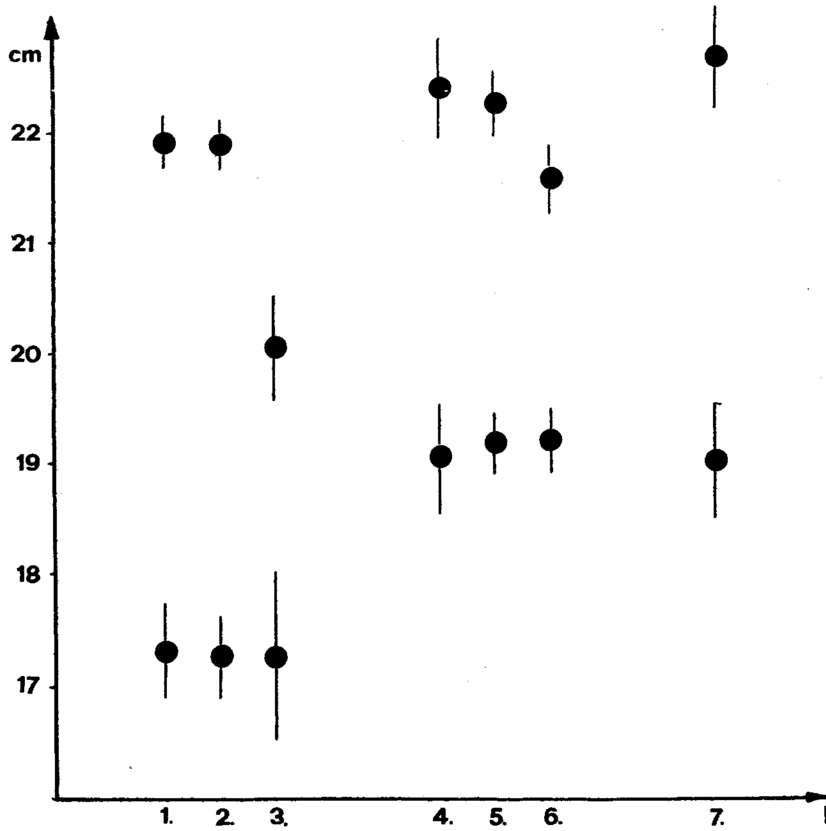


Fig.24: Estimation of Population Size: Animals in Pair Bond



Spoors recorded in the study area. For each sample at least 10 clearly visible hindfoot prints on hard soil were measured.
(All spoors recorded within 3 months, increase of print size therefore negligible)

Conclusions:

pair 1 = pair 2 ≠ pair 3
4 animals, 2 of which are calves

pair 4 = pair 5 ≠ pair 6
4 animals, 2 of which are calves

pair 7 ≠ pair 4, pair 5
probably 2 animals, 1 is a calf

(distinguished by time and distance)

Resulting estimate of rhinos in pair bond in the study area: 10 animals.

2.2.2. Results

67 spoors with over 1000 footprints were recorded in the study area. 36 of these spoors met the criteria mentioned above and were used for the census.

22 sets of prints from solitary animals were measured (Fig.23). 6 animals can be distinguished by different foot print measurements.

14 sets of prints from animals in pair bound (mother/calf pairs) were recorded (Fig.24). 10 animals can be distinguished.

Because observation of the area was carried out with intervals of at least 3 months and because in each trip not the whole study area was surveyed, the actual number of rhinos which were temporarily living within the study area is most probably somewhat higher than 16 animals.

In an effort to estimate the total population of the rhino area of Gunung Leuser I make the following assumptions:

1. The area is on the average visited in the same frequency as the study area.
2. All the individuals have a home range of approximately the same size.
3. The study area has been visited by 20 individuals.

In this case the population will be:

$$\frac{\text{Total core area of Gunung Leuser}}{\text{Individual home range}} \times 20 \text{ individuals}$$

In order to determine the size of the home range we would have to count the time proportion, the average individual has spent within the study area.

$$\text{home range} = \text{study area} \times \frac{\text{Total time of survey}}{\text{Time the average individual was found in the study area}}$$

However it was not possible to determine how long the different individuals stayed in the study area and therefore no conclusion of their total home range could be made. In addition not all the area is used by the same frequency and by the same number of animals for the same duration.

I am therefore limited to give a guess of 20 to 40 rhinos for the Gunung Leuser area.

For the remaining areas in Sumatra only conjectures can be made. The estimation of the population here is based on the number of sets of tracks actually found, the size of the still existing rhino area and comparable data from the study area in the Gunung Leuser reserve (Tab.7). In a long living species it is possible that for several years a single animal, or some few which do not reproduce, survive as a local population rest. Therefore we count for the areas 2, 3 and 5 as a minimum number the number of tracks actually observed.

Tab.7: Estimation of Number of Rhinos in Sumatra

Area	App. time spent in the field	Conjectured rhino area	Minimum number (tracks of different individuals found)	Estimated number
1.Gunung Leuser	more than 6 months	1000 km^2	16 (incl.5 calves)	20 - 40
2.Langkat	7 weeks	400 km^2	2	2 - 5
3.Torgamba	2 weeks	?	1	1 - 5
4.Kerinci/Seblat	6 weeks	unknown, over 1000 km^2 in a forest covered area of ca. 4000 km^2	6 (incl.1 calf)	15 - 20 (?)
5.Sumatera Selatan I	2 weeks	500 km^2	2	2 - 5
Total Sumatra			27	40 - 75

3. Survival Chances for the Sumatran Rhino in Sumatra

An estimated 40 to 75 rhinos are still surviving in five different areas in Sumatra.

The Gunung Leuser population probably totals 20 to 40 animals. Tracks of 5 calves were found. The intact rhino area covers approximately 1000 km^2 (in the centre of a reserve which measures over 4000 km^2). The rhinos still maintain an extensive wallow-, trail- and saltlick-system. The Gunung Leuser population has a fair chance of survival, if the area can be properly protected.

The Kerinci/Seblat area has the highest population of rhinos outside the Gunung Leuser reserve. The approximate rhino range covers well over 1000 km^2 and lies in the middle of a forest which covers more than 4000 km^2. Without further disturbance this population of 15 or more animals, of which at least one is a calf, has a fair chance of survival. The Gunung Leuser and the Kerinci/Seblat areas should become key areas in a programme designed for rhino protection.

The Langkat population is very small. Probably 2 to 5 animals range in an area of approximately 400 km^2. Since this remnant population lives in protected reserve, it may have a chance to recover.

Since the range of the few rhinos in the lowland forests of Torgamba is surrounded by timber concessions and shifting cultivation, this small population is probably doomed.

The few rhinos living in the northern part of the Sumatera Selatan I reserve still maintain a system of trails and wallows. However the undistrubed primary forest area is already small and felling will continue - factors which reduce the chances of survival of this population.

A recent report of the presence of rhinos in the Berbak reserve needs corroboration.

4. Supplementary Remarks on the World Population of the Sumatran Rhinoceros

4.1. Recent information on distribution and population size

The historical changes in the distribution of the Sumatran Rhinoceros are well documented by van Strien (1974). A summary including recent information is given here.

The last records of the appearance of the Sumatran Rhinoceros in the Lushai- and Chitagong hills of India and Bangladesh stem from the end of the last century. No proof of the survival of the rhino has been recently found and it can be assumed, that it has become extinct in these areas.

Up to the beginning of the 20th century reports from all over Burma indicated, that the Sumatran rhino had a large range in that country. Today the rhino can no longer be found throughout most of this range and the population has been reduced to a few remnants. Colonel Hla Aung (pers.com.1975) estimates that 4 animals survive in the Shwe U Daung reserve. Kyaw Gyi and U Tun Yin (1973) believe the total population of the rhino in Burma to be 17 to 26 animals who are scattered throughout seven ranges. There is no effective protection for the species.

Very few rhinos survive in Thailand. McNeely and Laurie (1977) name three areas, where rhinos have been recently reported: the Tenasserim range, Khao Soi Dao reserve in Chantaburi province and the Phu Khio reserve in Chaiyphum province. McNeely (1972) estimates a rhino population of 6-15 animals in Thailand.

No recent reports are available from Vietnam, Laos and Cambodia, where the long years of war have probably led to the extermination of the last rhinos.

In West Malaysia, evidence of the presence of the Sumatran rhino can still be found in eight areas. 10 to 15 animals are estimated to occur in the proposed Endau-Rompin National Park, 6 to 10 in the Taman Negara National Park, 3 to 5 in Ulu Selama

and 2 to 4 in each of the following areas: Sungei Depak, Sungei Balah, Sungei Dusun, Ulu Belum and Ulu Lepar. The total population is estimated to be 30 to 50 individuals. (Information from Mohd.Khan and R.Flynn.)

The rhino's situation in Borneo is uncertain. The last report from the northern part of the island dates back to 1970, when McKinnon found rhino tracks in Sabah. Recent reports stem from only one area in Kalimantan: J.Blower (1976) found evidence of the presence of rhinos north of the Kutai reserve (Fig.25).

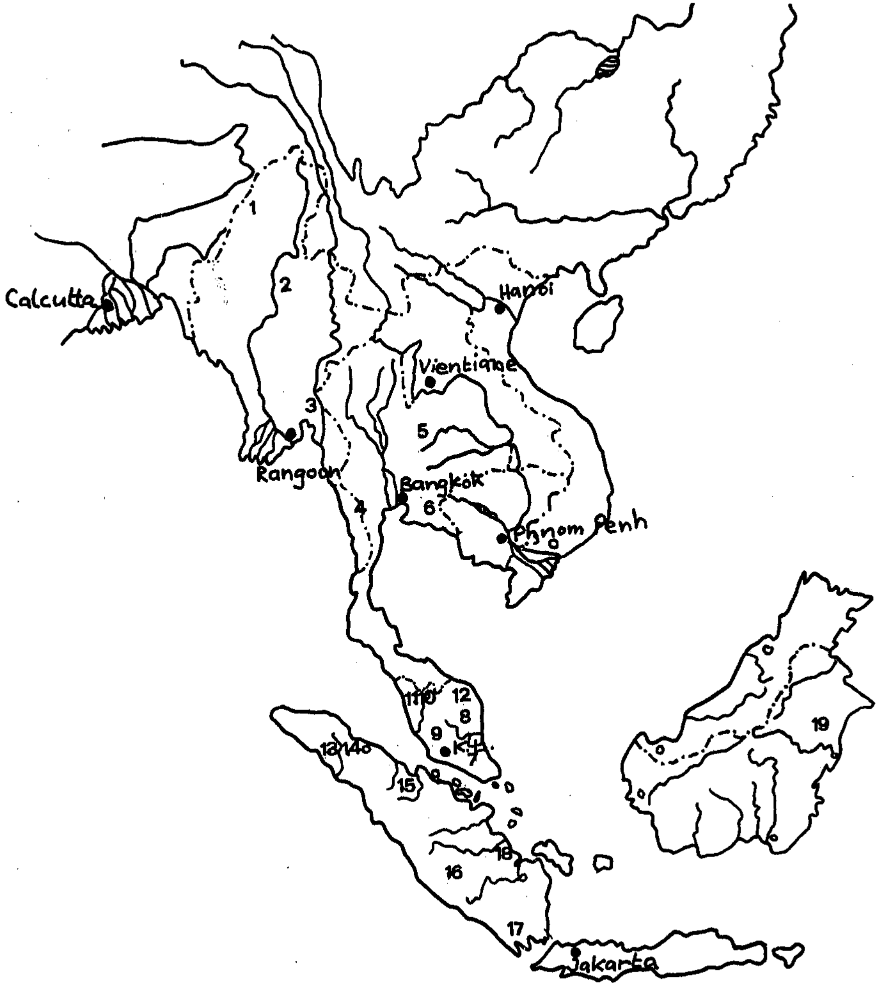
4.2. Conclusions

According to my own findings in Sumatra and recent reports from the remaining rhino ranges, I estimate today's world population of Sumatran rhinos to lie between 100 and 160 individuals.

Throughout the rhino's range, habitat changes, poaching and other encroachments by man threaten the survival of the Sumatran rhinoceros.

About half of the surviving rhinos are living in small isolated populations of only a few individuals. These animals seem to have a poor chance of survival. The other half of the rhinos are living in three areas, namely the Gunung Leuser and Kerinci/Seblat areas in Sumatra and the Endau Rompin area in West Malaysia. In each of these areas, breeding could be confirmed. In fact, if the Sumatran rhino is to be given a chance of survival in the wild, these three ranges have to become key conservation areas and all human disturbance must effectively be kept away from them.

Fig.25: Recent Distribution of the Sumatran Rhinoceros



Burma:

1. Upper Chindwin
2. Shwe-U-Daung
3. Kahilu
4. Tenasserim

Thailand:

4. Tenasserim
5. Phu Khio
6. Khao Soi Dao

West Malaysia:

7. Endau Rompin
8. Taman Negara
9. Sungei Dusun
10. Ulu Belum
11. Ulu Selama Sungei Depak
12. Sungei Balah Ulu Lepar

Sumatra:

13. Gunung Leuser
14. Langkat
15. Torgamba
16. Kerinci/Seblat
17. Sumatera Selatan I
18. Berbak

Borneo:

19. Kutai

PART II: ECOLOGY AND BEHAVIOUR

1. Rhino and Habitat

1.1. Problems and methods

It can be assumed that certain environmental factors are prerequisite for the survival of the rhino in an area, and that other factors - singly or in combination- have the effect of making the environment unsuitable as a rhino range. Each rhino area has a variety of local habitats. Whether a certain habitat is visited by the rhinos depends largely on the actual requirements of the animals. The following parameters were considered:

- Protection from persecution by man
- Food and water
- Possibilities for comfort behaviour
- Possibilities for movements
- Possible competition with and by sympatric species

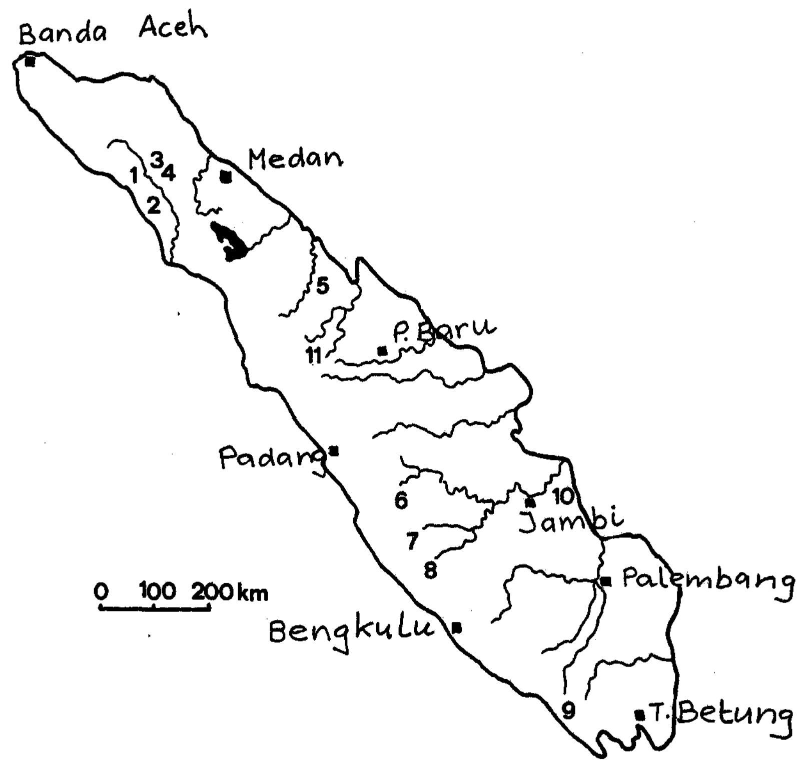
The use of the local habitat types by the rhinos was mainly studied in the Gunung Leuser, but also in all the areas where the species still ranges in Sumatra. In addition, this habitat use comparison was extended as much as possible to rhino habitats outside Sumatra and to information on the earlier habitat of the rhino in Sumatra.

In Tab.8 and Fig.26, a short characterization is given of areas in which surviving rhino populations occur or were still found a few years ago.

Tab.8: The Habitat of the Sumatran Rhino

	Gunung Leuser		Langkat
	1.Central Part	2.Bengkong (formerly)	3.Upper Bohorok
Recent occurrence of rhinos	+	-	+
Evidence of rhino	tracks, trails, wallows, salt-licks, faeces, direct observation, etc.	wallows, trails	tracks, trails, feeding marks
Altitude of rhino area	1000 m to nearly 3000 m	50 to 300 m	over 1200 m
Forest type	prim.submontane prim.damp moss forest	prim.lowland forest	prim.submontane prim.damp moss forest
Topography	steep, mountainous	steep, hilly, in some parts flat	steep, mountainous
Availability of water	water catchment area, many small streams, a few small rivers	many small streams, two large rivers	water catchment area, many small streams, one large river
Undergrowth	dense, mostly saplings	sparse, saplings, ratan	dense, mostly saplings
Availability of food	+++	+	+++
Distance to man-made second.growth	shifting cultivation ca.15 km	timber concessions ca.20 km	shifting cultivation ca.15 km
Reports of rhinos venturing into second.growth	-	-	-

Fig.26: The Habitat of the Sumatran Rhino



Areas used for habitat comparison:
(see Tab.8)

1. Gunung Leuser, central part
2. Gunung Leuser, Bengkong
3. Langkat, upper Bohorok
4. Langkat, Landak
5. Torgamba
6. Kerinci, Gunung Tucu
7. Kerinci, Lempur
8. Kerinci, Sungei Seblat
9. Sumatera Selatan I
10. Berbak
11. Rokan

4.Landak	5.Torgamba	Kerinci			9.Sumatera Selatan I	10.Berbak	11.Rokan (formerly)
		6.Gunung Tucu	7.Lempur	8.Sungei Seblat			
	+		+	+	+	+ (?)	-
tracks,trails, wallows	tracks,trails, wallows,faeces	tracks,trails, feeding marks, faeces	tracks,trails, faeces,wallows etc.	tracks,trails	tracks,trails, wallows,faeces	tracks	trails,wallows
200 to 400 m	0 to 100 m	from 2100 m to forest boundary at nearly 3000m	700 to 1000 m	over 800 m	500 to 1200 m	0 to 20 m	50 to 400 m
prim.lowland forest	prim.lowland forest with patches of swamp forest, second.forest	prim.damp moss forest	prim.submontane forest	prim.submontane forest	prim.submontane forest	prim.lowland forest with patches of prim. swamp forest	prim.lowland forest
steep, hilly	hilly and flat	steep,mountainous	steep,hilly,in some parts flat	steep,mountainous	steep,mountainous	hilly and flat	steep, hilly
water catchment area,many small streams, one large river	many small streams, some patches of swamp	water catchment area, small streams, one lake	many small streams, two large rivers	many small streams, two large rivers	water catchment area,many small streams, one large river	many small streams, patches of swamp	many small streams, one large river
dense,saplings, ratan	sparse,saplings	dense, mostly saplings	sparse, bamboo	dense, mostly saplings	dense, mostly saplings	sparse, in some areas dense	dense, mostly saplings
++	+	+++	++	++	+++	+	++
shifting cultivation ca.10 km	timber concession close by	shifting cultivation ca.3 km	shifting cultivation ca.5 km	shifting cultivation ca.2 km	shifting cult., timber concessions ca.5 km	shifting cultivation ca.10 km	shifting cultivation in the area
-	+	-	-	-	+	-	(+)

1.2. Results

1.2.1. Predation and disturbance

There is no doubt that the habitat disturbance and destruction caused by man (part I, section 1.3.) as well as hunting activities are responsible for the drastic decline of the rhino population and the equally drastic shrinking of the area of the rhino range.
The forest in the core area of the Gunung Leuser reserve is still undisturbed and the rhinos live at a distance of 15 to 20 km from the next human settlements and shifting cultivation. Poaching by professional rhino hunters however reaches the remotest areas and is posing a threat to the survival of the population.

In the Langkat, Berbak and Sumatera Selatan I reserves and in the Kerinci area, the rhinos are confined to shrinking areas of undisturbed forest. In Torgamba, where a few rhinos survive in an area that is presently under timber exploitation, no large undisturbed forest area to which these animals could retreat is left.

In the Bengkung area, where human disturbance attributable to fishermen, ratan collectors and hunters is considerable, the rhinos have disappeared in the last few years. In the upper Rokan area no undisturbed forest is left and the rhinos probably disappeared 10 to 15 years ago.

I have found no evidence that the rhino is exposed to predators other than man. The only large predator that could be dangerous to a rhino calf is the tiger (Panthera tigris sumatrensis). Although tigers frequently use the path system of the rhino and tiger faeces and scraping marks can often be found on rhino trails, I have no evidence that they prey on the rhino population.

1.2.2. Water and food

In the rhino areas, both in the lowlands and in the mountains, water is abundant. The rhino's favourite areas are found in the catchment areas of small rivers, where numerous small streams can be found.

Only in certain areas of the rhino habitat, like on mountain ridges, water is rare. Here rain water is collected in wallows that are made by the rhinos themselves.

The main food resource of the Sumatran rhino are saplings and shrubs (Tab.10, p.86). Such saplings are abundant in the area where submontaine forest is gradually changing into damp moss forest, where the trees are relatively small and the canopy is not closed. Enough light is able to reach the forest floor to induce a thick undergrowth, which consists mainly of saplings. In the lowland and hill forests, the undergrowth is usually sparse. But on the slopes of steep hills and on ridges, where topography breaks the forest canopy, much more light reaches the forest floor than in flat areas, where the canopy is compact. Therefore the undergrowth in the steep areas is denser than in the flat regions, regardless of the particular forest type.

In most rhino areas, the undergrowth is rather dense. Only in rhino areas of the typical flat lowland forest, like Torgamba, where the tree top canopy is completely closed, the undergrowth is somewhat sparse and saplings are less abundant.

