

How are the two species adapted to their preferred habitat, with regard to their morphology and feeding ecology? The different form of the foot of the two species are probably such adaptations. While the foot of the Javan rhino is almost circular with short toes, the foot of the Sumatran rhino has more elongated toes (van Strien 1970) giving it an almost claw-like appearance. Long toes probably enable an animal to get a better grip in the soil when moving up or down steep slopes.

Another morphological adaptation is the body weight. Although no reliable measurements of body weight are available for the two species (Groves and Kurt 1972, van Strien 1974) it seems clear that the Sumatran rhino is the smaller, and the lighter, of the two. Moving uphill or downhill requires a relatively larger increase of energy expenditure for large animals than for small animals (Taylor et al. 1972).

Concerning their feeding habits the two species are nearly the same. Sumatran rhinos feed on the leaves and twigs of saplings and bushes, as well as on fruit (Borner 1979, Flynn 1983). The low incidence of fruit in the Javan rhino's diet in Ujung Kulon may be because of the relative scarcity of large fleshy fruit there. Flynn (1983) found that although most feeding sites of Sumatran rhinos living in closed canopy forest were recorded to lie under the closed canopy, the rhinos showed a strong preference for vegetation growing in forest gaps. This preference is similar to that of the Javan rhino observed in Ujung Kulon (see 4.1.3). Overall there appear to be few differences between the feeding habits of the two species.

Presently Sumatran rhinos are found mainly in remote mountain forests, although one population in Malaysia (Sungai Dusun) lives in secondary forest in lowland (Strickland 1967). Do Sumatran rhinos prefer mountainous areas because primary

forest is the dominant type of vegetation and because they are better adapted to feed in that type of vegetation? This would be surprising. I have argued above (see 4.1.4) that saplings growing under a closed canopy are better defended against herbivores than plants growing in unshaded locations through their higher fiber content, lower nutritional value and higher concentration of toxic compounds. The metabolic rate of an animal increased only as a function of body weight to the power of 2/3 (Kleiber 1969). Larger animals therefore require less energy per unit of body weight than smaller animals and can exist on food of lower quality (Jenis 1976). At the same time their larger body size enables them to tolerate larger quantities of toxins. It would therefore appear more likely that it is the Javan and not the Sumatran rhino that is better adapted to live in a forest environment. The fact that Sumatran rhinos are presently found mainly in remote mountain regions is most probably due to human hunting pressure.

In conclusion I consider it most likely that each of the two species is better adapted either to lowlands (Javan rhino) or to mountainous areas (Sumatran rhino) mainly through morphological adaptations. These adaptations led to the ecological dominance of one species over the other wherever the two occurred sympatrically.

5. ASPECTS OF SOCIAL ORGANIZATION

In this chapter some findings relating to the social organization of the Javan rhinoceros shall be presented. Because of the difficulties of observing rhinos (see 1.4) very little direct information on the social behaviour and interactions between individuals was obtained, so that much concerning their social organization must remain speculative. Yet some observations and comparison with other rhinos species provide clues to the social organization of the Javan rhino.

5.1 Sexual dimorphism of home range size and overlap of home ranges

The size and location of the home ranges of several rhinos have been described above (see 4.5). Here I shall discuss the different home range sizes of males and females as well as the degree of overlap between home ranges with regard to social organization.

5.1.1 Home ranges of male rhinos

The home ranges of three males (D, F and G) are shown in figure 5.1 together with the locations where isolated tracks of other males were found or parts of home ranges of other male rhinos. There is little overlap between the home ranges of the males D, F, G and the male with the measurements 26/27

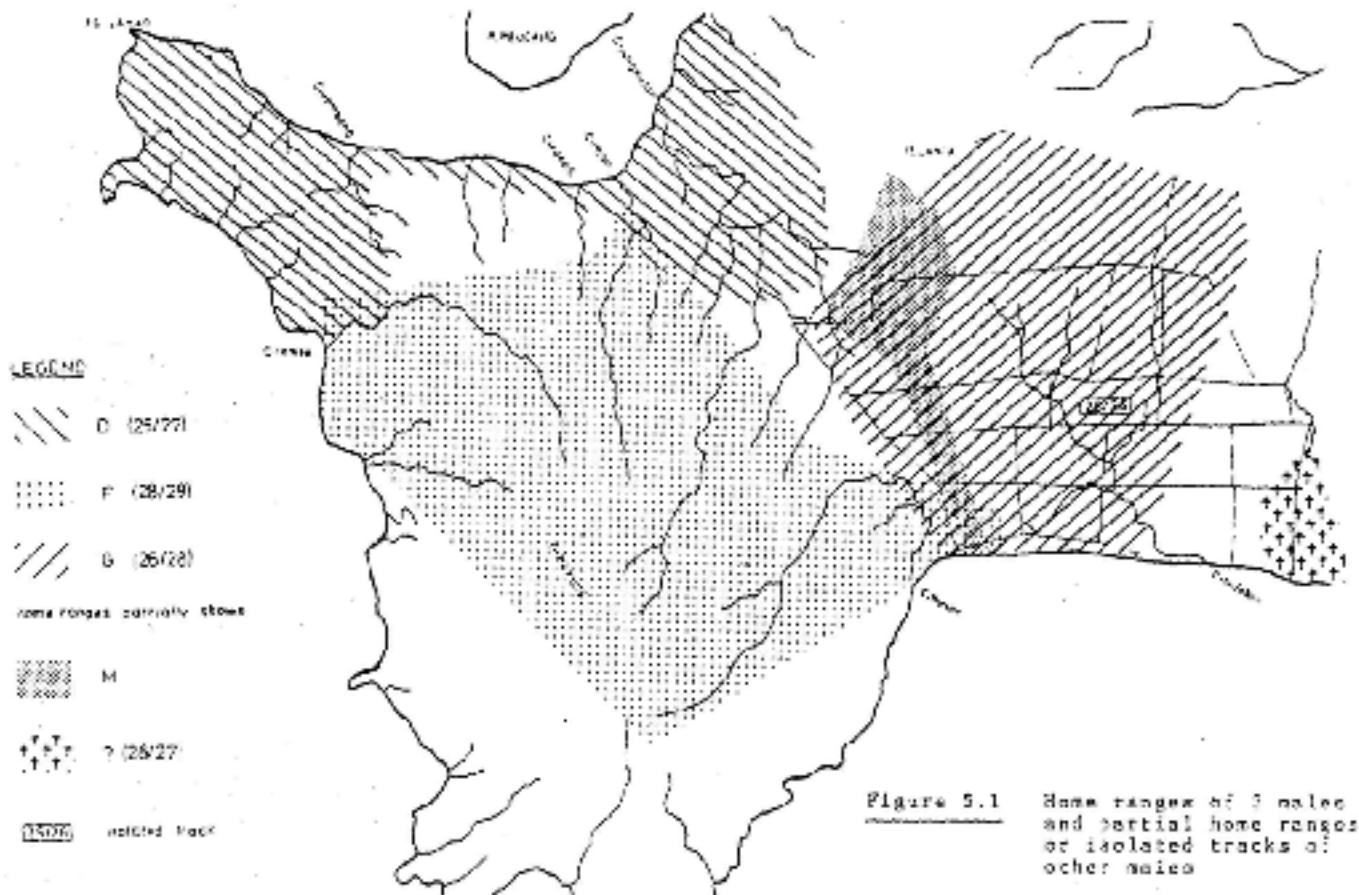


Figure 5.1 Home ranges of 3 males and partial home ranges or isolated tracks of other males

whose home range lay east of the study area. The only tracks of males found deep inside the home range of another male were those of M and of a probably still young male with the measurements 25/26. Some overlap was observed between the home ranges of males G and M. The main feeding areas of M lay to the north of the study area in the alluvial plain and on the Tolanca plateau. The narrow corridor leading towards the coast was probably only used when the rhino travelled to the coast in search of salt. The tracks of M were only rarely observed in the study area.

Very few observations were made of the tracks of F, and its home range was probably larger than shown in figure 5.1. Therefore, the overlap of the home ranges of D and F may have been somewhat more extensive. This, however, was not the case for the home ranges of F and G. The main patrol path that ran through the area of overlap was frequently travelled on, and from the few times the two males crossed over the path and the short duration of their stays on the other side it was concluded that the situation shown in figure 5.1 agreed with reality.

As was mentioned above (see 4.5), the observed home ranges of males were, on the average, considerably larger than those of females.

5.1.2 Home ranges of female rhinos

The home ranges of the females H, I, J and K/L are shown in figure 5.2 together with the locations where isolated tracks of other females were encountered. Female home ranges overlapped considerably more than the home ranges of males. The home range of the female I lay entirely within the home range of J and K/L. Female home ranges were smaller than the home ranges of males (see 4.5).

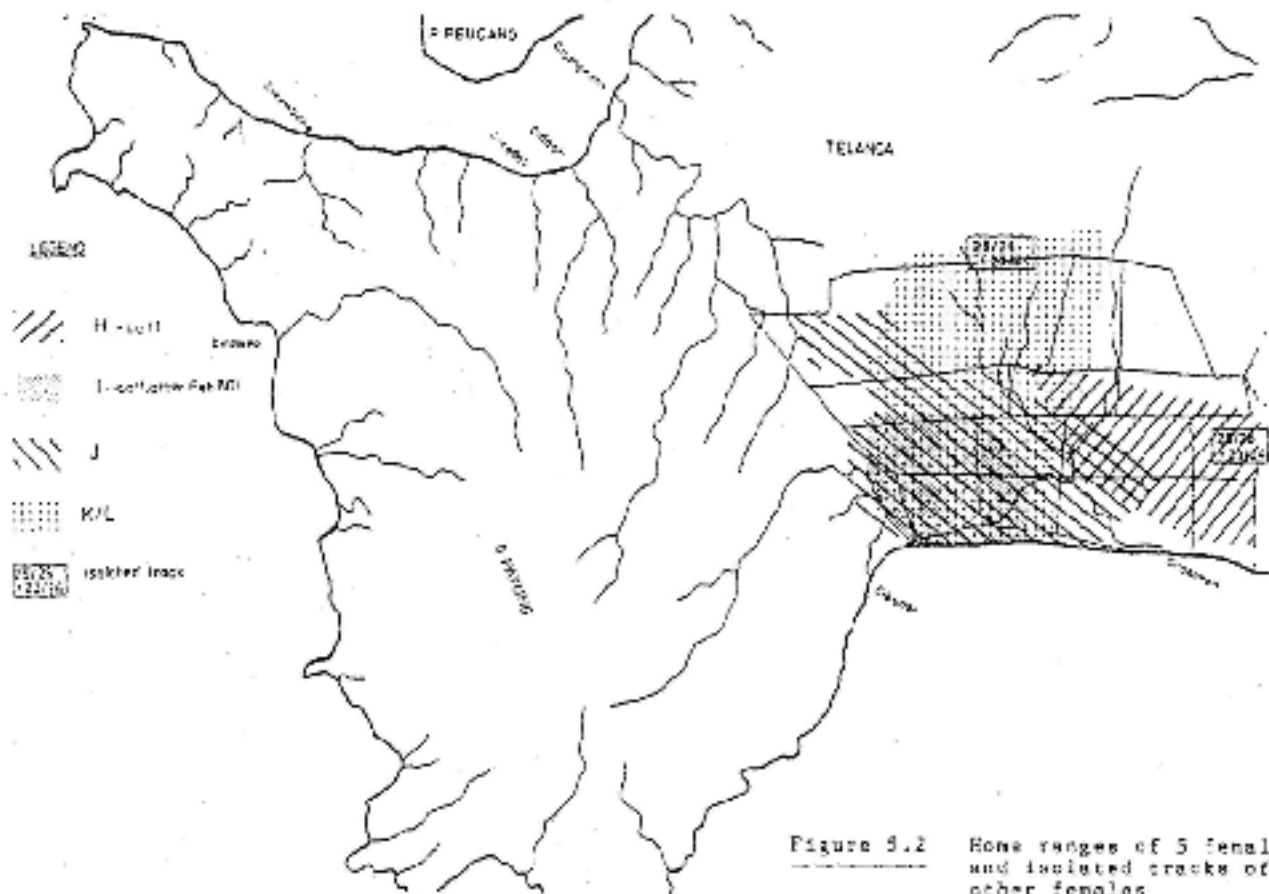


Figure 5.2 Home ranges of 5 females and isolated tracks of other females

5.2.3 Discussion

I will first discuss the different home range sizes of the sexes. This will lead to the question how the different degrees of overlap between home ranges of members of the same sex can be explained.

The home range of male Javan rhinos that were determined in this study, were, on the average, larger than female home ranges. McNab (1953) suggested that home range size could be correlated with the energy needs of an animal and its feeding habits (e. g. herbivorous, carnivorous etc.). In North American mammals body weight appears to be the most important factor that determines the size of the home range. Other factors such as the density of food resources or the number of conspecifics that use a certain area have a certain influence as well. Could weight differences between male and female Javan rhinos account for their different home range sizes (cf. Harestad and Sussell 1979)? Male Javan rhinos are not markedly larger than females (see 5.2) and both sexes appear to utilize the same food resources. It seems therefore that some other factor than differing energy requirements is involved.