Fig.27 shows the abundance of saplings in a typical rhino area.

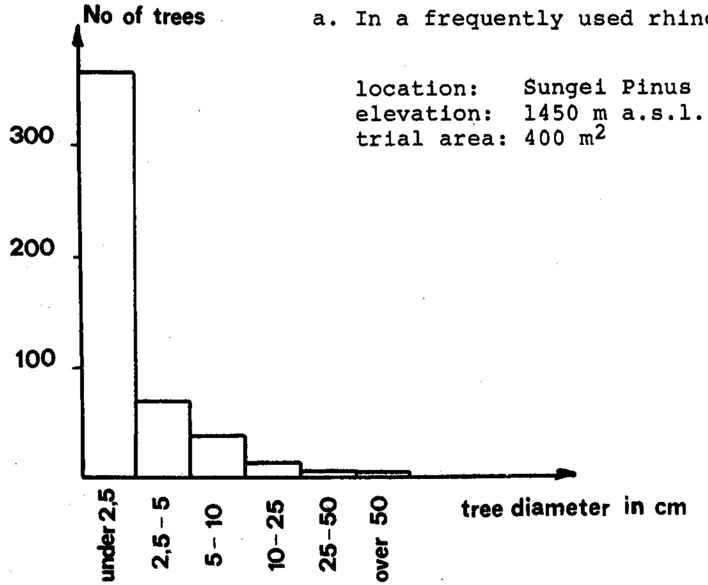
1.2.3. Possibilities for comfort behaviour and movements

To wallow the rhino needs loamy soil in small depressions (see 2.5.). Apart from wallows and saltlicks the soil in all rhino areas is usually firm. The rhinos avoid large swampy or boggy areas.

Fig.27: Tree Diameter Diagram

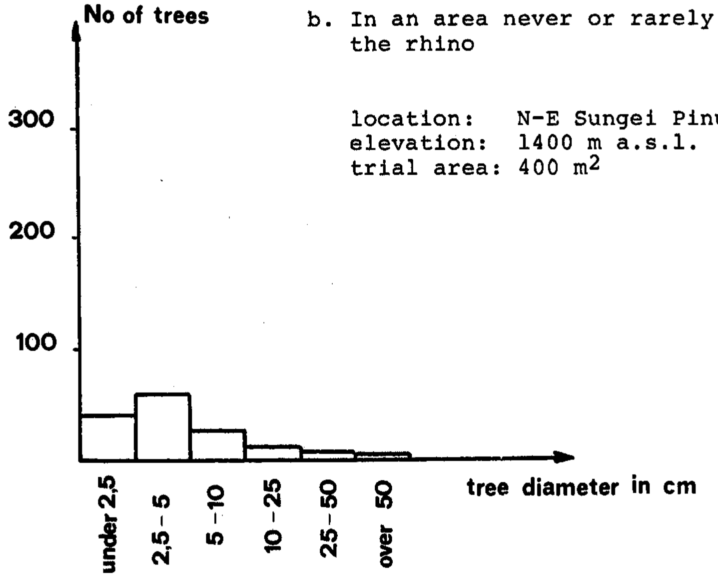
a. In a frequently used rhino area

location: Sungei Pinus
elevation: 1450 m a.s.l.
trial area: 400 m^2



b. In an area never or rarely used by the rhino

location: N-E Sungei Pinus
elevation: 1400 m a.s.l.
trial area: 400 m^2



No evidence of the rhino was found in the mangrove forests, nor in the large swamp forests of Central Sumatra. Although Metcalfe (1961) reported the existence of the rhino in the heavy swamp forest in Malaya, no signs or local reports, indicating the occurrence of the rhino in swamps can be found in Sumatra. Own observations showed that the rhinos live in primary lowland forest in which patches of swamp forest may be found (Torgamba and Berbak). However, it is only in dry seasons, when the ground is firm, that the rhinos venture into these swamp forest areas.

As shown in 1.2.2. the rhinos occur in steep mountainous country. The animals are very agile in these steep areas and seem to avoid only the extremely steep slopes.

1.2.4. Competition

The Sumatran rhino shares a large part of its total range with the elephant (Elephas maximus), but can occupy additional areas that are unsuitable for the latter. Where their ranges overlap, elephants and rhinos use the same main trails and sometimes even the same wallows (Silukluk ridge and Gunung Kemiri) and saltlicks (upper Kompas). Neither species is dependent on the other for the maintenance of the trails, wallows and saltlicks. Food preference of the two species is distinctly different. The elephant prefers soft secondary growth plant species like banana-stems or leaves of wild ginger (Olivier 1975), plant species never eaten by the rhino (part II, section 2.1.2.). Only in areas, where the supply of soft food plants is scarce (e.g. when a herd is crossing a mountain ridge), do the elephants occasionally browse on saplings, which are also part of the rhino's diet.

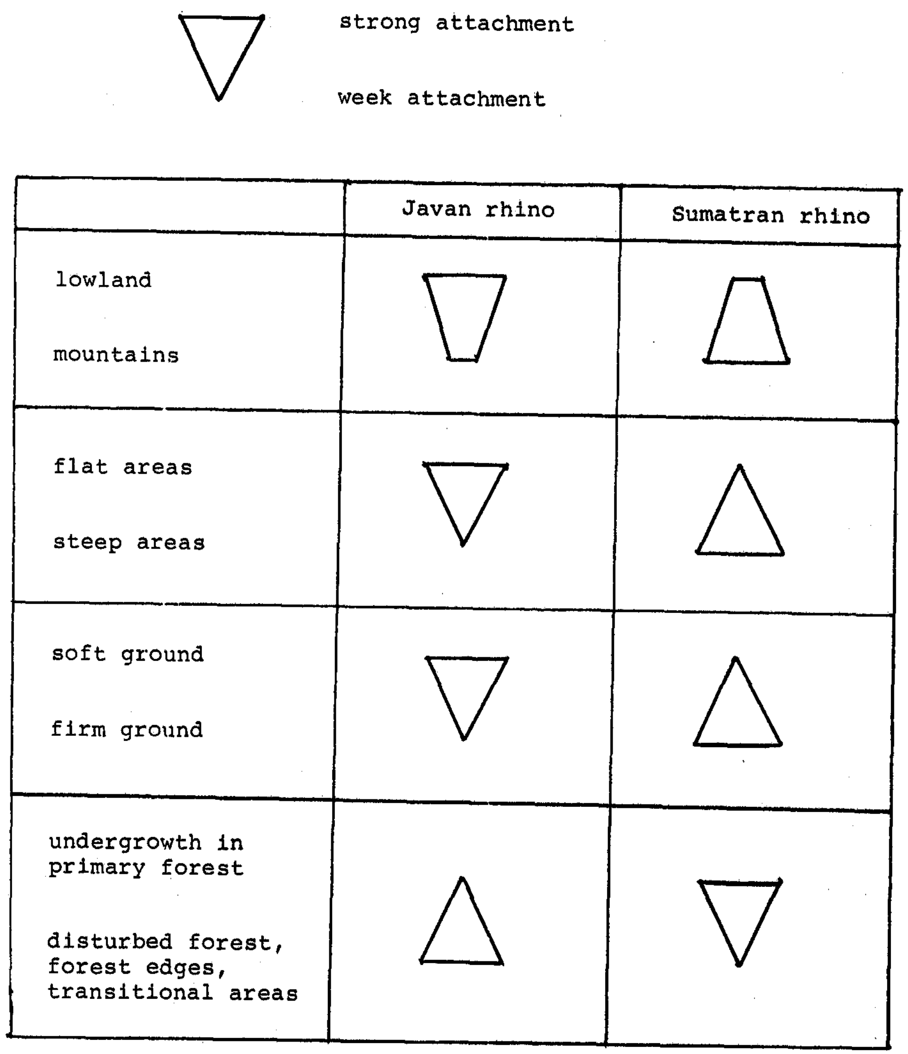
The tapir (Tapirus indicus) is found only in central and southern Sumatra. In four areas (Torgamba, Kerinci, Berbak, Sumatera Selatan I) rhino and tapir occur together. It seems that ecological competition is not pronounced. In general the tapir is less pursued by man and perhaps also more adaptable to man-made changes of the habitat. Although both species are browsers, it seems that the tapir most frequently feeds on fast-growing, soft-wooded saplings, frequently occurring as components of secondary growth, whereas the rhino appears more specialized to slow-growing, hard-wooded saplings typical of the primary forest.

Concerning the times when the Javan Rhino (Rhinoceros sondaicus) still occurred in Sumatra, there is no evidence reported of direct competition between this species and the Sumatran Rhino. However it is puzzling that in Java the former species was found from sea level to high mountains while in Sumatra it seems to have mainly been living in the lowlands. This might be a consequence of ecological competition and specialization to different ecological niches (Ecological displacement, Groves, 1967).

In Ujung Kulon, its last stronghold, the Javan Rhino can mainly be found in wide depressions with wet and loamy ground. It is known however to visit also the highest regions of Gunung Payung (R.+ L. Schenkel 1969b).

In Sumatra, the heavier Javan Rhino lived mainly in low and flat regions where the ground was soft and sometimes swampy, whereas the lighter and more mobile Sumatran Rhino occurred in higher and steeper regions where the ground was generally firm. In this high and steep area, where the forest canopy is relatively open, the Sumatran Rhino finds a rich undergrowth of saplings. In the flat lowlands, the forest canopy is closed and undergrowth is scarce. Here, forest fringe areas, glades and areas with natural or artificial secondary growth offered the richest food for the Javan Rhino.

Fig.28: Ecological Displacement



1.3. Conclusion and discussion

The present rhino range in Sumatra covers only a fraction of its original size. Today nearly all of the surviving rhinos live in the mountainous areas of the Barisan mountain range. Habitat destruction and disturbance by man seems to be the main cause of the loss of range area. Rhinos still survive in all large undisturbed areas of Sumatra, but they are vanishing or have already disappeared from areas where the forest is disturbed or destroyed. In Tab.9 an attempt is made to summarize environmental factors contributing to a suitable rhino habitat.

Evidence shows, that the mangrove and the heavy swamp forest were never a suitable rhino habitat. No reports - past or present - indicate that the Sumatran rhino was ever found in such an area. Food availability is low and the rhino seems to prefer dry or loamy areas and to avoid boggy ground. The former and recent distribution shows, that the lowland forest, the hill and submontane forest and the damp moss forest belonged and still belong to the rhino habitat.

In Sumatra, most of the rhino areas are situated in primary forests. Secondary forest is only occasionally visited. As most secondary growth is man-made and therefore linked to human disturbance, it is difficult to ascertain, whether the rhinos avoid these areas because of food preferences or fear of man. In Sungei Dusun (West Malaysia) R. + L. Schenkel (pers.comm.) found abundant feeding traces of the Sumatran rhino in man-made secondary growth,e.g. along an overgrown track.

The Sumatran rhino has a preference for steep, hilly or mountainous areas. Several factors might contribute to this preference. The abundance of undergrowth, especially saplings, on slopes and ridges provides a rich food supply. In addition the slopes offer dry, firm ground and some protection against human disturbance.

Tab.9: Rhino Habitat in Sumatra

	Factors contributing to suitable habitat conditions:	Factors limiting the rhino in its distribution:
Vegetation	primary lowland forests; primary hill- and submontane forests; primary damp moss forest	mangrove forests; swamp forests; swampy patches in wet season; recently logged, secondary forests
Topography	steep, hilly or mountainous	large, flat areas
Food supply	abundant undergrowth, consisting mainly of saplings	undergrowth scarce
Surface water	water catchment area with an abundance of small streams	no water or only standing water in swamps
Soil condition	dry, firm or loamy	swampy, boggy
Human disturbance	undisturbed	logging, shifting cultivation, oil exploitation, hunting, general disturbance e.g. by fishermen, ratan collectors, etc.

Altitude, climate, competition and predation seem to have no effect on the distribution of the Sumatran rhino in Sumatra.

The availability of running surface water seems to be important for a rhino habitat. In all the forested areas of Sumatra however water is not scarce and it is not its lack which limits the animal's distribution range.

2. Maintenance Behaviour

2.1. Food and feeding

2.1.1. Methods

Since it is practically impossible to observe the rhino in the wild, facts about food and feeding behaviour have to be deduced either from traces produced while the rhino was feeding or from its dung.

While feeding, a rhino leaves three different categories of traces:

- Footprints on the soil reveal that a rhino has been present and active in an area. They show in what position the rhino stood in relation to trails, food plants, etc., and in what way it moved through the vegetation.
- Traces on plants give evidence that the rhino applied force to certain plants, and, together with the footprints, reveal the way in which this was done.
- Twigs or small branches, the ends of which have been chopped off, give proof that the rhino in fact fed on the plant.

If these three categories of traces were present, the first and second were analysed to deduce the rhino's behaviour and in accordance to the third, the plant was listed as a food plant of the rhino.

111 food plant samples were collected. For practical reasons, the samples were kept in plastic bags with alcohol until the termination of the field trip. Afterwards they were pressed and dried. Dr. Sukristijono Sukardjo of the Herbarium Bogoriense and Dr.W.J.J.O.deWilde from the Rijksherbarium Leiden identified the samples.

Dung analysis could provide a possibility to make quantitative statements on food composition, however such analysis requires a great amount of laboratory work, and time was not available for this.

2.1.2. Food plants

Van Strien (1974) compiled all available data on the food plants of the Sumatran rhino. He arrived at a total of 101 different species for the entire distribution range. 17 of these were collected in Sumatra. I found 71 species for Sumatra alone, 16 of which had already been mentioned by other authors (Tab.10 and 11). It is remarkable, that many species which showed signs of rhino feeding were found only once or twice.

Of the 111 identified food plant samples (representing 71 different species), 99 (89%) were small trees or saplings, with a stem diameter of one to 6 centimeters and a height of up to six meters. Along with the leaves the rhino had chopped off and fed on twigs and small branches. The composition of the dung confirms that such twigs are the main food source of the rhino (part II, section 2.3.2.).

On two occasions rhino dung consisted not only of bits of twigs and fibres, it also contained fruits of Garcinia mangostana and

Tab.10: List of Food Plants: Small Trees and Saplings

Latin Name	Family	Number of samples found with traces of feeding
Adinandra sp	Theaceae	1
Aglaia sp	Meliaceae	1
Ardisia sp	Myrsinaceae	4
Ardisia crispa	Myrsinaceae	1
Armadendron elegans	Magnoliaceae	1
S*Baccaurea malayana	Euphorbiaceae	1
Boehmeria clidemioides	Urticaceae	3
Calophyllum sp	Guttiferae	4
Calophyllum cymosum	do	1
Calophyllum dasypodum	do	4
Calophyllum inophyllum	do	1
*Dillenia sp	Dilleniaceae	1
Distylium stellare	Hamamelidaceae	1
Drypetes sp	Euphorbiaceae	1
Dysoxylum sp	Meliaceae	1
Elaeocarpus sp	Elaeocarpaceae	1
Elaeocarpus floribundus	do	1
Elaeoc. palembanicus	do	1
*Eugenia sp	Myrtaceae	5
Eugenia polyantha	do	2
Euonymus javanicus	Celasteraceae	1
*Fagraea blumei	Loganiaceae	1
*Ficus sp	Moraceae	4
Ficus microcarpa	do	1
Ficus sinuata	do	1
Ficus ribes	do	1
S*Garcinia sp	Guttiferae	5
Gordonia excelsa	Theaceae	1
*Hibiscus venustus	Malvaceae	1
Ilex sp	Aquifoliaceae	1
Ilex odorata	do	1
Ixora grandifolia	Rubiaceae	2
*Kayea suratmanii	Guttiferae	1
*Knema sp	Myristicaceae	1
Leea sp	Leeaceae	5
Lindera sp	Lauraceae	1
*Macaranga denticulata	Euphorbiaceae	1
*Melastoma sylvaticeum	Melastomataceae	1
Melisoma lepidota	Sabiaceae	2
Morinda citrifolia	Rubiaceae	1
Nauclea lanceolata	do	1
*Palaquium sp	Sapotaceae	2
Plectronia didyma	Rubiaceae	2
*Polyosma sp	Saxifragaceae	1

Latin Name	Family	Number of samples found with traces of feeding
Prunus acuminata	Rosaceae	1
Prunus spicata	do	2
Rhododendron sp	Ericaceae	1
Rhodoleia teysmanni	Hamamelidaceae	1
Schima wallichii	Theaceae	1
Scindapsus hederaceus	Araceae	1
Spondias pinnata	Anacardiaceae	1
Stemonurus scorpoides	Seacinaceae	1
Styrax paralleloneurum	Styraceae	2
Symplocos sp	Symplocaceae	1
*Terminalia gigantea	Combretaceae	1
S*Ternstroemia sp	Theaceae	5
Trigonobalanus celebica	Fagaceae	1
Trigonobalanus verticillata	do	1
Vaccinium lucidum	Ericaceae	3
Weinmannia fraxinea	Cunoniaceae	1

Tab.11: Herbs and Lianas

Latin Name	Family	Number of samples found with traces of feeding	
Antidesma sp	Euphorbiaceae	1	
*Calamus axillaris	Palmae	1	(ratan)
Cratoxylon cuneatum	Guttiferae	1	
Cyclophorus interuptus	Polypodiaceae	1	(fern)
Cyrtandra sp	Gesneriaceae	1	
Elatostema sp	Urticaceae	1	
Lophatherum gracile	Gramineae	1	(grass)
Polygonum paniculatum	Polygonaceae	1	
Rubus sp	Rosaceae	1	
Sebastiania remota	Euphorbiaceae	1	
Uncaria sclerophylla	Rubiaceae	1	(liana)
		110	

* Food plants, also found by other authors throughout the entire distribution range of the Sumatran rhino (according to van Strien 1974)

S* Food plants, also found by other authors throughout Sumatra (according to van Strien 1974)

Mangifera indica respectively. In both cases the seeds were sprouting.

Among other food items were herbs and lianas. 11 samples (10%) fit into this category, which indicates that they represent only a small portion of the rhino's diet (Tab.11).

The main portion of the rhino's diet consists of saplings. Such forest regeneration growth can be found in abundance where the treetop canopy is broken and allows a great deal of light to reach the ground. Saplings flourish therefore in the damp moss forest and the submontane forest. In the lowland forests regeneration growth is densest on slopes and ridges, where the topography brakes the treetop canopy, and also on the river banks (part II, section 1.2.4.). The secondary growth of large deforested areas seems, however, unsuitable for the rhino.

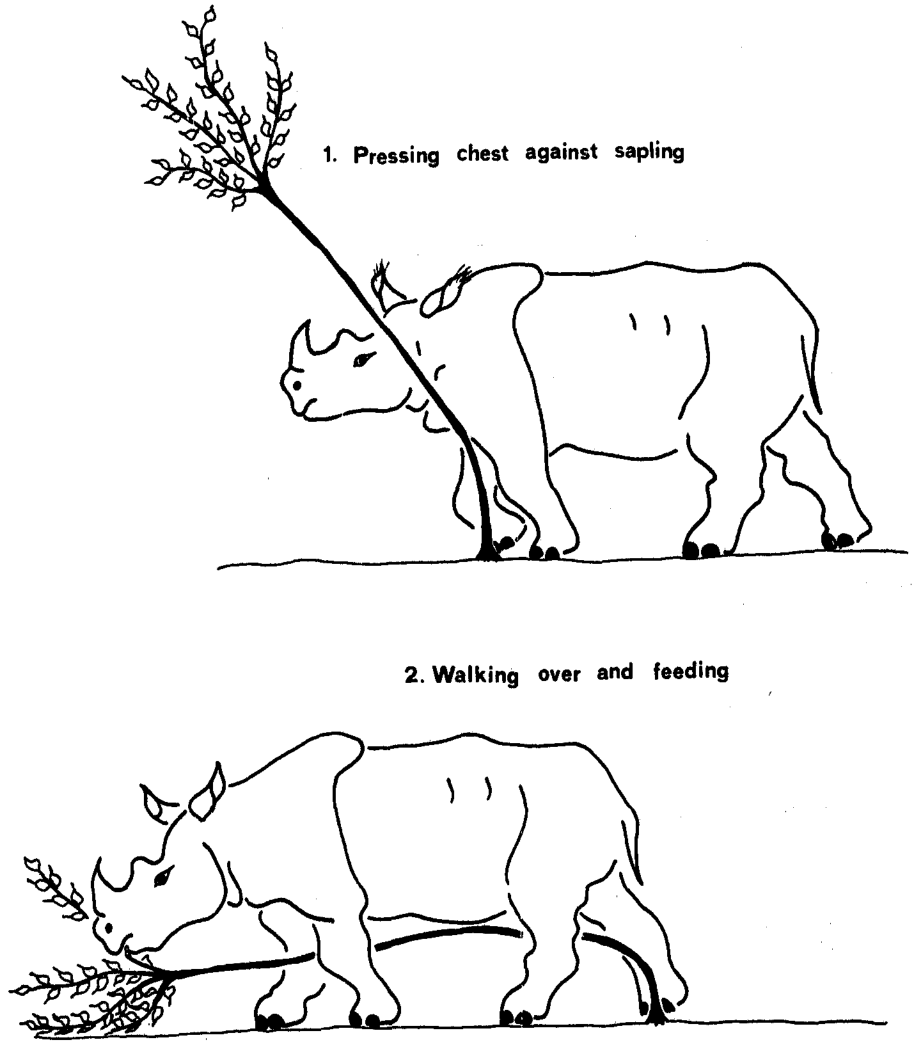
The facts that the rhino feeds on a great variety of food plants and that many plant species were found only once or twice with signs of rhino feeding indicate, that a rhino on a feeding trip constantly changes its diet as well as its eating place. If at a certain place several food plants are available, the rhino usually eats from only one before moving on.