Females have an upper limit to the number of calves they can have in a lifetime. They can maximize the number of their progeny by investing as much parental care as possible into each calf so that its chances of survival are maximized. Males who do not invest any parental care in their young and who can have a very much larger number of offspring compared to females, can maximize the number of their progeny by mating with as many females as possible. By increasing its home range relative to that of females, a male increases the number of different females it will meet. The different home range sizes of male and female Javan rhinos are probably to be explained by their different reproductive strategies.

Although, by having a larger home range a male may encounter more females, it still faces the competition of other males for these females. In order to reduce this competition and further enhance its own breeding success a male can deny other males access to females within its home range by maintaining dominance over its competitors. The question here is whether and what form of dominance exists among male Javan rhinos. Because of the lack of direct observations of the behaviour and interactions between males, I shall first consider the social organization, or rather the dominance hierarchy of two other rhinos species.

Male Indian rhinos can be classified into "strong" and "weak" males (Leunie 1978). These should not be viewed as two distinct categories but rather as the two extremes of a continuum. Practically only the strongest males are able to mate; weaker males are chased off when encountered in the presence of an oestrous female. Strong males do not exclude other males known to them -- both strong and weak -- from their home ranges. Strong males whose home ranges overlap tolerate each other and fights rarely occur between them. But when strange males enter the home range of another, especially a strong male, fights do occur.

Among white rhinos a territorial system has evolved. Males fall into one of two categories: territory owners and β males (Owen-Smith 1972, 1975). Territory owners maintain exclusive mating rights within their territory. Their behaviour differs from that of β males (e. g. territorial marking behaviour). Non-territorial males and passing owners of other territories are tolerated by a territory owner in his territory as long as they do not display territorial behaviour. When territory owners have to leave their territories, for example in search of water, they behave like β males in the territories of other males.

In view of the existence of dominance hierarchies among the males of other rhino species I consider it most probable that some form of dominance hierarchy exists among male Javan rhinos as well. The home ranges of males determined in this study scarcely overlapped. The situation shown in figure 5.1 suggests that these males were territory owners. On only a few occasions were the tracks of two other rhinos that squirted urine found inside the home range of one of the three males D, F and G. In one case the measurements indicated a young adult male (25/26); in the other cases it was the male M who occasionally travelled along the corridor to the coast. It is very likely that not all males that frequented the home ranges shown in figure 5.1 were recorded. This may be so because those males that were not recorded squirted urine much less frequently than the ones whose home ranges could be determined. This would imply that there are two categories of males that differ in the frequency with which they squirt urine. Assuming the latter were true, a dominance hierarchy similar to that in the white rhino could be proposed: On the one hand there are bulls of full status. These own territories in which they presumably maintain exclusive (or nearly exclusive) mating rights. They demonstrate their status by frequently squirting urine. On the other hand, there are the non-territorial males. These do not, or rarely, squirt urine. No statement is possible regarding the home range sizes of non-territorial males. Non-territorial bulls are tolerated within the territories of males of full status. Territory owners may pass through other territories as long as they behave as non-territorial males and do not squirt urine.

However, certain conditions of observation limit the validity of this conclusion:

Not all tracks that were encountered were followed over a long enough distance to clearly determine the sex of the rhino. (In fact in the majority of cases the tracks were not followed at all.)

Not all home ranges of the rhinos that frequented the study area were determined.

- Not enough tracks of different male individuals were followed, and the frequency with which they urinated determined.

It is possible that all males squirt urine frequently, and that other males besides those shown in figure 5.1 were not detected because of the small amount of time spent searching for them. If this were the case it would mean that the home ranges of males probably overlap in the same way as those of females. In this case the dominance hierarchy of male Javan rhinos would probably be more similar to that of the Indian rhino.

The presently available information makes a definite conclusion difficult. The situation as shown in figure 5.1 strongly suggests the existence of territories. However this may have been the result of the small number of home ranges that were determined. It may further be asked whether an old individual like male D (as mentioned, this male is presumed to have died in 1979) would be strong enough to defend a territory against competitors. The possibility of male Javan rhinos having a dominance hierarchy similar to that of the Indian rhino can therefore not be wholly excluded.

5.2 Sexual dimorphism

In this section two aspects of sexual dimorphism in the Javan rhino — body size/weight and the presence of a horn — shall be discussed.

Very few measurements of the body dimensions and weight of Javan rhinos have been taken. Hoogerwerf (1970) was of the opinion that females are larger than males, because the largest animals seen were always females. Guérin (1980) supported this view on the base of skull measurements from

which he inferred a smaller body size of males. Whether such inferences are valid is open to question. Guérin, for example, concluded from measurements of the post-cranial skeleton that the size difference between male and female Indian rhinos was very small. This is not supported by measurements taken from living, wild and captive, Indian rhinos (Lang 1961, Laurie 1978). The males of this species are considerably larger and up to 25 % heavier than females. It is possible that the females of the Javan rhino are, on the average, somewhat larger than males. Such a size difference, if it exists, is probably small. No statement can be made concerning any difference of body weight between the sexes.

There is some controversy concerning the size of the horn of male and female Javan rhinos. Former authors (see review in Hoogerwerf 1970) and Hoogerwerf (1970) claimed that females had only a small horn, in fact only a small hump. All rhinos observed by Schenkel and Schenkel-Hulliger (1969a) in 1967/68 had distinct horns and the two authors presumed that some of these must have been females, thus implying that at least some females carry horns. The only female I saw clearly had a small hump, while three adult males all had distinct horns. Recent photographs of female Javan rhinos (accompanied by calves) (Compost 1982, Honnert pers. comm.) showed them to have only small humps. I suggest that there exists a distinct sexual dimorphism regarding the size of the horn. Females have a horn but as a rule this has the form of a small hump. In exceptional cases a small horn may occur.

If in fact the sexual dimorphism, aside from the difference in horn size, is little pronounced in Javan rhinos and there exists a dominance hierarchy among males, this requires some explanation. If males fight for dominance their larger body size would be beneficial. In a closed environment with dense vegetation, however, a large body size might be detrimental

because of the energy costs involved in pushing a large body through the dense vegetation. The density of vegetation might also explain why male Javan rhinos do not develop pronounced skin folds in the region of the neck and throat such as the males of the Indian rhino. Such features probably function as optical signals (Laurie 1978). They would be of little value in dense vegetation where sighting distances are very small.

5.3 Groupings

5.3.1 Groupings of tracks

Whenever rhino tracks were encountered their number was recorded. The results are shown in table 5.1. In most cases solitary tracks were found. In about 20 % of the cases two or three (but never more) tracks of approximately the same age were found together.