2.1.3. Feeding behaviour

To reach the twigs of a higher sapling, the rhino bends or breaks it down. More than a hundred broken saplings were recorded. An analysis of the marks left by the rhino allowed a reconstruction of the rhino's feeding behaviour.

The rhino usually approaches small trees from uphill. With its head beside the tree it presses its breast against the stem (Fig.29). This produces a rubbing mark on the bark of the tree, which begins at a height of about 40 to 45 cm. To break or bend down the tree, the rhino simply walks over it without stepping on it. Depending on the tree species, the trunk is usually broken between ground level and 40 cm above the ground; some-

Fig.29: Feeding Behaviour



times, however, the tree is uprooted or only bent. Rubbing marks on the bark of the upper side of the trunk (which are deepest just at the beginning, 40 to 90 cm above the ground) and prints of the feet on both sides of the bent down trunk show, that the rhino advances over the tree, with the right fore- and hind-foot on one side of the tree, the left fore- and hind-foot on the other side. It presses down the trunk with its body. When its head reaches the treetop, it starts to feed on the twigs and leaves. Usually it feeds only on the part of the treetop that is facing upwards now, and which is in easy reach of its mouth. After it has finished feeding (usually only a small proportion of the available twigs and leaves) the rhino just walks on over the treetop. In doing so, it occasionally breaks some branches and if it has wallowed earlier, it leaves mud smears on the branches and leaves. If the tree is not broken or uprooted, it usually returns to an oblique position. Evidence of such feeding behaviour was found more than a hundred times.

Rhinos seem to be able to push down trees of a diameter of 5 cm or less effortlessly. If the rhino wants to break down a thicker tree, it sometimes experiences difficulties. In several cases the scratches of its nails on the tree showed, that the rhino had tried to use its forefeet to break down the tree. One example near "Tempat Medan" showed this behaviour clearly: A rhino had tried to push down a tree with a diameter of nearly 8 cm. Failing to do so only with its breast, it used both its forefeet. Scratches left by the nails and body on the bark of the tree as well as footprints showed, that during this process the animal rose on its hindfeet. Another tree with a diameter of 10 cm was successfully pushed over with the help of the forefeet.

In four cases I observed that the rhino had only used its forefeet and not its body to bend down a sapling. I found five cases where, after bending down the tree in the usual way with its breast, the rhino had stepped on the stem when proceeding to

the treetop. Such "trampled down" stems were always broken into several pieces.

On one occasion I discovered a small sapling with a diameter of 2 cm which the rhino had broken down with its teeth at a height of 110 cm. The tooth marks on the broken part were 7 cm apart on one side (lower teeth) and 9 cm on the other side (upper teeth).

I found no evidence that when the rhino feeds on low growing saplings, shrubs or herbs, it steps on or breaks down the plant.

I found creepers on which a rhino had fed on four occasions. Two of these creepers had been bitten off from the stems on which they were growing.

In one case a rhino had fed on a creeper hanging down to the ground. In the fourth case a rhino had torn down a creeper which was hanging from a branch of a tree 7 cm in diameter and 7 meters high. Footprints on the ground as well as nail and tooth scratches on the stem showed that the rhino had used its teeth to pull down the liana and its feet to prevent it from bouncing back. Then it had released the hold of its teeth in order to get hold higher up. As soon as it had pulled again, it stepped again on the creeper. This process was repeated eight times. Since the creeper was firmly anchored in the treetop, the tree had been bent over more and more until it finally broke. The rhino fed then on the leaves of the creeper, without eating those of the broken tree. Tooth marks on the creeper were 11 cm apart on the one side (upper teeth) and 8 cm on the other side (lower teeth).

2.1.4. Feeding areas

Within the study area signs of feeding were concentrated in some parts. For example evidence of feeding was abundant along the main trails since rhinos fed directly along the trails or on poorly maintained side trails (part II, section 2.7.2.).

In other regions, feeding signs are scattered over a larger area. Fresh rhino tracks reveal that the animals usually cross these feeding areas without following a trail and that they frequently stop for feeding.

In the study area, such feeding areas were found at Sungei Ikan, Sungei Tampu, Sungei Pinus, Tempat Medan and upper Kompas river among others.

2.2. Saltlicking

2.2.1. Location of saltlicks

In the limestone areas of the Barisan mountains and in the alluvial plains of eastern Sumatra, saltlicks are rare.

In my study area in the Gunung Leuser reserve I found four regularly used saltlicks. Two of these were very close together at Sungei Pinus, the third was about 5 km to the north-east of Sungei Pinus, the fourth was situated in the catchment area of the Kompas river. Just outside the reserve boundary in the Renun river area, there are several saltlicks that were previously also used by the rhinos.

I found no saltlicks on the large plains of eastern Sumatra. Only in the foothills of the Barisan mountains (upper Rokan river area) did I find an old, overgrown rhino saltlick.

2.2.2. General characteristics of saltlicks

The saltlicks of Sungei Pinus, situated at an altitude of 1350 m a.s.l. are the largest ones I found (photo 5).

The two saltlicks are situated 100 meters apart, one in each of two small valleys with tiny streams flowing parallel to each other. The saltlicks are centers of a network of well

maintained rhino trails; four trails lead to the northern, six to the southern saltlick. Since the soil is loamy, the trails form narrow ditches up to 1.5 m deep and 60 cm wide. Four main trails lead to the saltlick area. The saltlicks are situated between large rocks at the bottom of the valleys. The soft rock has been carved out by rhinos and shows traces of their horns. Water trickles out of the rocks into a small puddle of sand and mud. Black stains on the rocks and small stones as well as the typical strong smell indicate that the spring contains sulphur.

A third saltlick, which is located five kilometers north-east of Sungei Pinus, looks much the same, but is smaller. Seven main trails, two of which are deeply cut into the ground, lead to the saltlick, situated on a slope close to a small river. Sulphurous water trickles out between limestone boulders, which have been broken up by the feet and horns of the rhinos. For a distance of two meters the ground in front of the limestone is wet and softened by the rhinos' feet.

The overgrown saltlick found in the Rokan river area, Riau, was of the same type as the latter.

Several trails lead to the saltlick in the upper Kompas river. This saltlick is merely an exposed area of earth, there are no rocks. Minerals are consumed from the ground beneath a tree root at the foot of a slope. The soft earth has been carved out by rhinos.

The saltlicks at Renun river consist of caves carved out of dry limestone by elephants.

2.2.3. Minerals of the saltlicks

Analysis of samples taken from the saltlicks revealed the following mineral components (mg/100 g soil):

	Na^+	K^+	Ca^{2+}	Mg^{2+}
Sungei Pinus I	42	11	52	6
Sungei Pinus IIa	70	9	88	6
Sungei Pinus IIb	40	7	130	11
North East S.Pinus	46	7	400	27
Renun I	149	18	33	12
Renun II	64	6	32	8

2.2.4. Frequency of rhino visits to saltlicks

While most areas within the rhino range may not be visited by a single rhino for weeks, the saltlicks seem to be visited more frequently. On each of my trips to the Sungei Pinus area I found an abundance of old and new rhino tracks around the saltlicks. The newest tracks were sometimes only a few hours old and never older than a few days. While I was sitting on a tree hide in this area for more than three weeks, two animals visited the area 12 days apart. Only one of these animals actually entered the saltlick and ate soil. The other animal was just passing by.

On the basis of the tracks observed, I estimate that the saltlick at Sungei Pinus is visited every one or two weeks by a rhino. The sizes of the tracks indicate, that at least five different animals were using the saltlick.

I baited one of the two saltlicks at Sungei Pinus with additional salt for one year, but could not ascertain an increased frequency of rhino visits.

2.2.5. Behaviour in and around a saltlick

At Sungei Pinus where the saltlick stone is rather hard, the rhinos use their horns to break out small pieces. Such traces of carving are abundant at Sungei Pinus. They start about 30 to 40 cm above the ground and, because of the firmness of the stone, are only about 1.5 cm broad, 1.5 cm deep and 6 to 10 cm long. The rhino uses the anterior horn to break loose pieces of stone or clay even in softer material, in which case the traces left by the horn are much deeper and larger. In the saltlick north-east of Sungei Pinus, the rhinos used their forefeet to break down pieces of loose limestone. Then they eat the soil and small stones.

Probably the rhinos also drink from the water in the saltlicks.

In and directly around the saltlicks no faeces, urine or feeding traces can be found.

2.2.6. Other animals visiting the saltlicks

The saltlicks are not only visited by rhinos. At the Kompas saltlick I observed a barking deer (*Muntiacus muntjak*) while it was eating soil, and at the Sungei Pinus saltlick I frequently saw the tracks of sambar (*Cervus unicolor*) and wild boar (*Sus scrofa*). A golden cat (*Felis temmincki*) was observed entering the saltlicks and on rare occasions, tracks of the tiger (*Panthera tigris*) were detected nearby. I could not ascertain if the cats used the saltlicks.

Elephants (*Elephas maximus*) regularly enter the mud lick in the upper Kompas river. The dry salt licks at Renun are also used by serow (*Capricornis sumatrensis*) a.o.

At all the wet saltlicks, concentrations of bees and wasps can be found.

2.2.7. Discussion

The rhino and other herbivores are not able to satisfy their need for minerals with their normal diet. To balance the ion concentration in their body, they need additional sodium, potassium and other minerals (van Strien 1974). In limestone areas the soil of the tropical forest is usually poor in minerals. Therefore the few places, where a supply provides the necessary minerals, are very important for the rhino and other herbivores.

As some of the saltlicks observed are visited more frequently by rhinos than any other place in the rhino range, they might be especially important for intraspecific communication. Not only is the chance of direct encounter comparatively high near saltlicks, but these places offer the opportunity for effective conveyance of special information by marking behaviour (part II, section 3.2.5.).

2.3. Defecation

2.3.1. Methods

During my expeditions in the study area, I noted down the locations of the dung heaps I encountered. In order to avoid double counting, I marked the registered dung heaps with wooden sticks. Additional information like approximate age, distance to nearby dung heaps, general appearance of the dung, etc., were recorded. Tracks and other traces of rhino activity were analysed to reconstruct the rhino's behaviour.

A number of fresh dung heaps were marked and their rate of breakdown was observed. Some were washed away by the rain in a few weeks, others were soon decomposed by insect larvae, but, depending on weather conditions, some remained visible up to eight months (photo 6).

I did not systematically search the study area for dung heaps. The data collected on locations of dung heaps are necessarily biased for the following reasons: I usually travelled from one area to another on main trails since it is possible to proceed much faster on these trails than by cutting through the vegetation on a direct route. Consequently I have checked a much longer total distance of rhino route on trails than off those. In addition, when I tracked a rhino that did not follow a main trail, it took a very long time to check a short distance of the rhino's route for dung heaps. Furthermore the data on the location of dung heaps are influenced by the different decomposition rates and by the fact that dung dropped in riverbeds might be washed away.

2.3.2. General appearance of dung

The dung of an adult rhino consists of balls of a diameter of 6 to 10 cm. The animals deposit 5 to 20 balls at one time, covering an area with a diameter of 50 to 80 cm. Apart from fibrous material from digested leaves, the dung contains an abundance of small, wooden sticks. These remains of the twigs and small branches the rhino has eaten, are about one centimeter long, usually split lengthwise, without bark and give the dung its typical rough texture. In the Kompas area dung containing small stones was observed.

The dung balls of young animals are smaller, 4 to 6 cm in diameter, but similar in texture. I cannot confirm Hubback's (1939) observation, that dung of adult rhinos appears coarser than that of immatures.

2.3.3. Location of dung heaps

I have recorded the location of 316 dung heaps in the study area. The result is shown on table 12.

Tab.12: Location of Dung Heaps

	Number of faeces	Percentage of total
Deposited on main trails	212	67.1%
In or directly beside water	56	17.7%
On feeding trails	46	14.6%
In wallows	2	0.6%
In and around saltlicks	0	0 %
Total	316	100 %

Tab.13: Behaviour Components of Defecation

St	Stopping
Stt	Stopping and turning to side of trail
D	Defecating
Tw	Twisting of sapling
Shb	Shrub beating
Tur	Turning around, rear against sapling
ScH	Scraping with both hindfeet alternately
USh	Urinating in shower

Behaviour sequences deduced from traces:

St - D	295 cases observed
St - D - ScH	2 " "
St - ScH - D - ScH	3 " "
Stt - Tw - Tur - D	6 " "
Stt - Shb - Tur - D/USh - ScH	2 " "
Stt - Tw - Tur - (ScH) - D - ScH	8 " "
	316

As I have explained above the data are somewhat biased, so that the actual percentage of dung heaps on main trails would be somewhat lower, and the percentage of dung heaps deposited in water and in feeding areas a bit higher than the above figures indicate. It can however be concluded that the rhinos have a preference for depositing their dung on main trails or close to a stream. They do not, however, or very rarely defecate in wallows and around saltlicks. Although the feeding areas represent a large part of the rhino range, relatively few dung heaps were found in such areas.

2.3.4. Dung piles

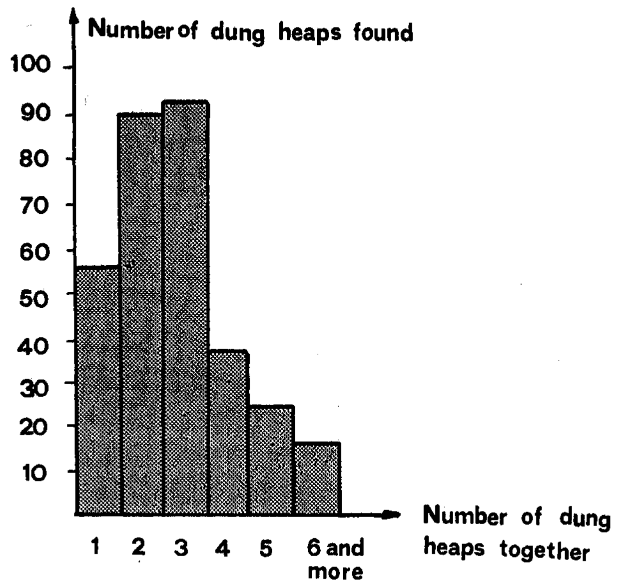
The recent rhino species often deposit dung at locations which had previously been used for defecation. Both African species use "lavatories" for defecation and usually beat their freshly dropped dung balls to pieces and rub their hindfeet in the dung (Owen-Smith 1974, Schenkel and Schenkel 1969a). The Indian rhino regularly drops its dung onto large piles.

The Javan rhino also displays the tendency to deposit dung at places which have been used previously. Sometimes new dung is found partly covering one or two old heaps, and up to 12 dung heaps of different age have been observed within an area of approximately 30 m^2 (Schenkel and Schenkel 1969b).

In my study of the Sumatran rhino I found "localized defecation areas" similar to those of the Javan rhino. The majority of dung heaps found in the study area are located on top or close to other dung heaps. Usually dung piles containing two or three dung heaps are found, the largest consisted of 10 heaps deposited close to each other (Fig.30).

Judging from the varying diameter of the dung balls of different dung heaps in one dung pile it can be concluded that the piles are not made by a single animal alone, but by different individuals.

Fig.30: Dung Piles (study area, 316 samples)



Number of dung heaps found:

- alone	55	(17.4%)
- in piles of two	90	(28.5%)
- in piles of three	93	(29.5%)
- in piles of four	36	(11.4%)
- in piles of five	25	(7.9%)
- in piles of six or more	17	(5.3%)

2.3.5. Behavioural aspects of defecation

When a rhino enters a stream or river it usually defecates with its forefeet in the water, depositing the dung on the bank of the river at the edge of the water. A few times tracks showed that the rhino had defecated while standing with all its feet in the water or immediately after leaving the river. Usually the rhino passes an old dung pile in its path and deposits its dung on top, close by, or a few meters from the old dung.
The dung is occasionally deposited 20 to 30 meters behind the dung pile.

Analyses of tracks reveal that in most cases (93% of the observed dung places) the rhino just stops in its path and drops its dung.

In some cases the traces gave evidence that defecation had been combined with certain components of ritualization (Tab.13,p.96).

In two cases the rhino stopped in its path, dropped its dung and then scraped the ground with both hindfeet. In scraping the ground, the rhino moved its hindlegs backwards and slightly outwards, producing a scraping mark that was slightly wider on one end than on the other. The scraping marks had a length of 40 to 50 cm. Part of the dung balls were damaged by the scraping and small dung particles, mud and leaves were cast more than a meter behind the dung heap.

On three occasions the rhino had stopped, scraped with both hindfeet, deposited its dung in the mould and scraped again with the hindfeet.

In several cases tracks showed that the rhino had not merely stopped on the path, but had positioned itself at a particular angle to the trail, with its rear close to a group of shrubs or a tree. Only then did it start to defecate and to scrape.

In 16 cases another complex behaviour pattern was observed. The rhino stopped in its path, turned toward the side of the trail and started to twist down a sapling with its horn (see part II, section 3.2.3. for further discussion of tree twisting) or beat a small shrub with its head. The rhino then turned around completely, positioned its rear close to the twisted sapling or beaten shrub and scraped the ground with both hindfeet. It defecated and in two cases sprayed an urine shower over the shrub. Finally it again scraped the ground with both hindfeet. Occasionally components of this pattern were left out or slightly modified (Tab.13, p.96).

The fact that trees are twisted down with the horns - which is probably only possible for the males whose horns are relatively long (part II, section 3.2.3.) - indicates that the behaviour pattern described above might only be displayed by the bulls.

Evidence of such associated behaviour was found in a few places only. Six of the 21 cases were found near Jambur Batu (Sungei Pinus) and were made by the same rhino. All dung heaps were situated along a main trail over a distance of about one kilometer. In eight cases they were located at main junctions of the path system (3 at Sungei Ikan Kaleng, 2 at Gunung Orang Pulang, 2 at Gunung Pinus and 1 at the Mamas poachers camp). Two cases were found in the surrounding of the saltlick at Sungei Pinus and five in various places along main trails.

2.3.6. Discussion

In the study area in the Gunung Leuser reserve the dung piles are obvious. But in the other rhino areas of Sumatra, where the population density is very low, I seldom found dung piles consisting of two or more dung heaps. Some authors questioned the existence of dung piles altogether (Strickland 1967, Talbot 1960). Others stated that accumulation of faeces can only very rarely be found (Hubback 1939, Thom 1935, Evans 1905). Only Metcalfe (1961) was of the opinion that such deposits were the rule. All authors agreed that the rhino prefered certain locations for defecation in captivity (Anderson 1961, Skafte 1961, Sonne-Hansen 1972, Lang pers.com.).

The existence of dung piles and the location of the dung heaps give some evidence that not only physiological, but also environmental stimuli influence defecation. Contact with water in streams and rivers seems to release defecation in a motivated rhino. Contact with already existing dung places seems to have a similar effect (olfactory stimulation?). On the other hand saltlicks and wallows seem to inhibit defecation.

The specific locations of dung heaps, the multiple use of defecation places and the occurrence of associated defecation behaviour indicate that the function of the defecation is not only a physiological one. This will be discussed in part II, section 3.2.5.

2.4. Urination

2.4.1. Urine and urination places

61 sites of urination were recorded. Most of these were found in feeding areas, some along the main trails.

Usually the fresh urine droplets have a yellow to amber colour. Old, dried droplets are dark brown. At 8 urination places (13%) I observed that the urine droplets contained a pure white slime. This slime was about one fifth of the volume of the drops and was heavier than the rest of the urine and had therefore become concentrated at the lower end of the droplets. After the urine droplets had dried out and the brownish urine was hardly visible, the dried slime could still be clearly detected on the leaves as white "crescent-moon-shaped" spots.

It is rather easy to locate fresh urination sites because of their typical and persistent smell which can be recognized even by humans for several days after urination has occured. At one urination site that I observed regularly, I could still smell the urine after three days of light rain.

In three cases (5%) a wet spot on the ground, which smelled of urine indicated that the rhino had released the urine in a splash. In two of these cases the urine formed a spot with a diameter of about 50 cm, in the third, the rhino had urinated while walking slowly and had left an urine trail about two meters long.

In all other urination sites I observed, the rhino squirted the urine backwards in a shower (58 cases, 95%), covering the vegetation with small urine droplets. At such urination sites the leaves of saplings and shrubs in an area 2 to 3 meters long and about 1.5 meters wide, are covered with small urine droplets which are found up to a height of 110 to 130 centimeters (Fig.31).

2.4.2. Behavioural aspects of urination

While releasing urine, the rhino merely stops in its path or walks slowly and lets out a continuous stream of urine downwards and backwards. Analyses of tracks and other rhino traces indicate that, when spraying the urine in a shower horizontally or even slightly upwards behind itself, the rhino shows a behaviour pattern similar to the ritualized defecation.

The first type of ritualized urination is characterized by the fact that the rhino stops in its path and, without aiming, squirts the urine in a shower backwards (Tab.14). This occurs most frequently when a rhino not following a trail penetrates dense vegetation (12 cases observed, 20%).

The second type of ritualized urination is linked with scraping of the hindfeet and other behavioural components (Tab.14). In 29 cases (48%) the rhino stopped in its path, turned around, adjusting its hindquarters close to a small tree (up to 15 cm diameter) or shrub and squirted urine over the tree and the surrounding vegetation. It then scraped with both hindfeet alternately, kicking loose pieces of soil for a distance of one to two meters backwards. Sometimes the rear of the rhino was so close to the small tree, that scraping marks could be found on both sides of the trunk.