Unless the identity of the individuals was known it was often not possible to estimate the length of their association. Such associations could either be permanent or temporary, i. e. lasting a few days at most. It was not even possible in

Table 5.1 Number of rhino tracks found together

	Solitary	Pairs	Triples	Total
Records	566	144	6	716
%	79.1	20.1	0.8	100.0

all cases to determine whether two (or three) rhinos had been moving together, or whether one rhino was following the other at a distance. A time difference of only a few hours would have been impossible to detect. In this latter case the one rhino could have been following the other rhino's track or both rhinos could have been travelling along the same animal trail independently without the following rhino being attracted by the first rhino's track.

In some cases a more precise interpretation was possible, however. Permanent associations existed between cows and their calves. About one half of the records of pairs of tracks were of this type. One permanent association between two adult females was observed (the pair (K/L)). It is likely that this was an old female accompanied by her last calf, now adult. Temporary associations between a male and one or two females were recorded. The duration of associations between males and females lasted 4 days or more (see 5.5). Temporary associations were further observed to occur between a cow/calf pair and a subadult individual (see 5.6.2). Hoogerwerf (1970) observed temporary associations between two adult males. Multiple tracks of adults were not always investigated closely and it is possible that some of these were associations between males.

5.3.2 Loosely associated groups

Schenkel and Schenkel-Hulliger (1969a) thought they had evidence of some form of loose association between several rhinos. Their observations indicated that on some occasions several rhinos had moved into an area almost at the same time and also left it again simultaneously, though they did not move together as a close group. To investigate this question, the movements of all rhinos in the study area were monitored simultaneously. On each patrol of the study area (description

of patrols (see 2.1.1.2) all tracks found were marked on a map together with the date on which the rhino was estimated to have crossed the patrol path. Tracks with the same measurements, which appeared to belong to the same individual but found in different places or on different patrols, could then be connected together to give a rough picture of each rhino's movements.

For each month during which the study area was patrolled a map was made. An example is shown in figure 5.3. There appeared to be no coordination of movement among any of the rhinos except for pairs which were associated over long periods such as cows and their calves or the pair of females K/L. Maps made for the other months showed similar results.

The number of rhinos present in an area may fluctuate quite widely as shown above (see 2.2.1.2). The observations made by Scheckel and Schenkel-Hulliger may have been of this natural fluctuation caused by the uncoordinated movements of the rhinos in that particular area. It is also possible that the rhinos left the area at the same time because of the presence of humans. In this case their movement would have been a common reaction to a disturbance but not coordinated movement.

5.4 Communication

In higher vertebrates intraspecific communication transmits information on motivational state and intentions (Leuthold 1977) as well as individual identity and social status. This information is transmitted through a variety of signals which can be classified, for example, according to the channel through which they are perceived: visual, acoustical, olfactory and tactile (Leuthold 1977).

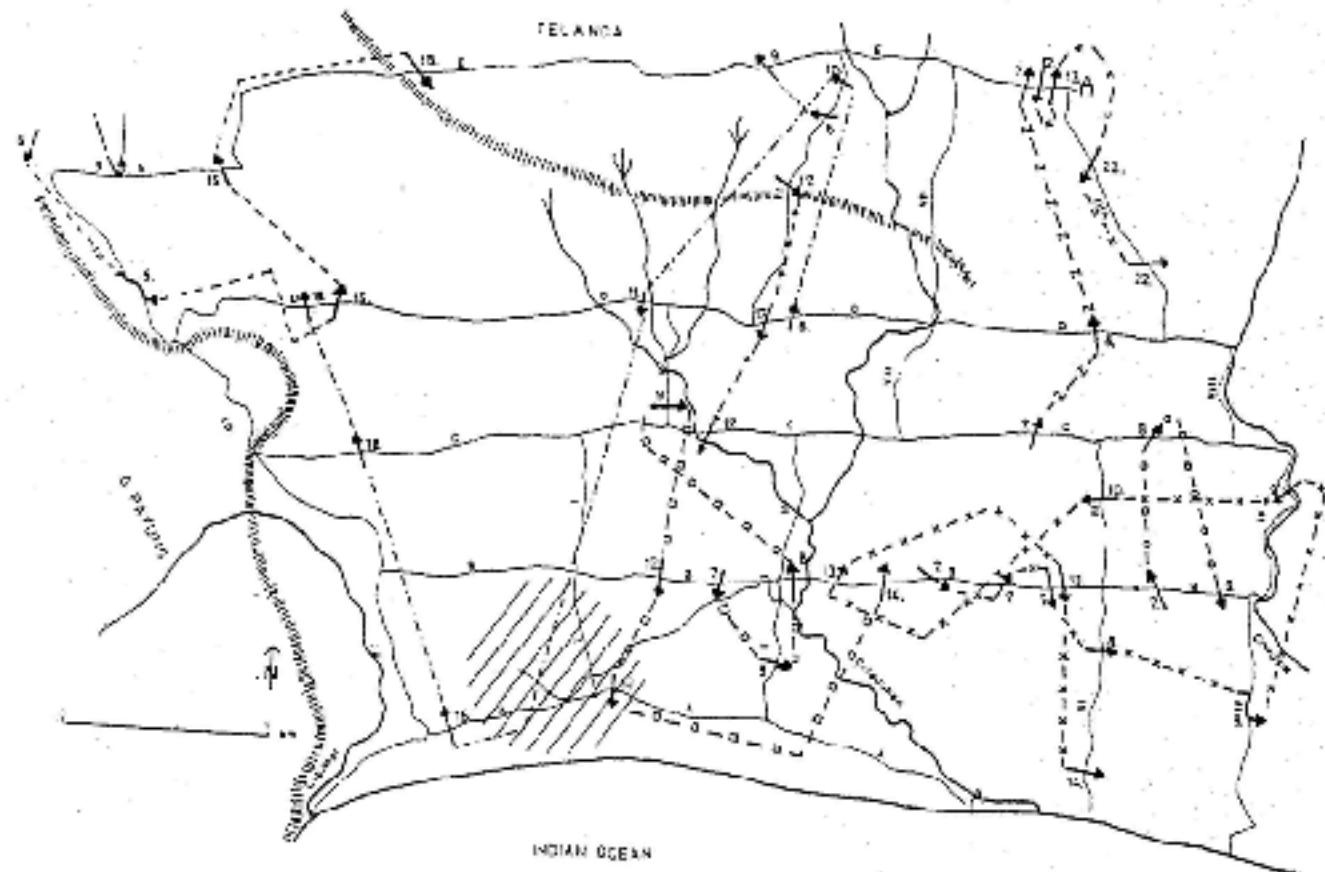


Figure 5.3 Movements of rhinos in the study area, 6.-22. February 1960

Legend to figure 5.3

- direction and estimated date of passage
- x-x- connection between two sightings. This does not represent the exact route of the rhino
- 26/28 ♂ (G)
- _____ 25/26
- 26/27 + 25/25 ♀♀ (K/L)
- - - 24/25 + 23/24 ♀ (H + calf)
- 26/27 + 23/25
- o-o- 26/27
- +-- 25/27 1/2
- 2-2- 25/26
- o-o- 24/26
- o-- 24/26
- /// 25/27 ♀ (I + calf): the tracks were sighted repeatedly between 9. and 25. February within the area shown. The route of the pair could not be reconstructed.