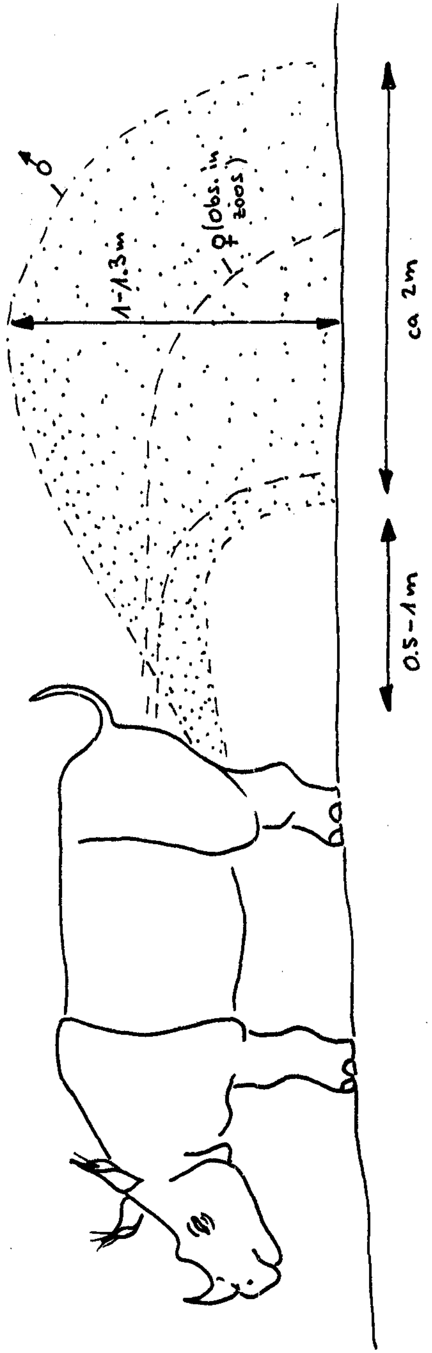


Fig.31: Urination in a Shower

Tab.14: Behaviour Components of Urination

USp	Urine splash, continuous stream of urine downwards
USh	Urine shower upwards/backwards
USh aimed	Urine shower, aimed at tree, sapling or shrub
ScF	Scraping with both forefeet alternately
ScH	Scraping with both hindfeet alternately
Stt	Stopping and turning to the side of trail
SM	Standing motionless or moving slowly
Tur	Turning around, rear against sapling/shrub
Tw	Twisting of sapling
Shb	Shrub beating
D	Defecating

Behaviour sequences deduced from traces:

SM - USp	non ritualized	(3 cases)
SM - USh	Type one, ritualized	(12 ")
SM - USh - ScH	Type two, ritualized	(3 ")
Stt - Tur - USh aimed - ScH	"	(29 ")
Stt - Tw - (ScF) - Tur - USh aimed - ScH	"	(7 ")
Stt - Shb - Tur - USh aimed - ScH	"	(5 ")
Stt - Shb - Tur - D/USh aimed - ScH	"	(2 ")

In 14 cases (23%) traces showed that the rhino stopped in its path, turned against the side of the trail and twisted down a sapling with its horn (part II, section 3.2.3.) or beat a shrub with its head. While performing this activity it sometimes scraped with its forefeet. The rhino then turned completely around, positioned its rear close to the twisted sapling, sprayed urine and finally scraped with both hindfeet. This behaviour sequence showed variations, some elements were sometimes dropped or changed (details in Tab.14).

Evidence of this second type of urination was found only in a few places, mostly those, where also traces of ritualized defecation were found. Comparison of such urination ceremonies with similar behaviour in other rhino species leads to the conclusion that this form of urination might be shown by bulls only.

Hubback (1939) suspected that only the bull urinates in a shower. The two captive female rhinos at the Kopenhagen and Basel Zoos were urinating in a splash as well as in a squirt (Anderson 1961, Schenkel and Lang 1969, Sonne-Hansen 1972). Atomization of urine seems to be less pronounced in cows.

Functional aspects of the ritualized urination will be discussed in part II, Section 3.2.5.

2.5. Comfort behaviour

2.5.1. Wallows, their features and origins

I examined and measured 94 wallows in the different rhino areas in Sumatra. Wallows are usually oval, about 2 meters wide and 2.5 meters long. Sometimes a log or a rock lies at the edge of a wallow influencing its shape (photos 7 and 8).

Freshly used wallows are filled with a broth of suspended clay, 20 to 50 cm deep. When a wallow is not used for several days, the clay settles down and the water on top of it becomes more or less clear. Sometimes the sheet of water may dry up, but after heavy rains the whole basin of the wallow may be filled with water. If the wallow is not used for several weeks, the clay layer is covered with dead leaves and the overlaying water is completely clear. A wallow that has not been used for several months becomes partly overgrown with herbs.

There is evidence that wallowing is usually combined with digging activity. In wallows situated on a slope, digging proceeds in direction towards the side of the mountain. Wallows which have been regularly used over a long period of time, display a vertical, sometimes overhanging clay wall, which slowly grows in height. This clay wall usually shows traces of rubbing by the rhino's flanks, sometimes scratches from its horns and, rarely, from its forefeet.

The origin of a wallow could be studied at a place where a rhino had started to dig a new one, but left it unfinished, probably because it was disturbed by my approach. Traces showed that the rhino had started to scratch and work the soil with its forefeet and its horn into a small natural depression. It had softened the scratched up clay by trampling an area of about 1.5 x 1 m.

2.5.2. Location and distribution of wallows

As to the topography of the location of the wallows shows that 38% are situated on mountain ridges, 22% on slopes, 34% in plains and 6% in valleys close to a river or stream. Considering the areas that are most often used by the rhinos I found that about one third of the wallows are located in feeding areas and about two thirds along main trails.

Along main trails the wallows are fairly evenly distributed, usually within a distance of less than a few kilometers from each other. The longest distance found between two wallows situated along a main trail was three kilometers (Silukluk ridge). Most of these wallows are situated singly, but in especially suitable places like broad saddles or plateaus two or three are

sometimes located close to each other. Where a main trail follows a water course, wallows are rare; here bathing probably replaces wallowing.

In feeding areas wallows are located both singly and close together. In one place at Sungei Ikan Kaleng there were 7 wallows within an area of about 10 m x 20 m. In the same area a total of 14 wallows were found within approx. 4 km^2 and in the Kompas feeding area 7 wallows were located in an area of app. 3 km^2.

The rhino chooses small natural depressions with soft and wet clay ground to establish a wallow. Such places lend themselves easily to digging and assure the collection of rain water to keep the wallow wet throughout the year. Suitable wallow places are abundant only in flat areas. On mountains, nevertheless, broad ridges, saddles and plateaus provide opportunities to build wallows.

In areas where topography and soil conditions make the land unsuitable for wallows, the few existing wallows are used for generations. In areas with favourable conditions, the rhinos frequently dig new wallows close to old ones instead of constantly using the latter. Near Sungei Ikan Kaleng I found an old, completely overgrown wallow which had been reopened and was being used again.

The density of the surrounding vegetation seems to have little influence on the selection of a wallow site. In feeding areas, the wallows are sometimes hidden by dense vegetation, while on a mountain ridge or a plateau in the damp moss forest, the wallows are usually located in comparatively wide open places with little undergrowth.

2.5.3. Wallowing

I have little or no information about how often and how long an individual rhino uses a wallow, or whether the frequency of wallowing depends on the climatic conditions or is correlated with other activities of the rhino.

Pawang Husin had observed a rhino in a wallow on two occasions. In one case the rhino remained in the wallow for three hours during the early afternoon, and in the other for two hours at night (photo 9).

There seems to be a tendency of the rhino to wallow more often in dry weather. Freshly used wallows in the study area were only recorded between March and August, the drier season in northern Sumatra. In August 1974, an exceptionally dry month, 9 of 14 inspected wallows had been freshly used. In October of the same year (beginning of the rainy season) only one and in December none of these wallows showed fresh signs of rhino activity. The collected data are, however, too rudimentary to allow any final conclusions.

The rhino may cover long distances without stopping to wallow. I followed the track of a rhino that had wandered from Sungei Pinus to Sungei Ikan Kaleng. The trail was situated on a mountain ridge and did not cross a stream or river. The rhino walked a distance of app. 7 kilometers, climbing and again descending close to 1000 m. It passed five well established wallows but did not use one of them.

2.5.4. Discussion

Hubback (1939) and Metcalfe (1961) stated that wallowing is an important part of the daily routine of the rhino and that rhinos wallow for several hours once or twice every day. My limited data indicate, that the rhino does not use the wallows this frequently throughout the entire year.

Wallowing may function as a means of producing a protective covering against ectoparasites, especially tabanids. The only rhino I encountered at close range was followed by horse flies (compare: Hubback 1939, Skafte 1961, Schenkel and Lang 1969).

The increased frequency of wallowing in dry weather suggests that a second function might be to moisten the rhino's skin. Furthermore, since the rhinos spend great deals of time in the wallows, one can assume that the animals rest in these places. Since in the mountainous Gunung Leuser area the temperature is lower than 25 degrees Celsius even on sunny days, it is unlikely that wallowing has a temperature regulating function.

2.5.5. Rubbing and scratching

When a rhino walks through vegetation after leaving a wallow, some of the clay from its body gets smeared onto leaves and twigs. Once dry, such smears of clay are not quickly washed away by rain, but remain visible for weeks. According to the height of the rhino mud smears are usually found at a level of 50 to 100 cm above the ground.

The rhino does not always just walk away after leaving the wallow. Traces revealed that it often remains in the immediate surroundings, rubbing its head and body on trees and shrubs and scraping its feet. Saplings are pushed over, shrubs broken or bent down and bark is scratched away from tree trunks. Because of this rubbing and scratching, much of the vegetation around the wallow is smeared with clay.

2.5.6. Bathing in rivers

The Javan rhino is often bathing in river basins (R.+ L.Schenkel 1969b, Hoogerwerf 1970). Evans (1905) and Thom (1935) made similar statements for the Sumatran rhino. I have found no direct corresponding evidence. However the "relative" sparsity of wallows along main trails following rivers, suggests that the Sumatran rhino might bathe occasionally.

2.6. Resting

As indicated in the previous section, the rhinos are probably resting while in the wallow. I found eight resting places on dry ground. These places were oval, and had a length of 150 to 170 cm and a width of 100 to 130 cm. All growth had been pressed to the ground. In some cases, shrubs and grass were bent down in a whirling pattern indicating that the rhino had turned around before or while laying down.

Three of these resting places were surrounded and roofed over by fairly dense vegetation. Two others were surrounded by a wall of dense undergrowth, but were not roofed in. Two more were situated close to a rock, with openings on one side and to the sky. The last resting place was situated just above a landslide area and was completely exposed.

Seven of the resting places were located in feeding areas and one near a main trail on a ridge.

The small number of resting places found indicates that the rhinos usually rested in places where they left no traces. Such resting places could be wallows, riverbanks or main trails.

2.7. Locomotion and trail system

2.7.1. Locomotion

The Sumatran rhino is equipped with the same three patterns of locomotion as the other rhino species. When it walks, its legs follow this sequence of movements: left hindfoot - left forefoot - right hindfoot - right forefoot. The smaller hindfoot steps into the larger forefoot print but touches the ground a few centimeters to the outside and to the rear of that print. The traces of trotting were found once, of gallopping twice. In all three cases the respective rhino had probably been alarmed by our approach and had taken flight.

When walking, rhinos seem to avoid very dense and thorny vegetation, but in flight they break through such obstacles with ease.

Rhinos display a remarkable ability to master steep, rough country. In the Gunung Leuser reserve, I found tracks of rhinos in areas that were even for humans difficult to cross. At Sungei Pinus I observed that the rhinos had regularly climbed up a vertical, slightly overhanging step 140 cm high. Tracks showed, that the rhinos had to stand on their hindfeet and pull their bodies up with their forefeet.

Some main trails cross rivers where rhinos have to swim. One of them crosses the lower Mamas river at a point where it is deeper than 1.5 meters and where the current is strong. Old trails indicate, that the rhinos used to cross the Alas river near Jambur Serakut, where the river is several meters deep and about 50 meters wide.

2.7.2. Trails

A well maintained trail system covers the rhino area in the Gunung Leuser reserve (Fig.32). Within this system, trails of different appearance and apparently different functions can be distinguished. Hazewinkel (1933) suggested two trail types for the Sumatran rhino, namely main trails and feeding trails. Schenkel and Schenkel (1969a) distinguished three types for the Black rhino, namely main trails, feeding trails and moving-feeding trails. In addition Schenkel and Schenkel (1969b) describe a type of trail for the Javan rhino, which is caused by a canalizing effect of the topography, is short and at both its ends fans out into smaller trails.

The trail system in the Leuser reserve is very similar to those described by the above authors.

"Main trails" connect two or more important areas, places or points of the rhino range. They are formed and used by many generations of rhinos and by any of the individuals which make use of those areas, places and spots (see part II, section 4.4.). The main trails are fitted to the topographical conditions in a way that the animals can shift between feeding areas, wallows, saltlicks a.s.o. with a minimum of effort.

Among the obstacles which affect the course of the main trails are steep slopes, rocky or swampy ground and, to some extent, vegetation. The easiest way to cross a mountain is obviously to follow the ridges whose angle of ascent is not as steep as that of the mountain slope. Half of the total length of main trails found in the study area are situated on ridges (Tab.15), 25% in wide valleys following a river. Again the rhinos choose the easiest route, cutting through large river bends and crossing the river, whenever a bank is too steep. When the rhinos have to cross a mountain slope and the angle of ascent is steep, the main trail leads up the slope in serpentine curves. Some of these trails have been used so long that they now form a ledge on the slopes.

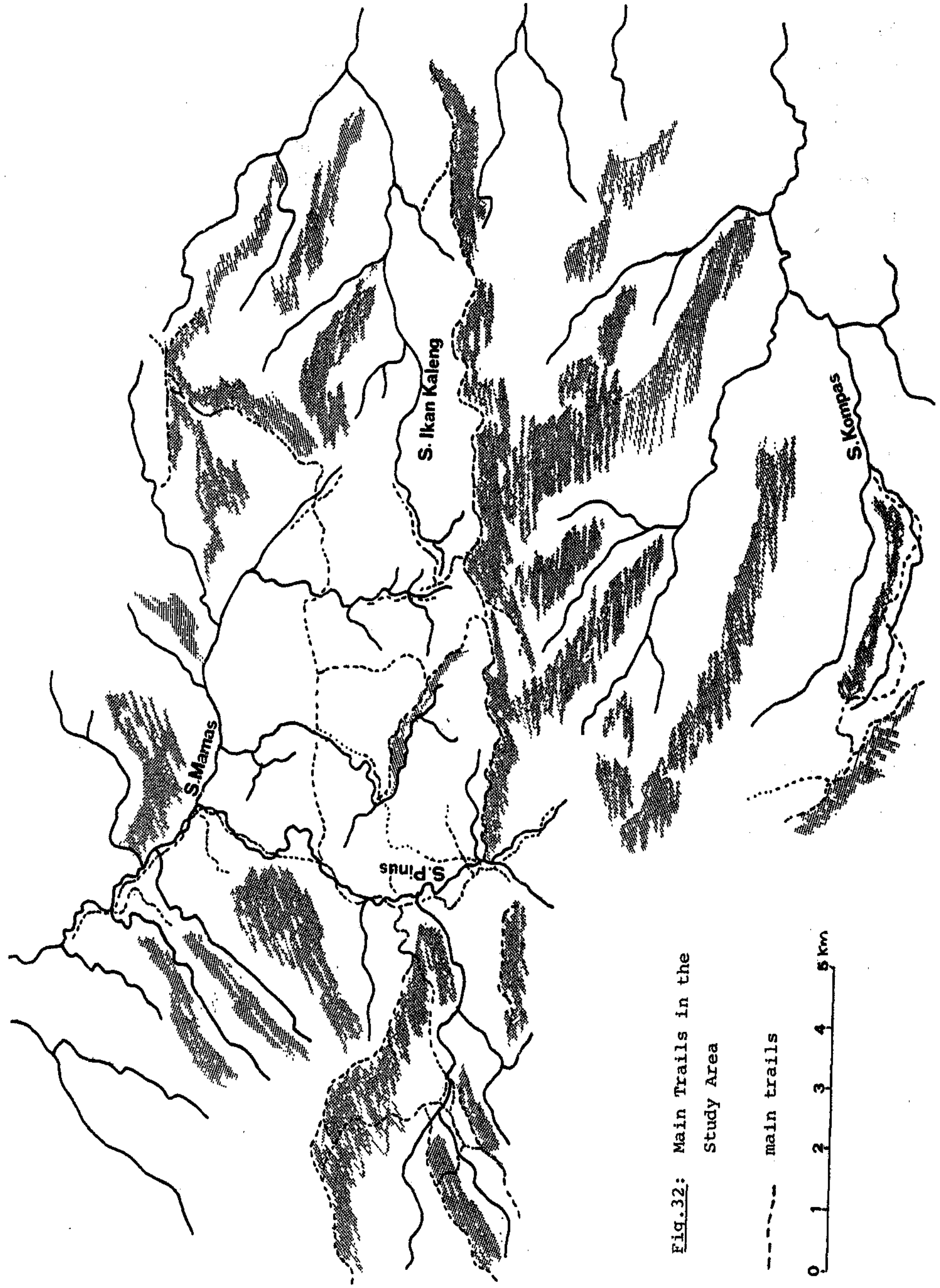


Fig.32: Main Trails in the Study Area

Main trails which are regularly used may extend over several kilometers. They are free from vegetation and about 50 cm wide. Within areas of dense vegetation, they may form tunnels that are 100 to 120 cm high and about 50 to 60 cm wide. Where obstacles or topographical conditions oblige the rhinos to follow a single course, the trails cut deep into the ground. Near intensively used places like saltlicks, the trails may form narrow trenches, more than one meter deep (part II, section 2.2.2.). Climbing up or down steep trails, the rhinos use the same places for foot holds. This results in a staircase-like main trail in steep areas. If a tree falls over an already existing trail, a bypass trail is soon established (photos 10 and 11).

On broad ridges, in flat areas and along rivers, where there are no topographical obstacles to have a canalizing effect, the rhinos occasionally leave the main trail and follow smaller paths which accompany the main trail.

Evidence of feeding is abundant along these moving-feeding trails. In the damp moss forest they may isolate small "islands" of dense vegetation a few meters long.

In feeding areas the main trails may split up into smaller feeding trails and these may vanish completely. These moving-feeding and feeding trails are, in contrast to the main trails, covered with vegetation.

Sometimes two adjacent feeding areas seperated by obstacles with a gap are connected with a short trail through the gap as described by R.+ L. Schenkel for the Javan rhino.

Sambar (Cervus unicolor), barking deer (Muntiacus muntjak), wild boar (Sus scrofa), tiger (Panthera tigris) and wild dog (Cuon alpinus) make use of the rhino's main trail system without having a major impact on it. Those sections used by the elephants (Elephas maximus), however, are wider and better cleared of obstacles. Even in dense undergrowth, they never form tunnels.

Tab.15: Net of Main Trails in Study Area (Part considered: approx. 70 km^2)

Situation of main trails	Approximate length	Percentage of Total
on mountain ridges	29 km	50%
in valleys near rivers	14 km	25%
in flat areas, not alongside a river	9 km	16%
crossing slopes	5 km	9%
Total	57 km	100%

3. Social Behaviour

3.1. Direct contact between conspecifics

3.1.1. Methods

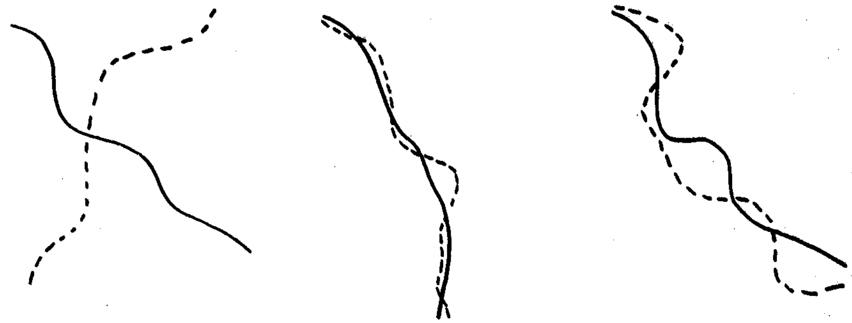
With the exception of the mother/child unit, the Sumatran rhinos live solitarily. Direct encounters are rare.

When two rhinos have walked on the same trail, it is practically impossible to ascertain from their tracks whether they moved independently or whether one individual followed the scent traces of the other or whether both individuals moved together. Off main trails, the rhinos' movements are not canalized. Spoors of two animals that walked independently follow different routes. If one individual followed the scent traces of another, both spoors have the same route and are close together. If two rhinos moved in direct contact, the two spoors follow more or less the same route, but are not closely aligned with each other (Fig.33).

I found ten examples of the tracks of two adult animals in the same place and of about the same age. In only two of these cases could I ascertain that two adult rhinos had been moving together in direct contact (Tempat Medan and Sungei Ikan Kaleng).

Fig.33: Spoors of two Rhinos off a Main Trail

a) animals moving independently   b) one individual on the scent traces of another   c) in direct contact



3.1.2. Observations

In May 1975 I followed the fresh tracks of two adult rhinos who moved in direct contact for about 4 km near Tempat Medan.

The tracks of the two animals were located on a main trail entering an area of natural secondary growth at Tempat Medan. Where the trail formed a tunnel in the dense secondary growth, one rhino had walked behind the other. At one point the tunnel opened up on a round spot about two meters in diameter, where the rhinos must have turned around several times. The vegetation was trampled down and bent in one direction.