Communication may be direct either when two animals are in the vicinity of each other or the time lag between production and reception of the signal is short (e. g. vocal communication over a distance). Animals may also communicate indirectly when they are not near each other. In this case the signal is the more or less lasting product of the actor's behaviour, i. e. a mark which may act in releasing reactions in conspecifics. Visual and olfactory marks are frequently used in indirect communication. (I use the term olfactory mark here to include all substances produced by special glands or whose deposition is accompanied by special forms of

behaviour (cf. Schenkel 1966)). Indirect communication and the setting of marks are of considerable importance in species where direct encounters between conspecifics are rare.

Direct communication between Javan rhinos was rarely observed. Only some few vocalizations were heard during this study, which are described in 5.4.1. Visual or tactile signals were not observed at all although, most probably, they occur. The communicative function of urination and defecation is treated in 5.4.2.

5.4.1 Vocalizations

Several different vocalizations were heard during encounters with rhinos. A description of each vocalization is given below followed by the context in which it was heard and an attempt at interpreting its function.

- "Neigh"

A sound like the neighing of a horse but without the staccato. It is high-pitched but not as high as a shriek. This was heard once from a male rhino that a short time previously had encountered a track of a female and then heard the observer's movement. After producing the sound the rhino approached the observer until, at a distance of approximately 20 m, it suddenly turned and fled, presumably upon catching the human scent. It is quite likely that the rhino combined the scent of the female with the sound of the movement caused by the observer and reacted to this situation by calling. The function of the neigh is probably to establish direct contact over longer distances. This sound corresponds to the "loud blowing whistle" described by Schenkel and Schenkel-Halliger (1969a, Schenkel and Lang 1969).

- "Bleat"

A sound like the bleating of sheep but shorter. This was heard three times: twice from a cow/calf pair and once from the pair of adult females K/L. It is not clear whether it is the cow, its calf or both that bleat. This appears to be a contact sound used in the cow/calf bond.

- "Snort"

A sound like air being pressed out explosively through the nostrils; reminiscent of a steam engine. Snorts are emitted either separately or as a series of snorts following each other rapidly. This sound was invariably heard when rhinos fled after encounters with the observer. On two occasions it was produced by rhinos that had heard the approaching observer but not yet caught his scent. This sound is probably produced mainly in reaction to disturbances. It may signal defensive excitement but possibly also contains an aggressive component (defensive threat).

- "Scream"

A very high-pitched sound emitted with great force. This was heard only once when a rhino made a short charge toward the observer, after which it turned and fled. It is most likely that in this case the rhino had neither heard nor caught the scent of the observer until he was only 5 meters away. The charge may have been a reflex action as the rhino suddenly became aware of the proximity of the observer. Screams are probably a more intense form of the snort, in which the motivational component of fear predominates.

- "Lip-vibration"

A vibrating sound reminiscent of the sound produced by horses by vibrating their lips. It was heard once from a feeding rhino that was unaware of the observer's presence. The "lip-vibration" probably has no communicative function, but rather belongs into the context of contact behaviour.

5.4.2 Olfactory signals

5.4.2.1 Urination in the context of communication

Beside its basic function of excretion, urination also plays a role in communication between rhinos. Urine transmits information on the identity of the maker, on the phase of the oestrous cycle of females and possibly also on the social status of males.

Both male and female Javan rhinos regularly urinate when wallowing. The mud with which they cover themselves is thus heavily impregnated with urine and is left as a scent mark wherever it is scraped off onto the vegetation (Schenkel and Schenkel-Hulliger 1969, Hoogerwerf 1970).

Aside from this, however, males and females show different patterns of urination. These patterns have been described above (see 2.1.2.3). The males whose tracks were followed during this study squirted urine frequently while travelling. The male emitted one squirt or a series of squirts while it walked a few meters between each squirt. These series were repeated at intervals of fifty to several hundred meters; the average for males that were not following the tracks of a male was 163 m. The urine was squirted mostly in medium dense to dense undergrowth, so that the droplets were caught by the vegetation above the ground. There may be a bias in this observation as urine droplets on the ground may be more difficult to detect. However, the fact that male rhinos squirted urine often just after passing through very dense vegetation, which ensures that the urine falls on the vegetation and not on the ground, indicates that the foregoing observation is correct (the same observation was already made by Schenkel and Schenkel-Hulliger (1969a)).

Subadult males probably do not squirt urine regularly. This was observed in a subadult that was tracked over a distance of almost 2 km. An adult, but probably young, male (footprint measurements 25/26) was noted to have squirted urine.

Male rhinos not only squirt urine while travelling, but also in reaction to an encounter with the tracks of other rhinos or with man. Male D squirted urine upon encountering the fresh track of another rhino. The subadult male mentioned above did squirt urine after it had caught the observer's scent and fled. It had not squirted urine over the 2 km it travelled before the encounter, however. Possibly rhinos also squirt urine in direct encounters with other rhinos.

Males that followed a female squirted urine more frequently than when travelling alone (see 5.5). Squirting urine apparently plays a role in the temporary associations between males and females.

Females urinate much less frequently than males, about two to three times per day.

5.4.3.2 Defecation in the context of communication

From observations made in other rhino species it may be concluded that in the Javan rhino as well, defecation not only has the function of excretion but also a communicative function. Dung probably not only conveys the information that a member of the species passed by but possibly also on the identity of the rhino that defecated and, in the case of females, in which stage of the oestral cycle they are.

Javan rhinos defecated when standing still, depositing their balls of faeces in a small heap. Occasionally, just before stopping for defecation, the rhino may sway a foot and

produce a scrape mark. After defecating the rhino walks away without kicking, scattering or scraping the dung with its feet. Males and females do not differ in the manner they deposit dung.

Two aspects of defecation which appear important in the context of communication will be treated here: the location of dungheaps and the tendency to defecate onto previously deposited dung, i.e. the tendency to form piles.

The locations where dung heaps were found are summarized in table 5.2. The location "ridge" was placed in one category together with the location "trail", since in steep terrain ridges frequently offer the easiest routes for travelling and usually animal trails are found on them. There is a bias towards the detection of dung deposited on trails (especially

Table 5.2 Location of dung heaps

Location	Dung heaps	%
In or next to water	206	59.9
On or next to trails (animal and man-made)/ridges	76	22.1
Acacia forest	33	9.6
Other*	29	8.4
Total	344	100.0

* open meadows, forest, shrub vegetation away from trails and water

man made) as these trails were frequently used by the observer and dung heaps deposited there were more likely to be encountered than dung deposited elsewhere. Most of the dung heaps were deposited in water -- usually running water, but occasionally in stagnant rivulets or pools as well. Another large percentage was found on or next to trails -- both animal and man-made -- or on ridges. About 10 % were found in Arenga forest, in most cases in small patches of this vegetation type situated on top of hills. No dung was ever found in willows. These results concur with the observations made by Schenkel and Schenkel-Hulliger (1969a).

Seventy-nine dung heaps (= 23 % of all dung heaps) were found in piles (I call a pile a group of dung heaps all within a circle of 10 m diameter). 34 piles were found, with an average of 2.3 heaps per pile (26 piles with two heaps, 5 with three, 3 with four).

When tracking a rhino I recorded its reaction to rhino dung it encountered -- that is whether it defecated within 10 m of that dung or not. It could not be determined whether the encountered dung had been deposited previously by the rhino being tracked or by another individual, so that it was not possible to say whether rhinos react differently to their own dung than to that of other rhinos. The results are shown in table 5.3. On 40 % of the occasions when a rhino encountered dung it defecated as well. In groups of adult rhinos (pairs/triples) this tendency was somewhat lower (28.6 %). There was no significant difference between males and females in their tendency to defecate onto other dung.

In two cases the growth of dung piles could be followed. The first increased to four dung heaps, the other to three dung heaps, both within a period of two months. Thereafter, until the end of the study, four months later, no more dung was added although rhinos passed by these spots on several occasions.

Table 5.3 Reaction of (tracked) rhinos to dung

Category	Defecate	Do not defecate
Solitary males	9	12
Solitary females	7	0
Male/female groups	4	10
Cow/calf pairs	2	3
Total	22	33

5.4.2.3 Reaction to tracks of and wallows used by other rhinos

Javan rhinos do not impregnate the soles of their feet with dung like the black rhino (Schenkel and Schenkel-Hulliger 1969b) or male white rhinos (Owen-Smith 1975). However, pedal scent glands have been described from the genus Rhinoceros the secretion of which impregnates the soles of the feet (Cave 1962). The effect of impregnation of the feet either with dung or the secretion of the pedal scent gland is that rhinos leave a strongly scented trail behind them. Goddard (1967) showed that black rhinos can distinguish the tracks of different individuals. The same is possibly also the case for the two species of Rhinoceros.

I recorded the reactions of solitary rhinos, whose tracks I followed, to other rhino tracks they encountered. The results are summarized in table 5.4.

Table 5.4 Reaction to tracks of other rhinos

Reaction	fresh tracks (< 24 h)	old tracks (> 24 h)
no reaction	2	27
follow short distance (< 25 m)	4*	1
follow longer distance (> 25 m)	4	-
wallow**	1	-
defecate***	2	1
Total	15	31

* On one occasion a (male) rhino squirted urine upon encountering a fresh track, and then followed it a short distance.

** On all three occasions when rhinos encountered freshly used willows they wallowed in them as well. The tracks of the rhino that had been there first were not followed.

*** In all three cases the rhino defecated in reaction to dung deposited by the first rhino, but did not follow its tracks.

Tracks that were older than 24 hours elicited no reaction from the second rhino or, at most it followed them for a few meters only. When it encountered a track that was less than 24 hours old it was more likely to follow that track, sometimes over distances up to several hundred meters. On one occasion a male that encountered a fresh track of a female followed until it caught up (see 5.5). It is interesting to note that fresh tracks were always followed in the "right"

direction, that is in the direction the first rhino had travelled. With older tracks this was not always so. This suggests that fresh tracks have an olfactory polarization which disappears as the tracks age.

In the three cases observed when a rhino came upon a freshly used wallow it wallowed there as well. After wallowing, the second rhino did not follow the tracks of the first rhino but left the wallow in a different direction.

On three occasions a rhino came across a track in a place where the first rhino had defecated. In all cases the second rhino defecated as well but did not follow the track of the first rhino.

5.4.3 Discussion

The small number of signals used by Javan rhinos in direct communication that were recorded during this study does not imply that Javan rhinos do not possess a larger repertory of signals. A wide range of visual (movements of the ears and mouth, body postures and forms of locomotion) and acoustical signals has been described for the black, white and Indian rhinoceroses (Schenkel and Lang 1969, Schenkel and Schenkel-Hulliger 1969b, Owen-Smith 1973, Laurie 1970). It would not be surprising if a larger number of visual, acoustical and tactile signals than described here could be observed in Javan rhinos given adequate possibilities of observation.

In the Javan rhino indirect communication is achieved through olfactory marks which are produced when urinating or defecating or by the secretion of pedal glands. No visual marks such as the twisting of trees by the Sumatran rhino (Borner 1979) or the smashing of bushes by the black and

Sumatran rhino (Schenkel and Schenkel-Hulliger 1969b, Horner 1979) were observed during this study (but cf. Schenkel and Schenkel-Hulliger 1969a).

The olfactory marking behaviour of *H. sondaicus* is somewhat different from that of the other rhino species. As mentioned previously Javan rhinos do not impregnate their feet with dung by scraping or kicking it like the black rhino (Schenkel and Schenkel-Hulliger 1969b) or male white rhinos (Owen-Smith 1975). This difference of behaviour probably stands in connection with the presence of pedal scent glands in the genus *Rhinoceros* (Cave 1962). Both the Indian and Sumatran rhino rarely scrape their hindfeet in dung (Laurie 1978; Horner 1979, it is not known, however, whether the latter species possesses pedal scent glands).

All rhino species except the Javan rhino show a strong tendency to defecate onto or near other rhino dung they encounter, so that over time piles of dung develop. In the Sumatran rhino Horner (1979) found that almost 83 % of all dung heaps had been deposited onto piles and in the Indian rhino Laurie (1982) registered 89 % of all dung heaps on piles. Both white and black rhinos defecate mainly onto piles (Owen-Smith 1973, Schenkel and Schenkel-Hulliger 1969b). In this study dung piles were found only rarely in Ujung Kulon and none was composed of more than four heaps. Only 23 % of all dung heaps were found on piles. Schenkel and Schenkel-Hulliger (1969a) and Hoogerwerf (1970) found piles of up to 15 heaps in Ujung Kulon, however, Hoogerwerf was of the opinion that rhinos defecated more often away from piles than onto them. The former existence of large dung piles made by Javan rhinos has been reported by some authors but others did not support this view (review in Sody 1959). It is possible that dung piles are built up in areas of very high population density (Schenkel and Schenkel-Hulliger 1969a). The degree to which the movement of rhinos is canalized may

play a role as well. In many parts of Ujung Kulon rhinos are not restricted by topographical features to the use of certain routes. Whereas, in mountainous areas, rhinos are often forced to travel along trails, and consequently dung is deposited comparatively frequently there. Therefore, dung heaps in these locations are likely to be encountered again by rhinos which add to them.