After this trampled spot, the tracks were lost in the dense net of main trail tunnels, but I was able to pick them up again further upstream in the primary forest. The tracks were still close together, offside a main trail. Near the Medan river, the rhinos had again trampled down a circular area somewhat more than two meters in diameter. Both animals had defecated while crossing the river and then proceeded to the other side where they turned and trampled down another spot. They then proceeded

about 50 meters up a main trail and urinated. They stood at an angle of about 90 degrees with their front feet on the main trail, and the rear ends close together. One or both animals were scratching vehemently with their hindfeet and were urinating in a shower over a single shrub. After urinating they proceeded further downstream more or less following a main trail. Footprints were deeply cut into the ground and mud had been cast around which indicates that they were walking swiftly. Two more circular trampled places were found close to each other. One or both of the rhinos had again turned on the spot, trampling and breaking all vegetation in one direction. About 200 meters from the last urination site, one or both rhinos urinated again. Traces showed two urination places where one or both rhinos had scraped with their hind-
feet, throwing mud backwards into the vegetation and spraying urine over the same group of shrubs. They returned to the river by a path off the main trail, producing another two trampled down spots on the way. From the river, they started to climb a steep slope, criss-crossing but not following a trail. No more signs of excited activity were recorded. The two spoors were no longer close together. Evidently the two animals climbed the steep slope loosely associated, but never seperating by more than 30 to 50 meters. Several feeding traces showed, that both of them had been feeding. On a ledge, near the top of the ridge, they produced another circular trampled down place. All vegetation was bent flat to the ground and a nearby tree showed scratching marks of the rhino's body. After climbing from 1400 meter a.s.l. to over 2100 m a.s.l., the rhinos reached the top of the ridge and arrived at a group of four wallows. They passed the wallows and joined the main trail of the ridge, where, after some distance I again lost their tracks.

In March 1974 I observed the tracks of two adult rhinos who had been walking together in the Sungei Ikan Kaleng/Sungei Tampu area. The tracks were more than a few hours old and tracking

was difficult. The recorded behaviour was more or less the same as that described above. One large resting place, where two rhinos had evidently rested together was found as well as four trampled down circular places. These were located in pairs at a distance of less than 10 meters from each other and showed signs of furious activity. Not only had the vegetation been trampled completely to the ground in a circular direction, but nearby saplings had been broken off by the rhino's head or body. Comparison with other rhino species indicates that the above mentioned traces were produced by temporary associated cow/bull pairs. Some of the traces indicate courting behaviour.
I was able to follow the tracks of five cows who were in pair bond with their calves over considerable distances. On four occasions the calves must have been rather young, since their hindfeet tracks measured little more than 17 cm. In one case the calf's hindfoot measured 19 cm. Cow/calf pairs with older calves, whose hindfoot measurements are 19 to 20 cm are difficult to distinguish from adult/adult pairs.

Analyses of tracks showed that the calf always walked very close to the cow. No interaction behaviour could be determined by track analyses.

3.2. Indirect contact

3.2.1. Introduction

Intraspecific communication is a prerequisite for the continuity of any population. But among members of a Sumatran rhino population direct encounters and accordingly direct communication are rare. Therefore the rhinos depend on an indirect system of communication where information is transmitted by markings (part II, section 3.2.5.).

Such markings may be created by ritualized maintenance behaviour like ritualized defecation (part II, section 2.3.) and ritualized urination (part II, section 2.4.). Other marking patterns are presented below.

3.2.2. Tree twisting

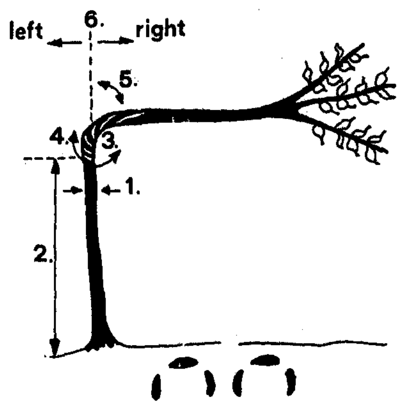
3.2.2.1. Methods

Frequently I found saplings twisted down in a characteristic way (Photo 12, 13, 14, 15). On 176 of such saplings the following data were recorded: 1. Place, altitude and date, 2. Diameter and approx. height of sapling, 3. How many centimeters above the ground the twisted part started and how long this part was, 4. In which direction the stem was twisted (torsion) and for how many degrees, 5. To which side the sapling was bent in relation to the rhino's position, 6. Whether bark was scraped off and where, 7. What kind of traces were associated with the twisted sapling, 8. The location of the twisted sapling in relation to the trail system, or a wallow, a saltlick and to the topography, 9. The distance to the nearest other twisted sapling (Fig.34). It was not always possible to record all these data from each sapling because of lack of evidence. The total number of samples in Tab.16 to Tab.22 differs accordingly. On many occasions examination of all the traces gave some ideas on the rhino's behaviour.

3.2.2.2. General appearance of twisted saplings

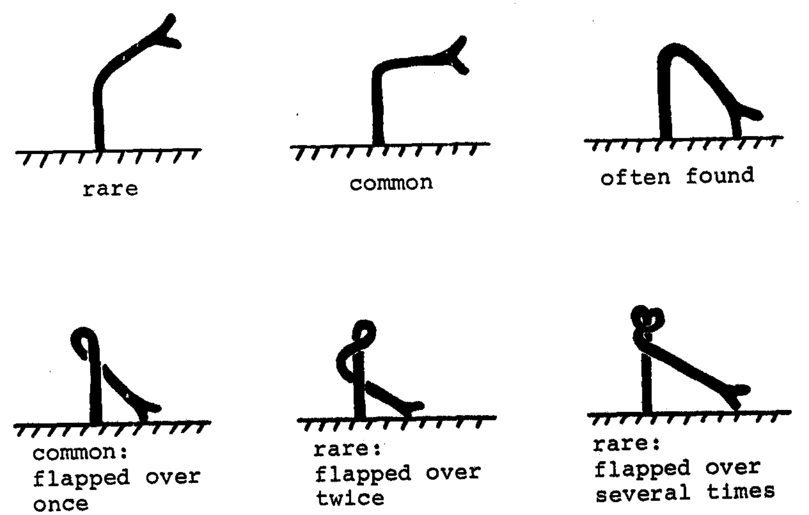
Saplings about 2 cm in diameter and 2 to 4 meters high were twisted by the rhino at a point starting about 80 cm above the ground. On the twisted section of the stem, which was about 20 to 30 cm long, the bark was pealed off or damaged. In most cases the sapling was twisted more than 90 degrees in a clockwise direction and bent over to the side where the rhino was standing (usually to the right). As a result of the torsion, the stem sometimes flapped over at the twisted part. Scratching marks produced by the horns started about 20 cm below the twisted part and reached to the treetop, where branches were broken upwards. (Detailed data in Fig.34,35 and Tab.16-22)

Fig.34: Twisted Sapling, Recorded Data



1. diameter of sapling
2. height at which twisted part begins
3. twisted part
4. direction of torsion, angle of torsion
5. angle to which the sapling was bent
6. direction of bending, seen from the side on which the rhino stood

Fig.35: Typical Forms of Twisted Saplings (photos 12 - 15)



Tab.16: Diameter of Twisted Saplings (132 samples)

Diameter in cm	1	1.5	2	2.5	3	3.5	4
Number of samples	5	32	51	20	8	3	3
% of total	4%	24%	47%	15%	6%	2%	2%

Tab.17: Direction of Torsion (110 samples)

Direction	clockwise	counter-clockwise
Number of samples	84	26
% of total	76%	24%

Tab.18: Angle of Torsion (85 samples)

Angle	up to 90° 1/4 times	90°-180° 1/4-1/2x	180°-360° 1/2-1x	1-2x	-3x	-4x	-5x
Number of samples	3	42	23	10	5	1	1
% of total	3%	50%	27%	12%	6%	1%	1%

Tab.19: Direction of Bending (101 samples)

Direction	to the right	to the left
Number of samples	66	35
% of total	65%	35%

Tab.20: Angle of Bending (105 samples)

Angle	less than 90°	around 90°	90° - 180°	more than 180°
Number of samples	3	47	34	21
% of total	3%	45%	32%	20%

Tab.21: Relation of Direction of Torsion to Direction of Bending

Direction of bending	right		left	
Direction of torsion	clockwise	counter clockwise	clockwise	counter clockwise
Number of samples	42	4	8	9

Tab.22: Scratching Marks from Horns (49, resp. 51 samples)

	below twisted part				above twisted part			
	only front	only behind	front+ behind	others	only front	only behind	front+ behind	others
Number of samples	20	6	19	4	16	6	17	12
% of total	41%	12%	39%	8%	31%	12%	33%	24%

If two saplings were standing close together, they sometimes were twisted together like a rope.

If the tree was only slightly twisted and bent, the sapling stayed alive, but the treetops of thoroughly twisted saplings dried out and broke off. I could observe that these saplings sprouted again below the broken part.

3.2.2.3. Species of twisted saplings

It is remarkable that without exception the twisted saplings examined never showed signs of having been used as food, although many of them were among the species known to be eaten by the rhino.

17 samples of twisted saplings were identified. 10 belonged to species which are known to be rhino food plants (Tab.23).

Tab.23: Twisted Saplings and Food Plants
(compare list of food plants, p.86/87)

twisted sapling species	family	also recorded as food plants
1. Ardisia sp	Myrsinaceae	+
2. Gordonia excelsa	Theaceae	+
3. Cryptocarya mentok	Lauraceae	-
4. Neolitsea sp	Lauraceae	-
5. Erycibe forbesii	Convolvulaceae	-
6. Eugenia sp	Myrtaceae	+
7. Eugenia cymosa	Myrtaceae	+
8. Kayea surtmannii	Guttiferae	+
9. Ganua sp	Sapotaceae	+
10. Melisoma lepidota	Sabiaceae	+
11. Medinilla sp	Melastomataceae	+
12. Pongamia pinuata	Leguminosae	-
13. Pithecellobium sp	Leguminosae	-
14. Quercus lineata	Fagaceae	-
15. Rhystoechia acuminata	Sapindaceae	-
16. Stemonurus scorpoides	Seacinaceae	+
17. Symplocos sp	Symplocaceae	+

3.2.2.4. Tree twisting behaviour

Analyses of traces indicate that the rhino uses its horns and head, but not its teeth, to twist the sapling. No detailed description of the rhino's behaviour can be made, but in the following, nevertheless, I give one possibility of how the saplings might have been twisted (Fig.36):

1. The rhino positions itself with its head to one side of the sapling.
2. The rhino lifts its head and turns it towards the sapling, grabbing the stem with its anterior horn.
3. The rhino continues to turn its head until the top of the sapling points towards the rear of the animal.
4. The rhino continues to turn its head and simultaneously lowers it. With the front side of its anterior horn and the section above its muzzle, the rhino presses the sapling down and bends it until the tree top touches the ground beside the animal.
5. The rhino pushes its head forward and turns it back into normal position. The top of the tree is forced between the rhino's head and the stem of the tree to the other side of the animal.
6. The sequence is repeated from 2.
7. Finally the rhino, with the sapling between the horns, turns its head away from the stem or moves away, releasing the twisted sapling.

The circular movement of the treetop (arrows in Fig.36) results in a torsion of the stem on the level of the rhino's horn. The sapling is bent down at the twisted part, where the stem is split lengthwise. If the circular movement is repeated, the stem may snap into a loop, similar to a string which has been twisted many times.

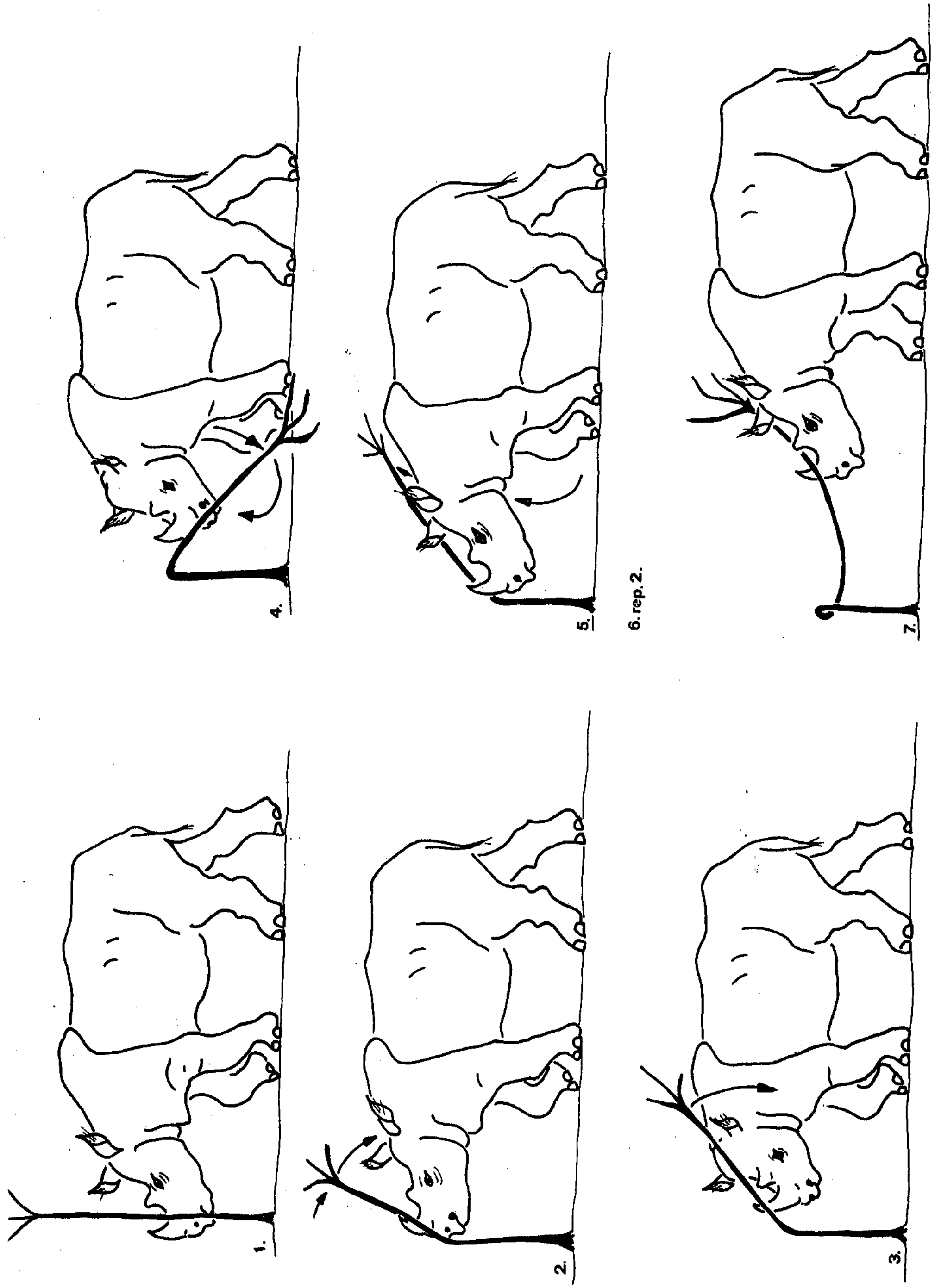


Fig.36: Tree-Twisting Behaviour

3.2.2.5. Associated behaviour

In most cases the rhino was only twisting down the sapling and left no evidence of additional behaviour. On some occasions however, traces showed that in the context of twisting the rhino had also scraped the ground with its forefeet. In doing so the rhino had the tree left or right beside its head or was facing the sapling. After twisting the tree the rhino frequently turned around, positioned its rear close to the sapling and scraped with both hindfeet. In this position it sometimes dropped faeces or sprayed urine (Tab.24 and 28). Mud, faeces and urine were found on the top of the bent-down tree, a clear indication that hindfeet scraping, defecating and urinating were carried out after the tree had been twisted. As traces of urine vanish quickly, it is likely that the rhino had urinated much more frequently over twisted trees than I was able to ascertain.

3.2.2.6. Location and accumulation of twisted saplings

The twisted saplings were not evenly distributed over the rhino's range, but were found concentrated in certain areas.

Most of the twisted saplings were situated along main trails. A number of them were found at the junction of main trail systems (Tab.25 and 26), some in the neighbourhood of a saltlick and some near a wallow. 60% of the saplings were concentrated in a few restricted areas, along main trails. Near Jambur Batu (Sungei Pinus) I found 31 twisted saplings on a main trail within a distance of less than two kilometers, near Mamas Poachers Camp 21 saplings within a distance of 2 - 3 hundred meters.

About 40% of the twisted saplings were located within five meters of one or more others. Usually these saplings had been twisted at different times (Tab.27).

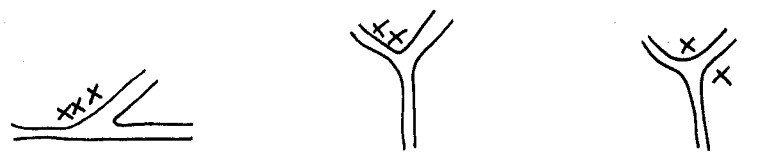
Some were found outside the study area in Kerinci/Lempur (6 samples), Torgamba (2 samples) and Langkat/Upper Bohorok (1 sample). Schenkel noticed some in Sungei Dusun, West Malaysia (Schenkel, pers.com.).

Tab.24: Evidence of Rhino Behaviour near Twisted Saplings (172 samples)

Associated Behaviour	Number of Samples	% of Total
None recorded	116	68 %
Scraping marks only - forefeet - hindfeet	11 24) 35	20 %
Faeces Faeces and scraping	6 8) 14	8 %
Urine Urine and scraping	0 7) 7	4 %

Tab.25: Location of Twisted Saplings at Main Trail Junctions (selected examples)

Gunung Orang Pulang   Sungei Pinus   Sungei Ikan Kaleng



x = twisted sapling

Tab.26: Location of Twisted Saplings (176 samples)

	Number of Samples	% of Total
1. At junctions of the main trail system	27	15.3 %
2. On main trails, entering a saltlick	12	6.8 %
3. On main trails, entering a wallow	10	5.7 %
4. On main trails, away from junctions, saltlicks and wallows	104	59.1 %
5. At other places	23	13.1 %

Tab.27: Distance of Twisted Saplings to one another (176 samples, distances measured along main trails)

Distance to next twisted sapling	0 - 5 m	5 - 100 m	more than 100 m
Number of samples	69	24	83
% of total	39.2 %	13.6 %	47.2 %

3.2.2.7. Discussion

The available literature cites little evidence that the Sumatran rhino uses its horn to twist down saplings. Metcalfe (1961) mentions it as a local belief. But based on the fact that the rhino's horns have no connection to the skull bones, he states that it is impossible for the rhino to use its horn to twist a sapling.

Kurt (1970) states that according to information supplied by local hunters, the rhinos use their horns to break down small trees, the trunk of which may be as thick as an arm. This information is probably based on observation of twisted saplings. Another local belief provided to Kurt, claims that the rhinos sharpen their horns on special trees.

Hubback (1939) is the only author to describe a twisted sapling: "A favorite trick of the rhinoceros when feeding is to get a sapling behind his front horn and twist it round and round, until it is thoroughly decorticated and covered with mud from the head." This is obviously the tree twisting behaviour described in this section. Contrary to Hubback I have never found this behaviour in the context of feeding. Hubback states further that tree twisting is performed by males and females alike. But this, in my opinion, is doubtful.

Although tree twisting is not known from other rhino species, it is similar to the "complex bull ceremony" of the Black Rhino (Schenkel and Schenkel 1969a) and the territorial behaviour of the White Rhino (Owen-Smith 1974): Tree twisting and behaviour associated with it contain elements of excitement and agression. The activity is not addressed directly to a conspecific but a sapling seems to serve as a substitute.

It appears justified to assume that twisting, together with associated behaviour components are displayed by dominant bulls and produce traces which have a communication function, i.e. such behaviour can be characterized as "marking behaviour" (see part II, section 3.2.5.).

3.2.3. Shrub beating and tree scratching

Shrub beating and tree scratching are probably only variations of tree twisting behaviour. In the case of shrub beating the rhino beats bushes and shrubs with its anterior horn and head. Such activity can - like twisting - also be combined with scraping, defecation and urination (Tab.28). Traces of shrub beating were found on 17 occasions.

In the case of tree scratching, the bark of trees with a diameter of 5 to 12 cm was scratched off down to the wood for about half a meter. The scratched section usually started about half a meter above the ground and reached half way around the tree. Footprints showed that the rhinos had stood in front of the trees. Traces on the tree indicated that the scratching was not made by the rhino's body nor its teeth but by its horn and keratinized snout. Twice I observed that a rhino had scraped with its forefeet on the ground while scratching a tree with the horn. Of the 18 scratched trees I found, 7 were located at main trail junctions, within a few meters of each other (Kerinci).

The Black, the White and the Javan Rhino display shrub beating behaviour (Schenkel and Schenkel 1969a+b, Owen Smith 1974). During the "complex bull ceremony", the Black Rhino bull rubs the region around its nose and mouth on a shrub, then it beats the shrub sideways with its head and anterior horn (Schenkel and Schenkel 1969a).
The White Rhino bull demonstrates a similar behaviour when marking its territory (Owen-Smith 1974).

Another, probably related kind of tree rubbing was observed by Schenkel and Schenkel (1969a) in the Black rhino. The rhinos rubbed the sides of their head, their snout and the base of the anterior horn on the trunks or stumps of trees. In this case, however, no signs of aggressive excitement were observed.