In other rhino species the squirting of urine by males often forms a component of more complex behavioural sequences to produce olfactory markers. In the Sumatran rhino it is occasionally associated with tree-twisting behaviour (Borner 1979), in the Indian rhino with the breaking of vegetation and the production of scrape marks (Laurie 1982); in the black rhino it often forms part of the complex bill ceremony (Schenkel 1966, Schenkel and Schenkel-Hulliger 1968b) and in the white rhino it is often associated with horn wiping and the production of scrape marks (Owen-Smith 1973). In the Javan rhino urine squirting does not appear to be associated with any other form of marking behaviour.

In the white rhino only territorial bulls squirt urine (Owen-Smith 1973); in the Indian rhino males of high social status squirt urine more often than males of lower status (Laurie 1982). In this study the males U and G were found to squirt urine frequently while travelling. Inside the home ranges of these males, other males that squirted urine were observed only rarely. It is possible that in Javan rhinos -- similar to Indian rhinos -- only high ranking bulls squirt urine frequently and that males D and G belonged to this category. More males may have been present inside their home ranges but were not recorded because they squirted urine only rarely.

5.5 Temporary associations between males and females

Twice groups of rhinos that consisted of one male and one or two females were tracked. In both cases the male involved was the male G.

- A) The male G whose track had been followed since the previous day was encountered and fled upon catching our scent. Just before this encounter the rhino had come across a fresh track with the measurements 25/26 which later turned out to be that of a female. From that point on the two tracks stayed together for four days. Then the two rhinos were encountered together. Both rhinos fled upon catching the observer's scent. The tracks remained together for another two kilometers and then separated.

Since only the male alone was met in the first encounter and both rhinos together in the second, it follows that the male must have caught up with the female. Where the male had joined the female could not be deduced from the tracks. The subsequent separation of the two rhinos was probably not caused by the human disturbance, since after the second encounter with the observer the two rhinos had wallowed together.

- B) The fresh track of the male G was found in the company of two other tracks of approximately the same age. These subsequently turned out to be the pair of females E/G. The male was following the female with the smaller footprint measurements. This trio could be tracked without interruption for five days when the pursuit had to be broken off. At this point the tracks were 24 hours old. As the rhinos had probably been together at the time when their tracks were encountered for the first time and still were together when tracking was discontinued it must be concluded that they stayed together for more than four days.

In both cases the track of the male followed that of the female relatively closely but not exactly. The two tracks separated quite often up to 50 meters from each other and over travelled distances up to 100 meters. The rate of travel per 24 hours was very low in case A (see table 4.13). In case B it corresponded to the rate of solitary rhinos.

The male squirted urine about twice as frequently when following a female than when travelling alone, i. e. once every 86 m on the average (cf. 5.4.2.1). (From the height at which urine droplets were invariably found, it was clear that only the squirting of urine by the male was recorded. In other rhino species females have been observed to squirt urine during oestrus (Schenkel and Lang 1969, Owen-Smith 1973). This was not observed in the Javan rhino during this study. Since the females of other rhino species squirt smaller quantities of urine and less vigorously than males it is possible that traces of this activity in female Javan rhinos were overlooked).

In some places traces indicated that some form of interaction had taken place: the tracks led in all directions and the vegetation in the vicinity had been trampled. It did not appear as if the latter had been done intentionally, e. g. as some form of display. Rather, it seemed that in the course of intense activity the rhinos moved around without paying attention to any obstacles such as during normal travel movement. (Similar observations were made by Borner (1979) along the tracks of a cow and a bull that were travelling together). The association between the male and the female(s) lasted four days in the first case and more than four days in the second.

I interpret these associations to have been between a bull following a cow in oestrus with the intention to mate with her. Because of the limited number of observations that were made, it is not possible to give a complete description of the courtship and mating behaviour of the Javan rhino. The information presented above will be discussed with reference to the known behaviour of other rhino species.

Female rhinos that come into oestrus probably transmit this information to males through substances in their urine

(Schenkel and Lang 1969, Owen-Smith 1973). In captive Indian rhinos the female in oestrus was observed to squirt urine frequently and emit a certain vocalization (Schenkel and Lang 1969). Once the oestrous female has been joined by a male there follows a consort period (Owen-Smith 1973) which lasts several days (Goddard 1966, Schenkel and Schenkel-Hulliger 1969b, Owen-Smith 1973, Laurie 1978). Possibly this phase is a result of the necessity for the partners to become familiar with each other. Possibly also the female tests the strength or social status of a male during this period. In *R. unicornis* attempts by the male to approach the female during this phase develop into noisy chases and fights (Schenkel and Lang 1969, Laurie 1978). Schenkel and Lang were of the opinion that between partners which are unfamiliar with each other chases and fights serve to define the role of each partner in the last phase through reciprocal stimulation. Laurie interpreted the function of these fights to be an advertisement of the situation to other males in the area. In this manner the strength of the male is tested. If a stronger male than the one following the female were in the area, it would presumably be attracted by the sounds of the chase, drive the first male away and attempt to mate itself. In the two African species aggressive interactions in the consort phase are little pronounced (Goddard 1966, Owen-Smith 1973). In the white rhino the female tests the social status and physical vigour of a male by attempting to leave his territory during the consort phase. The male demonstrates his status by successfully keeping a female from leaving his territory (Owen-Smith 1973).

The consort period is terminated after the female finally lets the male mount and copulate. In the white and Indian rhino the pair separates shortly after copulation (Owen-Smith 1973, Laurie 1978).

The associations between a male and (a) female(s) Javan rhino(x) described above, were interpreted as associations between a bull and an oestrous cow. The duration of the associations suggests, (from comparison with other rhino species, that copulation is preceded by a consort period. In case A above it could not be determined from the traces left by them, if or when the two animals had copulated. In case B the rhinos probably copulated after tracking had been stopped.