Tab.28: The Marking System: Connexion of Components

No. of samples	Prob. produced by male (m)/ female (f)	Defec.	Urinat.	Tree twist.	Shrub beat.	Tree scratch.	Scrap.
295	m + f	+					
5	?	+					+
8	m	+		+			+
6	m	+		+			?
2	?	+	+		+		+
15	m + f		+				
32	?		+				+
116	m		?	+			?
7	m		+	+			+
35	m		?	+			+
8	?		?		+		
5	?		+		+		+
4	?		?		+		+
15	?		?			+	
3	?		?			+	+
10	?						+

(+)— occurrence confirmed

?---- occurrence suspected but not confirmed

3.2.4. Scraping with fore- and hindfeet

Marks produced by scraping are easily identified. Usually the rhino scrapes only once with either each hind- or each forefoot. Both scrapes together cover a surface about 40-60 cm wide and 60-80 cm long. On rare occasions the traces revealed that the scraping movements of the legs involved had been repeated.
The direction of scraping can be determined because anteriorly the nails cut sharply into the ground while the rear end of the scrapes are blurred. Mud is sometimes thrown as far as one meter behind the mark.

Judging from the position of the animal in relation to the surrounding vegetation and from the size of the feet involved in scraping, I could usually determine whether the scrapes had been made by the rhino's fore- or hindfeet.

Whenever scraping serves a digging function, e.g. at a saltlick or a wallow, the rhino uses its forefeet. In contrast, scraping as a component of marking behaviour is usually performed with the hindfeet. Of 107 traces found, 11 were made with the forefeet (in combination with tree twisting and tree scratching), 96 with the hindfeet.

In other rhino species scraping occurs in hostile encounters of bulls as well as in the context of ritualized behaviour of bulls on their own. As Schenkel and Schenkel (1969a) have shown for the Black rhino it is self assertion behaviour and an expression of aggressive excitement.

3.2.5. The marking system

By ritualized urination and defecation, tree twisting, shrub beating, tree scratching and scraping, the rhinos produce very differentiated traces. Comparison with other perissodactyla leads to the conclusion that these ritualized behaviour patterns have been developed to produce "marks", i.e. emittors of stimuli deposited in the environment which are means of indirect communication.

The motivational aspect of marking behaviour is difficult to determine on the basis of traces only. However, in other rhino species very similar and obviously homologous behaviour patterns occur in actual encounters as well as when a bull is on his own. It seems justified to determine the motivation as self assertive and aggressive.

Undoubtedly the effort invested in these activities must serve a function. Again comparison with related species leads to the conclusion that these ritualized activities have been developed to produce "marks" acting on conspecifics visiting the same location and on the producer himself. The marks accordingly are organized means of indirect communication and, for the producer, of orientation.

It seems that in rhinos information is transmitted mainly by scent; urine, dung, skin excretions have a strong smell, and rhinos undoubtedly are able to recognize individual characteristics and/or pheromones typical for sex and status of the producer.

For the human observer it is difficult to state by which stimuli a complex mark acts upon a rhino. We ignore stimuli which the rhinos can perceive, e.g. pheromones. Others remain perceptible for us only for a few days, e.g. smell and optical appearance of urine droplets. On the other hand scrapes remain visible to us for several weeks and twisted saplings for many months.

It cannot be excluded that also visual properties of marks play a role in the rhino. McCain and Stepter (1968) and Fasnacht (1974) have produced experimental evidence that rhinos have remarkable capabilities of optical differentiation. It might be possible that optical stimuli catch the attention of the rhino whereupon olfactorial properties will be examined.

Different kinds of marks may reveal different categories of producers. Certain marks are only made by males with full social status, so-called dominant bulls. They might intimidate

inferior bulls or those unfamiliar with the location and attract females in oestrous. The traces left by a cow on heat may stimulate bulls and enable them to follow her.

Marks are also stimuli acting upon their producer. To the surrounding they attach familiar olfactorial quality. The marking of routes facilitates orientation in the home range (Schenkel and Schenkel 1969, Leuthold 1977). Goddard (1967) showed that the Black rhino has a tendency to follow the traces of its own dung scent.

The fact that the Sumatran rhino does not visit large parts of its home range for periods of months, suggests that for orientation it cannot depend on scent marks only. Most probably also features of topography and vegetation contribute to the rhino's orientation as well as main trails, wallows and saltlicks.

However, the marking system is an important component of the rhino's communication and orientation system and therefore of paramount importance to the continuity of a Sumatran rhino population. If poaching reduces population density below a certain limit, or if human disturbance drives the rhinos from their traditional range, maintenance of the marking system will become insufficient or even be given up. On such a situation the survival of the local population is severely threatened.

4. Time and Space in a Rhino Population

4.1. Problems and methods

This section is concerned with the problems of daily activity rhythms, home range, movements and male territoriality.

Without direct and continous observation of individual rhinos, and accordingly the possibility to trace individually known animals, the problems mentioned cannot be studied adequately. Olivier (1977, in press) has proven in his study on elephants that radio tracking with observation from the air is possible in a tropical rain forest. The use of such methods was not within the scope of my project.

I was able to identify all kinds of traces in tracking fresh rhino spoors. However, everyone leads to smaller or larger areas where the soil does not show footprints. If this is the case on a main trail which the rhino's track so far had followed, the chances are good to detect the prints on the trail further on again. On the other hand if a track is lost in a area away from any trodden trail, it is often impossible to find its continuation again.

If a track was continuous it was possible to deduce from the traces left the sequence of the animal's activities; if on the other hand the spoor was interrupted, footprint measures together with similar age of the prints provided evidence that the same individual was the producer of the traces.

Periodical surveys of the study area with checking and measuring all fresh rhino tracks provided only fragmentary information on home range and shifting.

Encounters in which the rhino was heard or even seen provide some information on the activity in the time preceeding the encounter. Information of this kind I also obtained from local hunters. It will be referred to as "local information".

4.2. Daily activity

4.2.1. Results

Little evidence concerning the daily activity of the rhino could be collected.

I once saw a rhino in full daylight at five o'clock in the afternoon. Its tracks indicated that it had been feeding. On another occasion I was following a fresh track at about noontime along with Pawang Husin. Before we could see the animal, we heard it breaking through the undergrowth and running away. According to its tracks it had not been feeding but had been travelling on a main trail. A heavy rain which had fallen in the morning made it possible for me to fairly accurately judge the age of a rhino track I found at Sungei Pinus. This animal had been travelling between 10 a.m. and 2 p.m. It had crossed a wallow without wallowing and had walked downstremas without leaving any signs of feeding.

Pawang Husin made direct observations of rhinos twice in the Kompas area. On one occasion he met a travelling animal at about 1 p.m. On his approach the rhino fled. On the other occasion he found a rhino wallowing at about 3 p.m. The rhino was not disturbed and stayed in the wallow for about two hours, despite the fact, that Husin and two of his helpers were building a spear-fall trap close to the wallow (local information).

In 1971 rhinos were seen on two occasions on the Kotacane-Blangkedjeren road in full daylight (information from H.Rijksen).

Night observations are extremely rare.

Once as I was sitting in a treehide at Sungei Pinus I heard a rhino visiting a nearby saltlick at about 1 a.m. The following morning the tracks showed that the animal had come down a mountain slope, had entered the saltlick, eaten some soil and continued its way downstream. For as far as the tracks could be followed, I found no evidence of feeding. On another occasion a rhino passed our camp between 10 p.m. and 5 a.m. This animal crossed a ridge from one valley into another. I again followed the track as far as I could (about 3 km from Sungei Ikan Kaleng to Sungei Tampu) and again found no indication that the animal had been feeding, but it had urinated frequently. While he was sitting in a treehide during a rhino hunt in the Bengkung area, Pawang Husin heard two rhinos using a nearby wallow at about 10 p.m. (local information).

4.2.2. Discussion

Many ungulates and especially rhinos show alternating periods of activity and resting during day and night. It seems that in hot climates, the hours of intense heat are passed in resting (Schenkel and Schenkel 1969a+b). Concentration of activities at night may also be a consequence of the frequent disturbance by man.

The data shown above indicate that all activities can take place day and night. They however are insufficient to make any definitive statements concerning the daily activity programme of the Sumatran rhino.

4.3. Home range

4.3.1. Terminology

I have used the term "home range" according to Jewell's definition (1966): "The home range is the area over which an animal normally travels in pursuit of its routine activities." An animal moves over considerable distances, using some areas intensively and making little use of others.

"Daily range" is used for the area through which an animal has travelled during one day.

4.3.2. Size of home range

To obtain reliable data on the size of a home range, long-term observations of known individuals must be carried out. Such observations were not possible in this study.

Following the fresh tracks of individual animals would have provided comparatively accurate data on that animal's daily range, but it was rarely possible to follow a single track over long distances.

There is some evidence that the daily range of the rhino varies according to its activities. In feeding areas rhinos move only short distances each day (Sungei Ikan Kaleng: 1.5 km, Sungei Kompas: 2.5 km). On main trails they can cover considerable distances in one day (Silukluk ridge: 6 km, resp. 5 km, Sungei Medan: more than 7 km). (Fig.37)

If it were possible to reliably identify individuals by their footprints and to continuously survey a large enough area, it would be possible to determine the home ranges of the individuals concerned.

In Fig.38 location records of two print-identified rhinos (A,B) are presented. By connecting the peripheral location records, an area of 50 km^2 is obtained in the case of A and 22 km^2 in the case of B. Evidently the entire home range of A and B can only be larger than 50 km^2 and 22 km^2 respectively. However I ignore how much. I evidently cannot make any statements concerning differences in the size of the home range of individuals of different sex or age.

4.3.3. Overlapping of home ranges

Undoubtedly the home ranges of A and B (Fig.38) are overlapping. There is, however, some evidence indicating that the home ranges of the individuals of the entire population are not all identical. Fig.39 shows location reports of six animals that were "print-identified" (A to F). All of them use the saltlick area at Sungei Pinus. Yet, only tracks of A and B were found near the saltlick at the soutnern tributary of Sungei Kompas (Fig.39), and those of A on the upper Sungei Medan. It seems justified to assume that the home ranges of C to F extended more to the north and east. This assumption would imply: firstly that certain home ranges are largely overlapping (e.g. A + B). Others overlap mainly near locations of great attraction or importance as e.g. saltlicks. Sceondly that the whole rhino area of the Gunung Leuser must be considerably larger than the home range of all or at least most individuals. As the core area of the Gunung Leuser population covers approximately 1000 square kilometers (Fig.41), we have to assume that individual home ranges are most probably smaller.

4.3.4. Utilization of the study area by the local rhino population

Hediger (1942/50) has pointed out that different sections of a home range show considerable variation in the way in which they are utilized by its inhabitants. Different utilization, determined by external factors like e.g. topography and vegetation as well as by the rhinos' needs, is clearly visible in the study area.

The main areas and locations ("fixed points", Hediger 1942/50) of importance for the rhino are feeding areas, saltlicks, places of comfort behaviour (wallows, rubbing places), resting places and to some extent dung heaps and marking places. Some of these areas and locations retain their significance for long periods, even for many generations of rhinos. They are connected

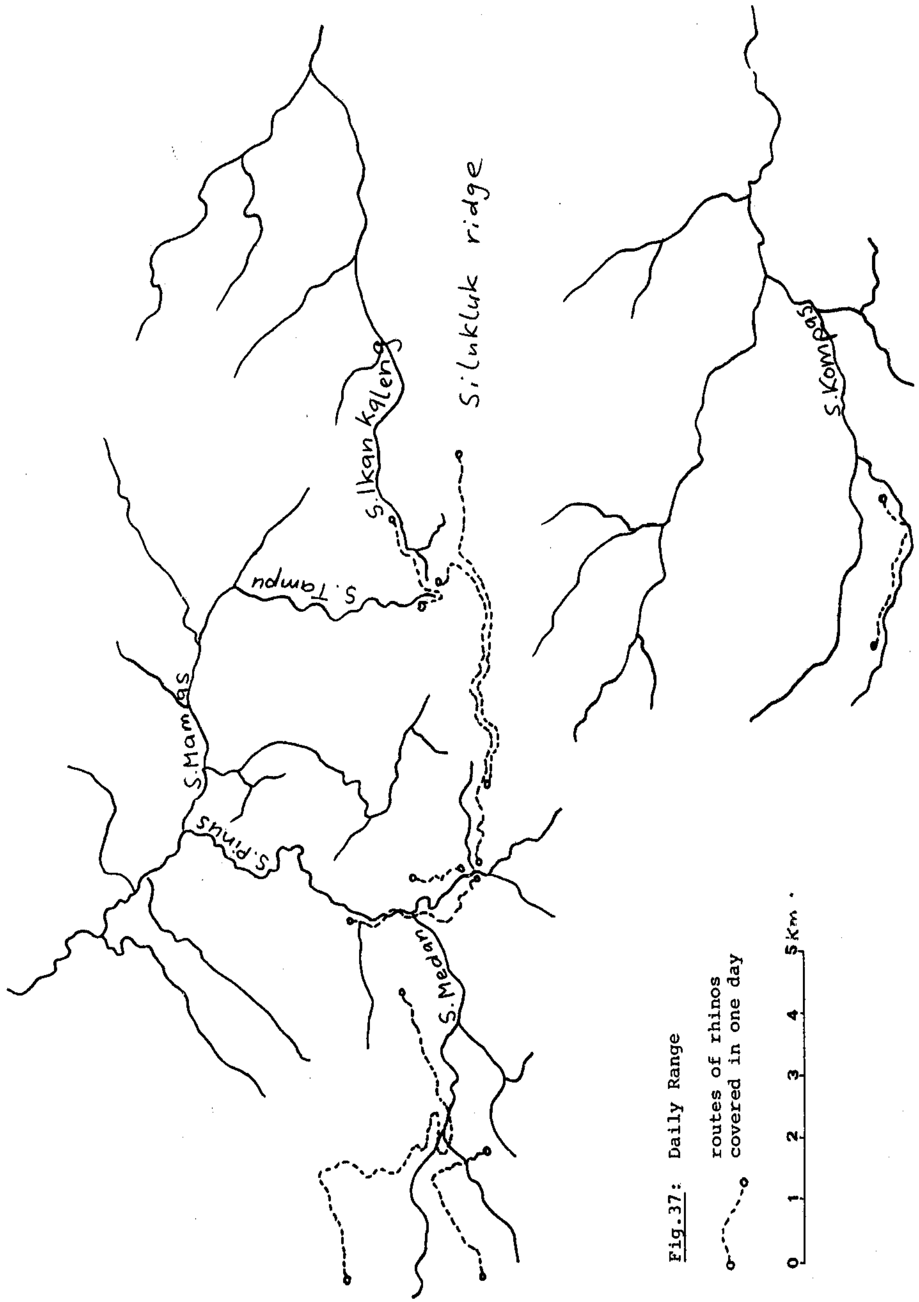


Fig.37: Daily Range

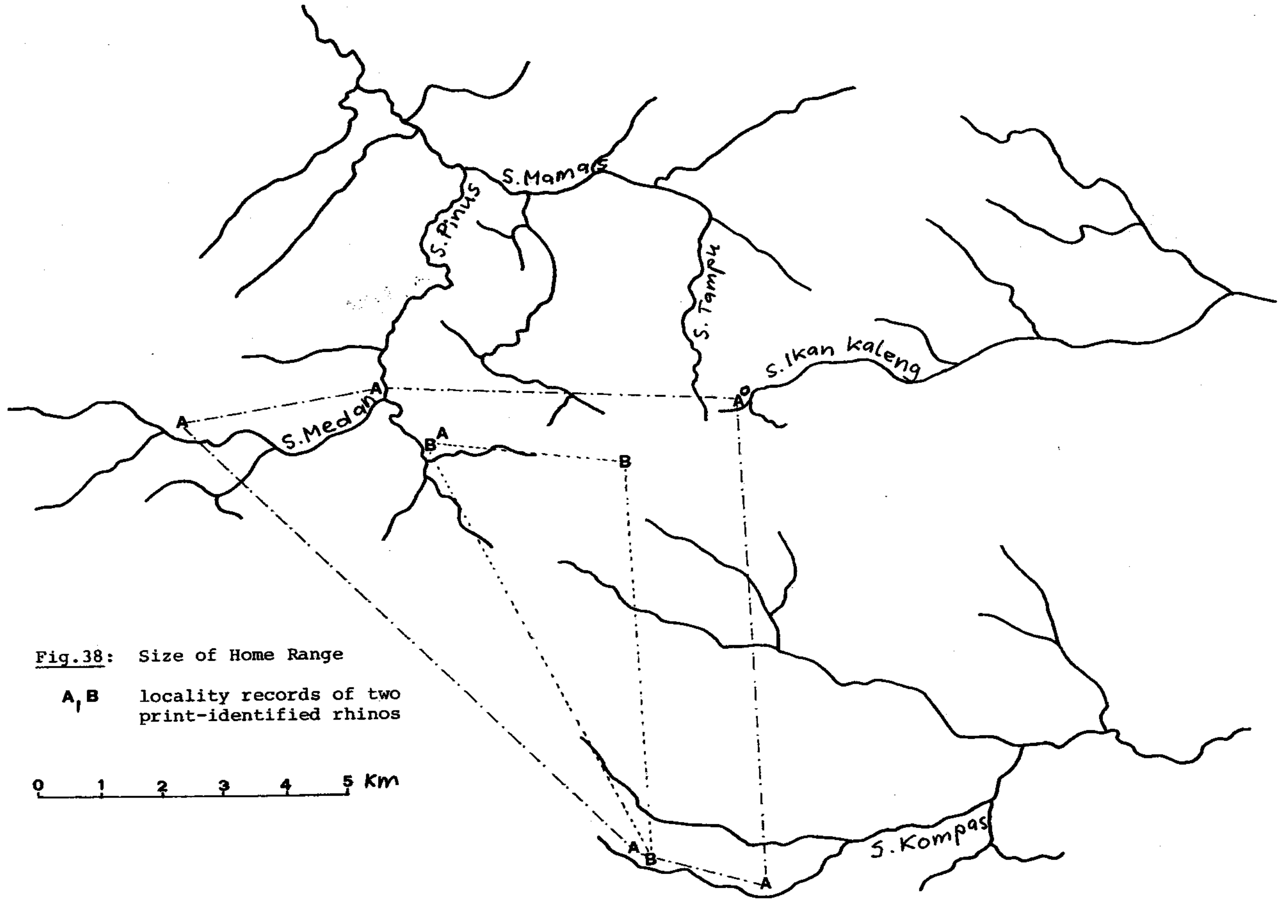


Fig.38: Size of Home Range

A, B locality records of two print-identified rhinos

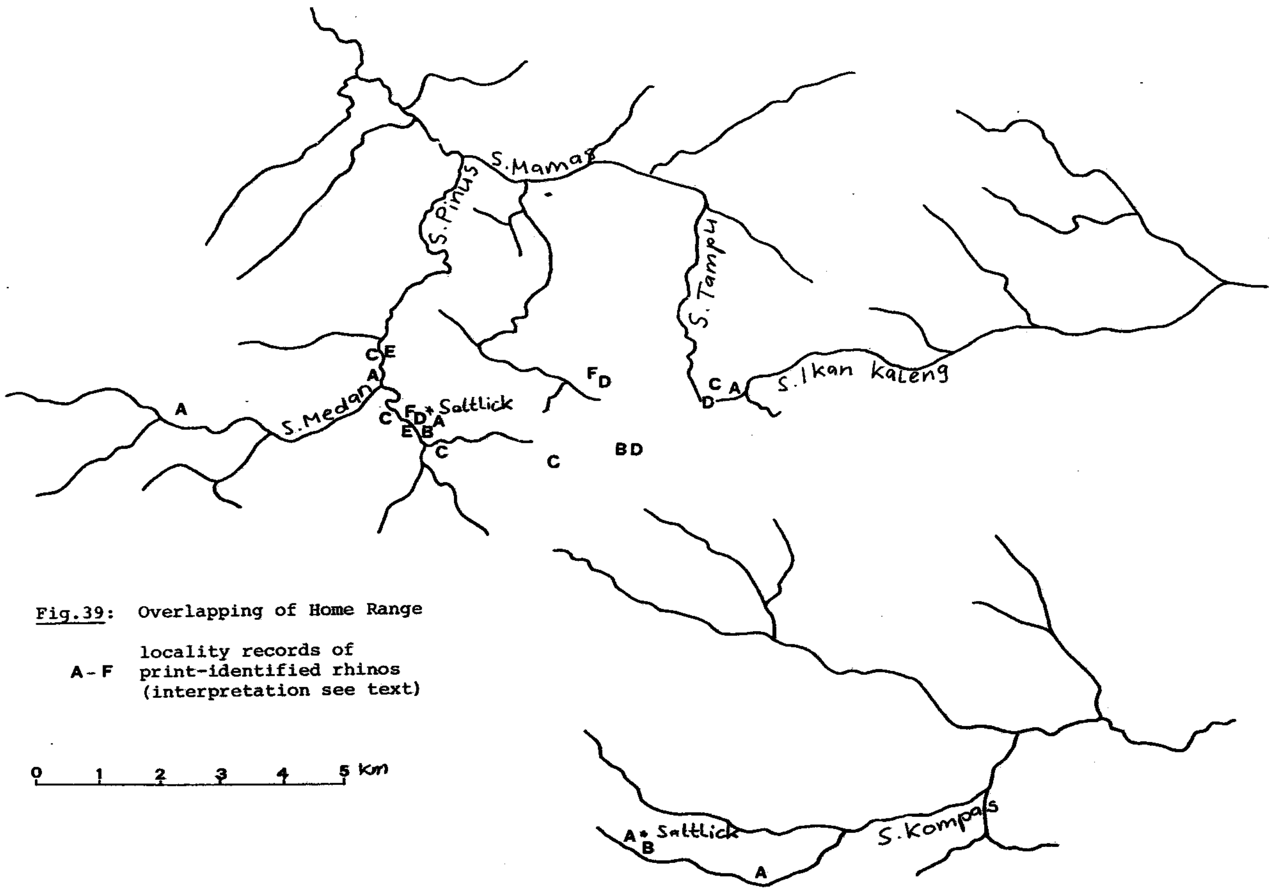


Fig.39: Overlapping of Home Range

A - F locality records of print-identified rhinos (interpretation see text) by a trail system which facilitates to satisfy the different needs in certain sequences.

4.3.5. Discussion

Strickland (1967) is the only author who gives information on the size of a home range. He found a range in the lowlands of Sungei Dusun (West Malaysia) with a size of approximately 10 square kilometers. If Strickland's statements are correct, the small size of home ranges at Sungei Dusun might be explained by the fact that in this lowland area much a greater proportion of the home range can be intensely used by the rhinos than in the Gunung Leuser area.

A functional aspect of the home range is that the individual animal is familiar with the area it is living in (Leuthold 1977) and knows where and how to reach the available resources such as food, saltlicks and wallows. It acquires this familiarity during childhood under the guidance of its mother and by its own exploration activity.

The fact that the owners of overlapping home ranges use common "fixed points" increases the probability of their indirect communication and consequently the chances of direct contact leading to mating.

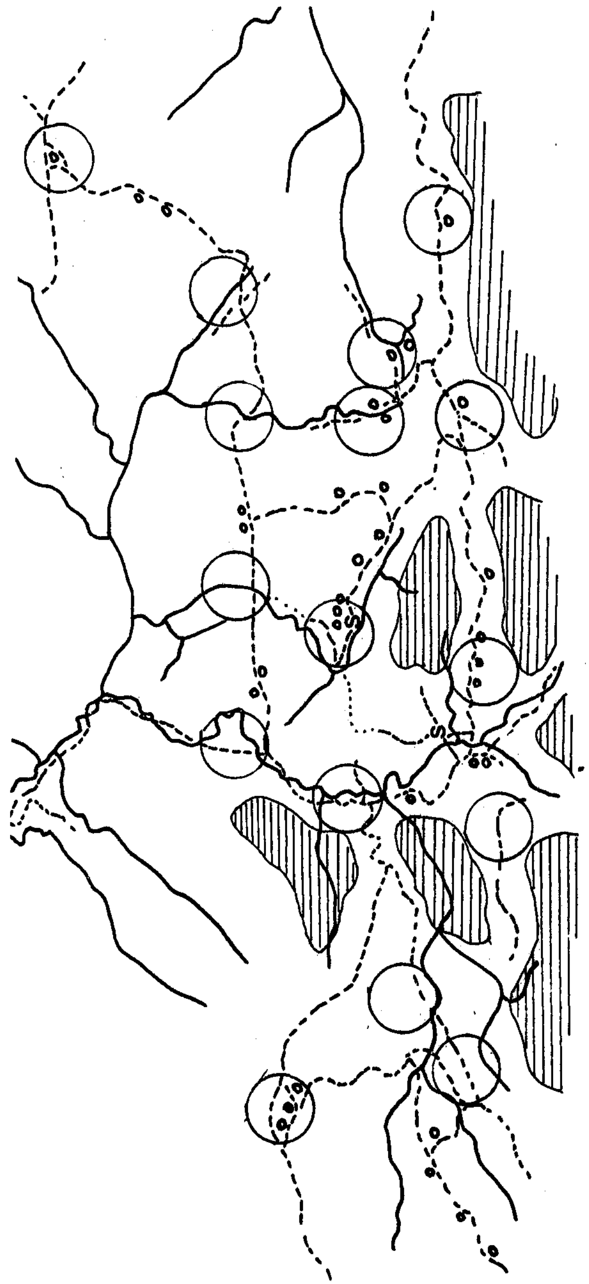


Fig.40: Utilization of the study area by the local rhino population
Study area simplified, including several individual home ranges.

areas without traces of rhinos

approximate areas with many feeding traces

rest: areas with only rare traces of rhinos

wallowing areas

saltlicks

main trails

0 1 2 3km

4.4. Movements

4.4.1. Temporal organization of movements

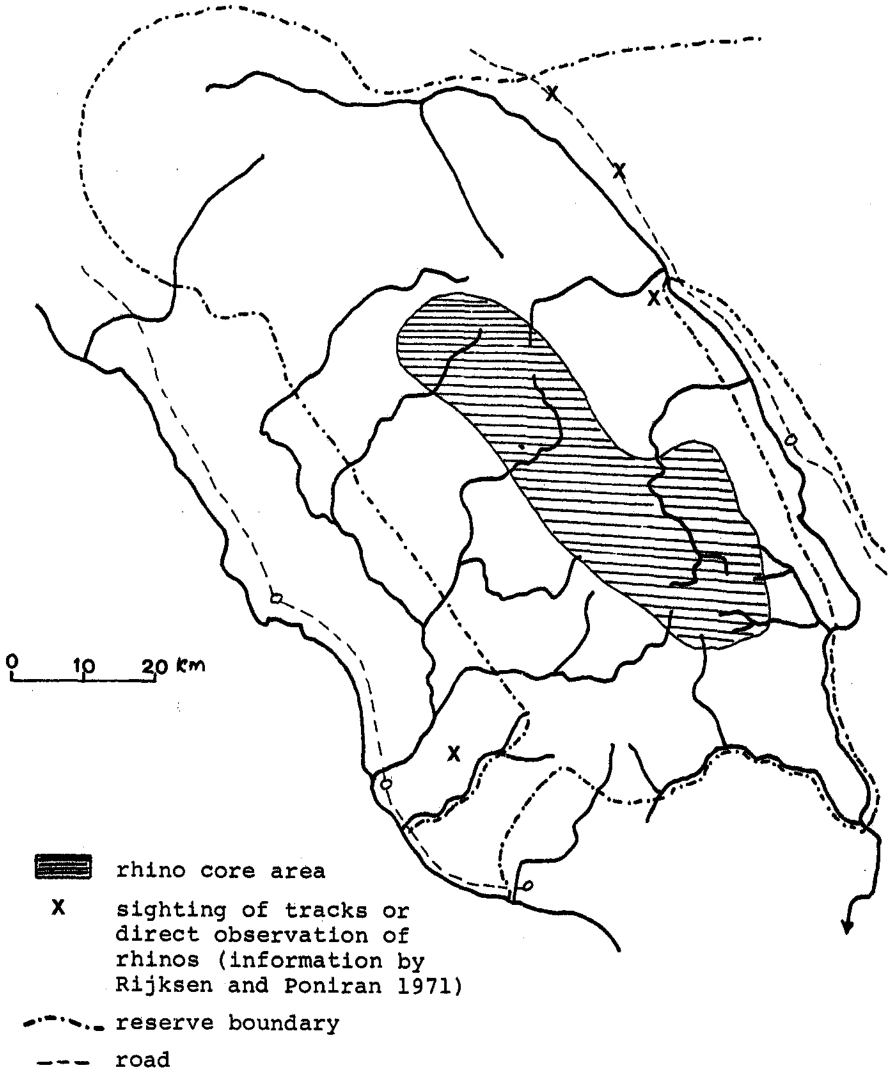
In part I1, section 4.2. and 4.3. it was shown that some days the rhinos spend most of the time for feeding and wallowing and only little for migration. On other days they interrupt their movements over long distances only for short feeding and possibly wallowing periods. In those cases, where the traces of one day's activity included shifting could be ascertained, the time spent in walking could approximately be estimated while duration of the other activities as e.g. wallowing and feeding could not. Fig.37 shows some examples. In the case of animals which remained in a relatively restricted area it was impossible to measure the actually covered walking distance.

4.4.2. Spatial organization of movements

As Fig.40 shows the movements within the home range are not carried out at random, but the rhino keeps to certain routes or areas. But on rare occasions rhino tracks can be found in areas which usually are not utilized by rhinos. I found evidence of two types of such exceptional movements. In the first type rhino tracks were found within the perimeter of the normal range, e.g. a rhino left the main trail of the Silukluk ridge, crossed a large area with no other signs of rhinos and reached the trail system again at the saltlicks of Sungei Tanah.

In the second type, excursions may lead considerable distances away from the core area of Gunung Leuser and consequently also from the normal home range of the individual (Fig.41). In 1971 tracks of a rhino were found in Ketambe and Gunung Setan, at least 20 kilometers from the Gunung Leuser core area. In the same year rhinos were seen twice on the road Kotacane-Blangkedjeren, near Agusan, 30 to 40 kilometers from the core area of the rhino range (Rijksen, pers.com.). In 1971 rhino tracks were also found near Bangko lake in the Kluet reserve, 40 kilometers from the Leuser core area (Poniran, pers.com.). In 1975 evidence

Fig.41: Rhino Core Area in Gunung Leuser and Excursions outside the Core Area



of a single rhino was found 45 kilometers away from the core area in the Sumatera Selatan I reserve (information Dinas Kehutanan).

In all these cases the rhino had just been wandering through the area and did not return to it. Even in an area that is under constant observation, like the Ketambe research area, rhino tracks were only observed once (Rijken, pers.com.).

4.4.3. Discussion

The major movements of ungulates are usually dictated by changes in environmental conditions, primarily in the availability of water and food. Thus they are related to the pattern of rainfall (Leuthold 1977). In the dry season the Black Rhino as well as the White Rhino are forced to cover considerable distances in order to reach watering places (Schenkel and Schenkel 1969a, Owen-Smith 1974). The Indian Rhinos at Kaziranga have to migrate because of floods caused by the monsoon rain.

In the tropical rain forest environmental conditions are relatively stable and water is abundant throughout the year. What then are the functional aspects of the Sumatran rhino's constant wanderings through its large home range? The Javan rhino in Udjung Kulon lives in a similar habitat. Schenkel and Schenkel (1969b) state, that the nomadism of the Javan rhino, together with its feeding technique, appears to be an adaptation to the type of food plants it consumes which are scattered and growing slowly and, if not broken in time, grow out of the rhino's reach and in absorbing light inhibit saplings to grow. This explanation seems valid for the Sumatran rhino as well.

I have no data concerning the ecological significance of the rhino's excursions outside its home range. They could be the result of heavy disturbance by man, or of an exploratory tendency of the rhino. Such exploratory behaviour could occur spontaneously or be the result of intraspecific pressure, e.g. general population pressure (which is highly unlikely) or bull competition.

4.5. The problem of male territories

It was recorded that the ratio of captured female to male rhinos is overwhelmingly outbalanced by the female. In three known cases of capturing, several females but only one male could be trapped within one capturing area. Of the seven rhinos caught by Husin near the Kompas saltlick area, only one was a male. Bahir of Kerinci caught two females and one male. Ryhiner and Skafte caught eight females and one male in Riau (Anderson 1961). Altogether twenty-two females and nine males were kept in captivity (van Strien 1974).

It is most unlikely that the sex ratio of the captured or killed rhinos reflects the sex ratio of the whole population. Rather capturing methods and local occurrence of male and female rhinos in the special capturing area are responsible for this uneven sex ratio.

Spear- as well as corral traps were always built at focal points of the rhino range (saltlicks, wallows, crossings of main trails). At such locations usually several traps were built within a few hundred meters of each other.

It must be concluded that such focal areas are visited by several cows but only one bull.

The occurrence of only one bull at a point of attraction can only be explained by intolerance of this individual towards conspecifics of the same sex. Intolerance of this male seems to be concentrated on the special location, which accordingly he occupies as his territory. He is able to maintain this position due to his status of dominance.

In the surrounding of fixed points the signs of male marking-behaviour are usually abundant (ritualized urination and defecation, tree twisting; see 2.3., 2.4., 3.2.2.). These marks must have been produced by the territorial bull. Tree twisting and associated behaviour is comparable to the "complex bull ceremony" with which the top Black and similarly top White rhino bull manifest their presence (Schenkel and Schenkel 1969a, Owen-Smith 1974).

In the White rhino, males of top status are territorial amongst themselves (Owen-Smith 1974). This applies also to the Black rhino for periods of good supply of food and water (Goddard 1967), whereas in the latter species during periods of prolonged drought the top males do no longer maintain territories (Schenkel and Schenkel 1969a).

It seems that in contrast to the African rhinos the top Sumatra rhino bull is intolerant towards all males in the surrounding of the fixed points (capturing sex ratio).

It appears almost certain that the top Sumatran rhino bull does not consistently remain close to a single fixed point for long periods. I have no clues as to whether a dominant bull is temporarily occupying several territories, each around a fixed point.

The maintenance of a territory would usually be achieved through indirect communication, i.e. by marks of the owner and occasionally by direct contact, i.e. hostile encounters or fights.

As already pointed out, the second important function of these marks would be the transfer of information to cows visiting the fixed point and thus the initiation of mating contact.

5. Population Problems

Insight into population structure and dynamics is essential for judging the survival chances of a certain population.

The available data from the Gunung Leuser population are only fragmentary: As has been shown the total population consists of about 20-40 individuals, including males, females and juveniles. This population is propagating, about 4-5 calves were registered during the observation period in the study area.

Propagation data for the Sumatra rhino are not known. Those for the African and the Indian rhinos are however available from zoos. These data show conformity for all three species. Taking into account that the Sumatra rhino is smaller one would expect the respective life cycle data to be slightly lower (Tab.29).

If we assume a present population of 40 rhinos, about 20 will be females. About one third of these - 6 to 7 animals - will be before their first parturition. Of the other 13 to 14 females, one third will give birth to a calf every year (interval between parturitions about 3 years). That would result in the production of 4 to 5 offsprings (females plus males) every year. A balance between birth- and death-rate can only be maintained if less than 3 adult females die per year and this number must include death by old age, accident and poaching!

It is evident that the preservation of each single individual, especially female, is of paramount importance for the survival of the Sumatra rhino in Gunung Leuser and elsewhere.

Tab.29: Life Cycle of Female Rhinos

	White Rhino (Owen-Smith 1974)	Black Rhino (Schenkel and Schenkel 1969a+d)	Indian Rhino Javan Rhino (Lang 1967)	Sumatran Rhino (conjectured)
Sexual maturity	5 - 5 1/2 years	3 1/2 - 4 years	3 - 3 1/2 years	3 1/2 - 6 years
Gestation period	16 months	15 months	16 months	15 - 16 months
First parturition	6 1/2 - 7 years	4 3/4 - 5 1/4 years	4 1/3 - 4 3/4 y.	4 1/2 - 5 years
Period of mother/calf unit	2 - 3 years	2 1/2 - 3 1/4 years	3 years	1 1/2 - 2 years
Life span		35 years		30 - 35 years

SUMMARY

On behalf of WORLD WILDLIFE FUND and the DINAS PERLINDUNGAN DAN PENGAWETAN ALAM (Indonesian Nature Conservation Department) a survey of the distribution and status of the Sumatran Rhinoceros (Dicerorhinus sumatrensis) was carried out in Sumatra from 1972 to 1975. The ecology and ethology of the rhino was studied in the Gunung Leuser reserve.

The Sumatran rhino has suffered the effects of poaching, habitat destruction and other disturbances by man. A mere 60 to 80 rhinos are believed to survive in six different areas in Sumatra. The 20 to 40 rhinos of the Gunung Leuser reserve and the approx. 20 rhinos of the Kerinci/Seblat area have a reasonable chance of survival provided that their habitat can be saved from destrution and that all human disturbance can be kept away from their range. The survival of the other remnant populations is doubtful.

The Sumatran rhinos range over the primary forests from the lowlands to the high mountains. The majority of the survivors live on hilly or mountainous terrain with a dense undergrowth.

Their diet is made up principally of a large number of various species of saplings of which they eat the leaves and twigs. If the branches are too high up, the rhino uses its body to bend or break down the stems of the saplings. To supplement its diet the rhino visits saltlicks.

Dung is usually deposited on main trails. Frequently two or more dung heaps are found close together. In most cases urine is squirted backwards in a shower. Urination, and to a lesser extent defecation, are ritualized.

The rhino moves mainly on trails. A network of main trails connects feeding areas, saltlicks, wallows, etc. These main trails are about half a meter wide, have no vegetation cover and can extend for several kilometers without interruption. Feeding

trails are partly overgrown, poorly maintained, and can be found in feeding areas or parallel to main trails.

The rhinos are active during day and night and wander over large distances. Their home range covers an area of more than 50 km^2. Home ranges of different individuals seem to overlap.

With the exception of the mother/child unit rhinos live solitarily. Direct contact between conspecifics are rare. For intraspecific communication a Sumatran rhino population depends on a marking system. Ritualized urination and defecation along with other behaviour patterns like tree twisting, shrub beating and tree scratching produce olfactorial as well as other markings that transmit information for the producer in his absence. Besides being a basic instrument of communication within the rhino population, the marking system is probably also of great importance for the orientation of the individual rhino.

RINGKASAN (LAPORANG SINGKAT)

Penelitian selama tiga tahun ini dilangsungkan atas permintaan World Wildlife Fund (WWF) dan Dinas Perlindungan dan Pengawetan Alam Indonesia. Penyebaran dan keadaan Badak Sumatra (Dicerorhinus sumatrensis) di pulau Sumatra diselidiki. Penyelidikan mengenai situasi ekologi dan ethologi badak-badak tersebut dilakukan pada reservat Gunung Leuser di propinsi Aceh.

Di reservat Gunung Leuser (3°-3°50' L.U. / 97°10'-97°55' B.T.) masih terdapat kira-kira 20 sampai 40 badak hidup. Ditemukan 5 jenak anak badak. Badak-badak itu hanya hidup di tengah-tengah reservat yang relatif tidak terganggu di suatu daerah seluas kira-kira 1.000km^2. Bilamana berhasil usaha untuk melindungi reservat (tempat pengawetan) ini, badak-badak itu akan dapat kesempatan untuk mempertahankan hidupnya.

Jumlah terbesar badak-badak diluar reservat Gunung Leuser itu terdapat di daerah Kerinci/Seblat. Kira-kira 20 ekor badak hidup di daerah ini yang terletak diantara Gunung Tucu (1°40' L.S. / 101°25' B.T.) di propinsi Jambi dan sungai Seblat (2°55' L.S. / 102°05' B.T.) di propinsi Bengkulu. Dari jejak-jejak yang ditemukan diketahui bahwa populasi ini masih berkembang biak. Tetapi ruang hidup mereka semakin dipersempit oleh ancaman kebakaran. Bila daerah itu dalam waktu yang akan datang dinyatakan sebagai reservat, dan badak-badak itu dapat dilindungi dari kemusnahan, maka populasi ini juga akan berkesempatan untuk mempertahankan hidupnya.

Sisa-sisa kelompok lainnya kecil-kecil dan kelangsungan hidupnya diragukan. Beberapa ekor badak masih terdapat di reservat Langkat, propinsi Sumatra Utara (3°20'-4° L.U. / 97°40'-98°05' B.T.); di Torgamba, propinsi Sumatra Utara dan Riau (1°45' L.U./ 100°20' B.T.); di sebelah utara dari reservat Sumatera Selatan I, propinsi Sumatra Selatan (5°05' L.S. / 104°10' B.T.) dan menurut keterangan PPA (Dinas Perlindungan dan Pengawetan Alam) juga ada di reservat Berbak, propinsi Jambi (1°20' L.S./104°20' B.T.).

Saya perkirakan bahwa diseluruh Asia Tenggara masih terdapat kira-kira 100 sampai 160 ekor badak, diantaranya kira-kira separohnya (40-75 ekor) berada di Sumatra.

Penyebab utama punahnya badak-badak Sumatra ini adalah pemusnahan hutan-hutan primer oleh manusia. Disamping itu, karena tanduk-tanduk binatang ini sekarang ini masih saja dinilai dengan emas, maka pembantaiannya juga memainkan peranan besar.

Ruang hidup badak-badak Sumatra berkisar dari hutan-hutan tanah-datar primer sampai hutan-hutan lembab. Rupanya badak-badak itu menghindari rawa-rawa dan paya-paya serta juga hutan-hutan sekunder yang dibuat manusia. Di dataran-dataran rendah serta di gunung-gunung binatang-binatang ini hidup di tanah-tanah curam dan tanah-tanah berbukit-bukit dengan semak-semak yang rimbun oleh pohon-pohon muda. Mereka lebih menyukai daerah-daerah yang bertanah-kering atau tanah-liat. Sering pula mereka hidup di pertemuan-pertemuan sungai dengan kali-kali kecil sekitarnya.

Badak-badak Sumatra suka makan daun-daun dan ranting-ranting tumbuhan muda. Bila ranting-ranting pohon tersebut tinggi letaknya, maka dengan dadanya badak ini mendorong-dorong pohon yang besarnya sampai 6 cm, membengkokkannya atau mematahkan pohon tersebut sampai jatuh ketanah dan memakan pucuk-pucuknya. Hanya kira-kira 10% dari makanannya berasal dari semak-semak atau tumbuhan-tumbuhan menjalar. Binatang-binatang ini makan sepanjang jalan-jalan yang biasa ditempuhnya atau di "daerah-makan" tertentu.

Untuk melengkapi kebutuhan mineralnya, badak-badak ini mencari tempat-tempat asin. Tempat-tempat asin seperti itu relatif sukar didapat. Di pelintasan badak yang berlobang sampai lebih dari 1 meter di daerah yang berdekatan dengan tempat-tempat asin itu membuktikan bahwa tempat tersebut telah dipergunakan oleh banyak generasi badak. Karena tempat-tempat asin itu

lebih sering didatangi badak-badak tersebut, maka agaknya juga penting artinya bagi ikatan sosial diantara kelompok-kelompok badak itu.

Kotoran-kotorannya terutama dibuang di pelintasan-utama atau kedalam air. Tumpukan kotoran terdapat diatas atau di dekat satu atau dua tumpukan kotoran lainnya. Tempat kotoran itu kadang-kadang sampai meliputi 10 tumpukan. Kebanyakan kotoran ini dibiarkan jatuh begitu saja. Tetapi kadang-kadang disertai perbuatan ritual, kotoran-kotoran itu dicakar-cakar dengan kaki belakang, kepala menyibak-nyibak semak-belukar, dan tanduk memilin-milin pohon-pohon kecil.

Pengeluaran air-seni kebanyakan disertai perbuatan ritual. Cuma dalam beberapa hal air-seni itu dibiarkan jatuh mengalir kebawah. Umumnya disemburkan ke belakang sehingga merupakan percikan-percikan halus. Serangkaian perbuatan itu, seperti mencakar dengan kaki belakang, meremuk-remukkan semak belukar dan memilin-milin pohon-pohon kecil dengan tanduk terjadi ketika mengeluarkan air-seni.

Kubangan-kubangan dibuat oleh badak-badak itu dengan jalan mengais-ngaiskan kaki ditempat yang baik untuk itu, yakni di lekukan tanah yang bertanah-liat lunak dan lembab. Kubangan tersebut umumnya berbentuk bujur-telur dan dibatasi terhadap pinggir gunung dengan dinding yang terjal. Selama berkubang, badak itu menutupi badanya dengan lumpur. Setelah berkubang, binatang-binatang itu menggosok-gosokkan badannya dengan keras pada batang-batang dan semak-semak.

Sebagaimana badak-badak jenis lain, badak Sumatra juga dapat berjalan dengan melangkah, lari atau meloncat-loncat. Kedua cara yang belakangan ini hanya terlihat pada binatang-binatang yang melarikan diri. Kemampuan badak-badak melewati tanah-tanah terjal mengagumkan. Rupanya mereka juga bisa berenang. Kebanyakan badak-badak itu bergerak di pelintasan-pelintasan yang dibuat sendiri. Dua macam pelintasan dapat dilihat.

Pelintasan-utama kira-kira setengah meter lebarnya, tidak ditumbuhi pohon-pohon, dan dapat mencapai lebih dari beberapa kilometer panjangnya dengan tidak putus-putus. Jaringan pelintasan sedemikian itu meliputi keseluruhan daerah badak di reservat Gunung Leuser dan menghubungkan daerah-daerah makanan, daerah-daerah asin dan tempat-tempat penting lainnya. Pelintasan-pelintasan utama ini tidak melalui route yang terpendek tetapi route yang paling enak, terutama ditanah yang bergunung-gunung, pelintasan ini melewati ngarai-ngarai. Juga dipergunakan oleh binatang-binatang lain, tetapi tidak begitu mempengaruhi keadaan lintasan tersebut, kecuali gajah-gajah. Pelintasan-makanan, macam kedua, sebagian ditumbuhi tanaman dan hanya bagian-bagian pendek yang terlihat. Kebanyakan jalan-jalan makanan ini sejajar dengan pelintasan-utama atau melintasi daerah-makanan.

Badak-badak aktif siang dan malam. Karena daerah-daerah makanan, tempat-tempat asin, dan lain-lain berjauhan letaknya satu-sama-lain, maka binatang-binatang itu menjalani jarak yang jauh-jauh. Wilayah yang dilewati oleh masing-masing badak itu selama hidupnya adalah luas. Di reservat Gunung Leuser, wilayah sedemikian itu (home-range) lebih 50 km^2. Wilayah-wilayah kampung masing-masing individu badak saling menutupi satu-sama-lain. Wilayah ini dibagi atas daerah-daerah inti, seperti misalnya daerah-daerah-tempat-makanan, tempat-tempat-asin atau kubangan-kubangan dan lain-lain. Pelintasan-utama menghubungkan daerah-daerah inti ini satu-sama-lain dan dengan demikian melintasi daerah-daerah yang tidak atau yang hanya jarang sekali digunakan oleh badak-badak itu.

Badak-badak Sumatra hidup sendiri-sendiri, kecuali kelompok yang terdiri dari 2 ekor, anak dan induk. Juga didaerah-daerah yang tidak ada gangguanpun kepadatan populasi-nya sangat rendah. Hanya 2 kali dapat ditemukan jejak-jejak dari 2 badak-dewasa, yang langsung berhubungan satu-sama-lain. Yang paling menonjol pada jejak-jejak ini adalah tempat yang melingkar

dengan tanam-tanaman yang tertindas, dimana binatang-binatang itu berkisar diatas sumbunya sendiri.

Karena badak-badak Sumatra hidup sendiri-sendiri, maka informasi yang bersifat intra-spesifis secara tidak langsung diteruskan dengan mempergunakan tanda-tanda. Pembuangan air-seni dan kotoran yang dilakukan secara rituil, ditambah dengan perbuatan-perbuatan lainnya menghasilkan suatu sistim tanda-tanda yang lebih bersifat bau, yang menjamin komunikasi didalam suatu kelompok. Perbuatan-perbuatan yang paling menonjol dalam hubungan tanda-tanda ini adalah pemilinan pohon-pohon kecil. Badak-badak itu memilin atau memelintir pohon-pohonan muda diantara tanduk-tanduknya sehingga sebagian membentuk sesuatu seperti kunci-not. Dalam hal-hal lain, semak-semak diremuk-remukkan dengan depala dan tanduk-tanduk atau kulit-kulit pohon dikelupas dengan tanduk. Tanda-tanda yang dihasilkan rupanya tidak saja dimaksudkan untuk komunikasi, tetapi juga besar artinya bagi orientasi badak itu sendiri.

Ketahanan-hidup kelompok badak Sumatra tergantung dari pada sistim komunikasi dan orientasi yang terpelihara baik. Tetapi sistim pengadaan tanda-tanda ini tidak stabil karena kepadatan populasi yang rendah. Bila karena pembantaian kepadatan ini makin diperkecil, atau bila akibat perbuatan-perbuatan perusakan oleh manusia badak-badak ini terdesak dari pelintasan tradisionilnya, maka tanda-tanda itu tidak lagi mendapat perawatan yang cukup. Sistim komunikasi dan orientasi berantakan, pengembang-biakan diragukan dan kelanjutan hidup kelompok binatang itu terancam. Bilamana badak-badak Sumatra akan diselamatkan dari kepunahannya, haruslah dilindungi daerah-daerah yang cukup luas disekitar ruang-hidup aslinya, kira-kira di Gunung Leuser atau di Kerinci/Seblat, dari penghancuran dan dicegah setiap tindakan perusakan oleh manusia.

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Im Gunung Leuser Reservat (3°-3°50'N/97°10'-97°55'O) leben noch ungefähr 20 bis 40 Nashörner. Spuren von fünf Kälbern wurden gefunden. Die Nashörner leben nur noch im relativ ungestörten Zentrum des Reservates in einem Gebiet von ca.1000 km^2. Falls es gelingt, dieses Reservat wirkungsvoll zu schützen, könnten die Nashörner hier eine Ueberlebenschance haben.

Die grösste Anzahl Nashörner ausserhalb des Gunung Leuser Reservates findet sich im Kerinci/Seblat Gebiet. Etwa 20 Nashörner leben hier in einem Gebiet zwischen dem Gunung Tucu (1°40'S / 101°25'O) in der Provinz Jambi und dem Seblat Fluss (2°55'S / 102°05'O) in der Provinz Bengkulu. Spuren bestätigen, dass sich diese Population noch fortpflanzt. Ihr Lebensraum wird aber immer mehr durch Brandrodung eingeengt. Falls das Gebiet in nächster Zukunft zum Reservat erklärt wird und die Nashörner vor Störungen geschützt werden können, hat auch diese Population eine Ueberlebenschance.

Alle anderen Populationsreste sind klein und ihr Fortbestand ist fraglich. Wenige Nashörner überleben noch im Langkat Reservat, Provinz Nordsumatra (3°20'-4°N / 97°40'-98°05'O); in Torgamba, Provinzen Nordsumatra und Riau (1°45'N / 100°20'O); im Norden des Sumatera Selatan I Reservates, Provinz Südsumatra (5°05'S / 104°10'O) und nach Angaben der PPA auch im Berbak Reservat, Provinz Jambi (1°20'S / 104°20'O).

Ich schätze, dass in ganz Südostasien noch ca. 100 bis 160 Sumatra Nashörner überleben, wovon etwa die Hälfte (40-75) in Sumatra.

Der Grund für das Verschwinden der Sumatra Nashörner ist hauptsächlich in der Zerstörung des Primärwaldes durch den Menschen zu suchen. Da ausserdem die Hörner der Tiere noch heute mit Gold aufgewogen werden, spielt auch das Wildern eine recht grosse Rolle.

Der Lebensraum des Sumatra Nashorns reicht vom primären Flachlandwald bis zum Mooswald. Die Nashörner scheinen den Mangroven- und den Sumpfwald sowie auch den vom Menschen erzeugten Sekundärwald zu meiden. Im Tiefland wie in den Bergen leben sie im steilen, hügeligen oder gebirgigen Gelände mit einem dichten Unterwuchs an jungen Bäumen. Sie bevorzugen Gebiete mit trockenem oder lehmigem Grund. Oft leben sie im Einzugsgebiet eines Flusses mit vielen kleinen Bächen.

Das Sumatra Nashorn ernährt sich weitgehend von den Blättern und Zweigen junger Bäume. Sind die Zweige zu hoch, so drückt das Nashorn mit der Brust gegen die bis 6 cm dicken Stämme, biegt oder bricht so die Bäume mit dem Körper zu Boden und frisst von der Krone. Nur etwa 10% der Diät besteht aus krautartigen Gewächsen oder Lianen. Die Tiere fressen entlang der Hauptwechsel oder in eigentlichen "Fressgebieten".

Zur Ergänzung ihres Mineralbedarfs suchen die Nashörner Salzlecken auf. Solche Salzlecken sind relativ selten zu finden. Ueber einen Meter tief in den Boden eingeschnittene Wechsel in der direkten Umgebung der Salzlecken zeugen davon, dass diese schon von vielen Nashorngenerationen benutzt worden sind. Da Salzlecken häufiger von den Nashörnern besucht werden als irgend ein anderer Ort des Nashorngebietes, sind sie wahrscheinlich auch für den sozialen Zusammenhalt der Nashornpopulation wichtig.

Dung wird hauptsächlich auf den Hauptwechseln oder im Wasser abgegeben. Die meisten Dunghaufen befinden sich auf oder nahe bei ein oder zwei anderen Dunghaufen. Solche Dungdeponien können bis zu 10 Dunghaufen umfassen. Meist lassen die Nashörner den Dung einfach fallen. Manchmal ist die Dungabgabe aber mit ritualisierten Verhaltensweisen kombiniert, es wird mit den Hinterfüssen gescharrt, Büsche werden mit dem Kopf zusammengeschlagen und kleine Bäumchen mit den Hörnern verdreht.

Urinieren ist meist mit ritualisiertem Verhalten verbunden. Nur in wenigen Fällen wird der Urin in einem Strom nach unten abgegeben. Im allgemeinen wird der Urin als fein versprühte Wolke nach hinten weggespritzt. Eine ganze Reihe von Verhaltensweisen, wie Scharren mit den Hinterfüssen, Zusammenschlagen von Büschen mit dem Kopf und Verdrehen von kleinen Bäumchen mit dem Horn kommen neben der Urindusche vor.

Suhlen werden von den Nashörnern durch Scharren mit den Füssen an geeigneten Stellen in kleinen Mulden mit weichem, feuchtem Lehmboden angelegt. Die Suhlen haben meist eine ovale Form und sind gegen die Bergseite hin durch eine steile Wand begrenzt. Während des Suhlens bedeckt sich das Nashorn mit einer Schicht von Lehm. Nach dem Verlassen der Suhlen reiben die Tiere sich heftig an Stämmen und Büschen.

Wie alle Nashornarten kann sich das Sumatra Nashorn im Schritt, im Trab und im Galopp fortbewegen. Die beiden letzteren Gangarten konnten nur bei flüchtenden Tieren festgestellt werden. Die Fähigkeit der Nashörner, steiles Gelände zu meistern, ist erstaunlich. Offenbar können sie auch schwimmen. Meist bewegen sich die Nashörner auf selbst angelegten Wechseln. Zwei Typen von Wechseln können unterschieden werden. Die Hauptwechsel sind etwa einen halben Meter breit, haben keinen Pflanzenbewuchs und können sich ohne Unterbruch über mehrere Kilometer hinziehen. Ein Netz von solchen Hauptwechseln überzieht das ganze Nashorngebiet im Gunung Leuser Reservat und verbindet wichtige Fressgebiete, Salzlecken etc. miteinander. Dabei folgen die Haupt-

wechsel nicht der kürzesten, sondern der bequemsten Route; diese führt im gebirgigen Gelände vor allem entlang der Bergkämme. Die Hauptwechsel werden auch von anderen Tieren benutzt; aber nur die Elefanten tragen zu deren Unterhalt wesentlich bei. Zweitrangige Wechsel sind schmäler, teilweise überwachsen und nur über kürzere Strecken sichtbar. Sie laufen meist parallel zu den Hauptwechseln oder durchziehen Fressgebiete.

Die Nashörner sind tag- und nachtaktiv. Um Fressgebiete, Salzlecken, Suhlen etc. aufzusuchen, wandern die Tiere öfters über grosse Strecken. Das Heimgebiet, d.h. der Raum, in dem ein einzelnes Individuum sein Leben fristet, ist im Gunung Leuser Reservat sicher weit mehr als 50 km^2. Die Heimgebiete einzelner Individuen überlappen weitgehend. Innerhalb derselben werden gewisse "Kerngebiete", wie Fressgebiete, Salzlecken oder Suhlen häufiger besucht und intensiv genutzt, andere nur selten und weitere überhaupt nie. Die Hauptwechsel verbinden die Kerngebiete.

Die Sumatra Nashörner leben solitär; nur Mutter und Kind sind vermutlich über mehr als ein Jahr vergesellschaftet. Nur zweimal konnten Spuren von zwei adulten Tieren gefunden werden, die in direktem Kontakt gestanden hatten. Auch in ungestörten Gebieten weist das Sumatra Nashorn eine stets sehr niedere Populationsdichte auf.

Die Sumatra Nashörner leben zwar solitär, unterhalten aber ein Markierungssystem, das die Kommunikation innerhalb der Population sicherstellt. Dieses System umfasst ritualisierte Harn- und Kotabgabe, Scharren, Bearbeiten von Büschen und jungen Bäumchen mit dem Kopf, insbesondere vermutlich mit dem vorderen Horn. Das Markierungssystem dürfte nicht nur für die interspezifische Kommunikation, sondern auch für die Orientierung der Nashörner äusserst wichtig sein.

Für das Ueberleben einer Sumatra Nashorn-Popula
intaktes Kommunikations- und Orientierungssyst
grösster Bedeutung. Wenn durch Wilderei die Pop

stark herabgesetzt wird, oder wenn aus Furcht vor dem Menschen einzelne Nashörner aus ihrem Heimgebiet mit den traditionellen Wechseln fliehen, so bricht das Kommunikations- und Orientierungssystem zusammen, die Fortpflanzung wird in Frage gestellt und der Fortbestand der Population gefährdet.

Soll das Sumatra Nashorn vor dem Aussterben gerettet werden, müssen grosse Gebiete, wo noch lebensfähige lokale Populationen existieren, vor Zerstörung geschützt und gegen jede menschliche Störung abgeschirmt werden.

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Photo 1

Sumatran Rhinoceros (Photo Buhadi/Bogor)

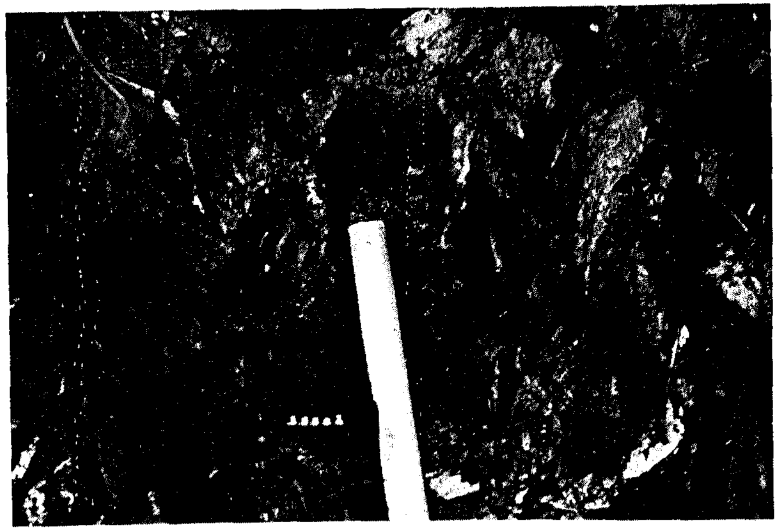
Photo 2

Spear trap in the Leuser area

Photo 3

Pit fall trap in the Kerinci area

Photo 4



Foot print of a rhino

Photo 5

Saltlick at Sungei Pinus, traces of the rhino's horn in the soft stone.

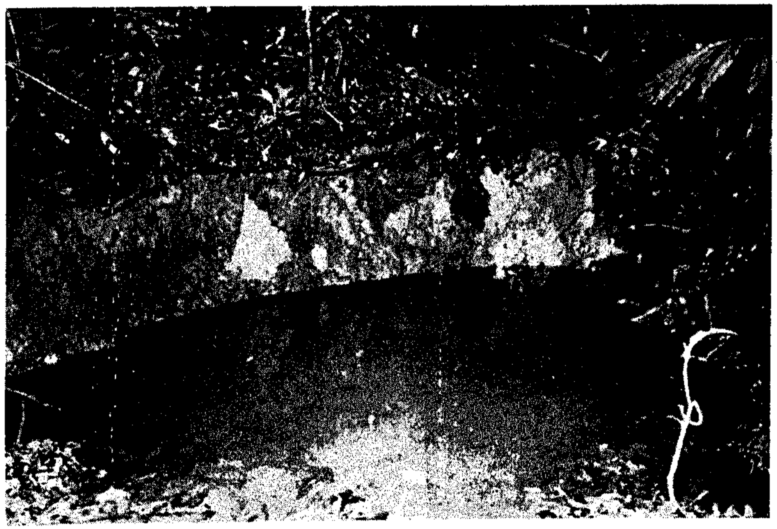
Photo 6

Dung heaps near stream

Photo 7

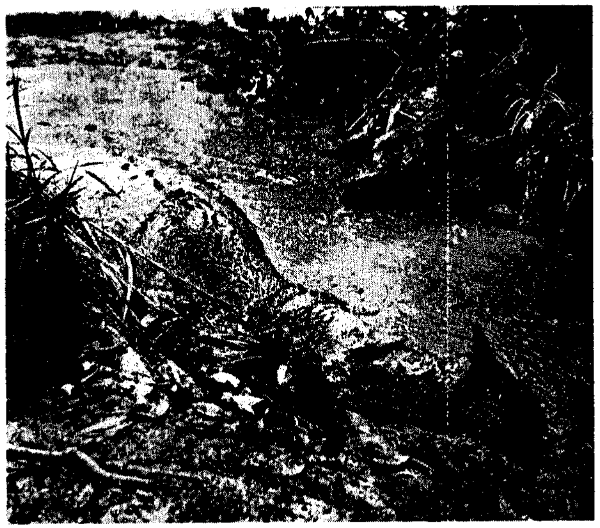
Rhino wallow

Photo 8



Rhino wallow, note the clay wall towards the slope.

Photo 9



Sumatran rhino in wallow. Riau, Central Sumatra.
(Photo Skafte, WWF)

Photo 10

Main trail, deeply cut into the ground, near saltlick at Sungei Pinus.

Photo 11

Main trail, forming tunnel in dense vegetation.

Photo 12

Twisted sapling, bent down

Photo 13

Twisted sapling, flapped over once

Photo 14

Twisted sapling, flapped over twice

Photo 15

Twisted sapling, flapped over several times

CURRICULUM VITAE

Name: Markus Borner

Place of birth: Thalwil, Switzerland

Date of birth: 23rd of April 1945

High school: 41/2 years Oberrealschule Zürich (Swiss Federal Maturity, Type C)

University: 5 years study of biology at the University of Zürich. Diploma received in zoology. Additional degrees in general and systematic botanics, chemistry, anatomy, anthropology and palaeontology.

Postgraduate studies:

- 1 year at the Institute for Ethology in Zürich with the "Arbeitsgruppe für Wildforschung" under Prof.H.Kummer and Dr.F.Kurt. Lectures and seminars on ecology and ethology. Assistant in a lecture on national park management. Field work on roe deer.
- 3 months of scientific assistance at the head quarters of World Wildlife Fund (WWF).
- 1972 to 1975: field work in Sumatra
- 1976: 3 months survey for WWF on the situation of the leopard in Turkey.
- 1976/77: preparation of thesis under the guidance of Prof.R.Schenkel, University of Basel.

Publications:

- Spontanaktivität und Reaktionen auf äussere Reize bei Hydra attenuata. (Thesis for Diploma)
- Sumatra's Orang-utans. 1976. Oryx, XIII,3, 290-293.
- Leopards in Western Turkey. 1977. Oryx, XIV, 1, 26-30.
- Status and Conservation of the Sumatran Tiger. 1977. Carnivore, Part 1, Vol.I.
- Tropenwelt. Fauna und Flora Südostasiens, 1977. Kümmerly + Frey. 159-188.
- various articles in magazines and newspapers

At the University of Zürich I have attended lectures and seminars of the following professors:

K.Akert, F.Ankel, J.Biegert, H.Burla, P.S.Chen, C.H.Eugster, E.Hadorn, H.Hediger, R.Hunsperger, H.Jungen, E.Jungen-Hauschteck, A.Krämer, E.Kuhn-Schnyder, H.Kummer, F.Kurt, F.Markgraf, B.Nievergelt, R.Nöthiger, H.R.Oswald, D.Rast, H.Rieber, O.Rohweder, H.Rüst, A.Rutishauser, R.Schenkel*, J.Schlittler, B.Stüssi, P.Tardent, E.Thomas, G.Töndury, H.Wanner, R.Wehner, V.Ziswiler.

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