Hoogerwerf (1970) mentioned several incidents of fighting between rhinos of opposite sex, but only in one case did he actually see the rhinos involved and was able to sex them. During this study no signs of fights or chases between male and female rhinos were observed or heard. The traces along the tracks of male/female associations which indicated that some form of interaction had taken place did not point to violent aggressive interactions. It is possible that fights and noisy chases are not a regular component of the courtship of the Javan rhino. There is no benefit for the female in trying to advertise the situation by vocal signals in dense vegetation where they will be heard only from a short distance.

In the white rhino almost only territorial bulls mate with oestrous females (Owen-Smith 1975). In the Indian rhino it is assumed that most matings are carried out by "strong" males (Laurie 1978). Most probably in the Javan rhino as well, the majority of matings are carried out by males of high social status, i. e. males that rank high in the dominance hierarchy of the owners of territories.

5.6 The development of young rhinos

Though the tracks of several young rhinos were encountered in the study area, only two were born by females whose home

range lay mainly in the study area. The tracks of these calves were found regularly. This allowed following the development of the footprint sizes of these two calves and correlating them with the age of the calf. Also the observations made of these two calves combined with isolated observations from other calves and subadult animals permit to give a rough outline of changes of the cow/calf bond.

5.5.1 Development of track sizes of calves

The development of the track measurements of two calves is shown in table 5.5. Calf 1 (accompanying female II) was encountered for the first time in October 1978, calf 2 (accompanying female I) in February 1980 and the growth of their foot measurements was recorded until the end of the study.

The age of each calf at the time of the first encounter was not known and had to be estimated. For this purpose the measurements taken from calves of *R. unicornis* raised in the Basel zoo were used as a reference (table 5.5). In the Indian rhino a forefoot width of 15 cm corresponds to an age of 2 - 3 months. Two months before the tracks of calf 2 were encountered for the first time, the unaccompanied tracks of its mother (female I) were seen for the last time. The calf with a forefoot width of 15 cm was therefore estimated to be somewhat less than 2 months old in February 1980. Calf 1 was older when encountered for the first time. Its presumed forefoot width of 19 cm would have corresponded to an age of 5 - 6 months in the Indian rhino. However, calf 2 was already 4 - 5 months old when the size of its forefoot reached 17 cm. The forefoot of this calf grew 2 cm (from 15 to 17 cm) in somewhat less than three months.

Table 5.5 Footprint measurements of two *B. sondaicus* calves and one captive *B. unicornis* calf

<u>Calf 1</u>		<u>Calf 2</u>		<u>B. unicornis*</u>	
Size (cm)	Days since first measurement	Size (cm)	Days since first measurement	Size (cm) (forefoot)	Age (days)
18/--	0	14/15	0	12.0 - 12.5	30
18/19	61	14/15	10	14.0 - 14.5	63
20/--	111	16/17	96	16.0	90
21/--	369			16.5 - 18.0	123
21/--	385			18.0 - 21.0	150
23/23	438			18.0 - 20.0	150

* Measurements taken from captive rhinos in the Basel zoo (Schenkel and Schenkel-Hulliger 1949a, Hoogerwerf 1970). Ranges of measurements taken from several calves are given.

Assuming it takes another two to three months for the forefoot to increase from a width of 17 to 19 cm, the age of calf 1 at the time it was first encountered was about 7 months.

Proceeding from these estimates and the information available in table 5.5 the ages corresponding to certain footprint sizes of calves can be estimated (table 5.6). Such an estimate can only be considered a rough approximation, however. The measurements taken from Indian rhino calves in the Basel zoo show that considerable variation may exist between different calves of the same age (table 5.5).

5.6.2 Changes of the cow/calf bond

At what age calves separate from their mothers is not known. In the black and Indian rhino this happens around the time of parturition of the cows next calf (Schenkel and Schenkel-Hulliger 1969b, Laurie 1978); this is most probably also the case in the Javan rhino. Calf 1 was still together with its mother at the age of 22 months.

Table 5.6 Forefoot width of Javan rhino calves and corresponding estimated age

Age (months) (approximate)	< 2	4	7	12	18	> 22
Width (cm)	15	17	19	21	22	24

After separation the juvenile may leave the home range of its mother. The following two observations were made in this context:

- In June 1978 the tracks of a subadult male (measurements 23/25) were found near the western edge of the study area. The animal was alone. Its tracks were never encountered again later.
- In January 1980 tracks measuring 23/24 were found in the western part of the study area. No tracks with these measurements had previously been seen in that area either alone or accompanied by another rhino. This animal was most probably a subadult that had separated from its mother and left its previous home range. Its tracks were sometimes seen alone or on some occasions in the company of the tracks of the female I and her calf.

The second observation indicates that subadults, after leaving their mother, may temporarily associate with some other adult female. Female subadults probably do not always leave the home range of their mother but remain close to it (see 4.5.3). In the black rhinoceros subadults were sometimes observed to rejoin their mother sometime after the next calf was born (Guggisberg 1966, Schenkel and Schenkel-Hulliger 1969b).

Occasionally a rhino may remain with its mother long after having reached adulthood. Conceivably this may happen if the female is old and has no further calves anymore, or when the female has lost a younger calf (Schenkel and Schenkel-Hulliger 1969b). The pair of adult females K/L is probably an example of such a persisting cow/calf bond. Laurie (1978) recorded one case in the Indian rhino where a subadult male rejoined its mother after the next calf had died.

6. REMARKS ON THE CONSERVATION OF

 THE SPECIES

The ultimate aim of any conservation measures undertaken for the benefit of a species should be to ensure its long-term survival in its natural habitat. Which measures are to be implemented depends upon, among other things, the actual situation of the species, e. g. to what degree the species is threatened with extinction or which factors are endangering its survival. Therefore, some aspects of the Javan rhino's present situation will be briefly recapitulated here. Following this, several conservation measures will be discussed most of which have been proposed earlier by various authors (Schenkel and Schenkel-Hulliger 1969a, Hoogerwart 1970, Blower and van der Zou 1977, Schenkel et al. 1978, Schenkel and Schenkel 1982).

Due to the relative remoteness of Ujung Kulon and the, up to present, efficient guarding there, the situation of the Javan rhino has improved considerably and its population size more than doubled in the last 17 years. The population has reached a size which can be considered sufficient for short-term survival (Franklin 1980). However, the species' long-term survival is by no means guaranteed and it must still be considered highly endangered. Because of its small population and the fact that Ujung Kulon probably harbours the only remaining population, the Javan rhino faces the possibility of extinction through various causes -- catastrophic events (natural disasters, extreme drought periods, disease), poaching, demographic instability and inbreeding depression (reduced fecundity and viability).

Conservation measures should, therefore, be aimed at (1) increasing the number of Javan rhinos and (2) increasing the number of local populations. Concretely this means that optimal conditions in Ujung Kulon should be provided so that the population there increases to the maximum possible size (subject to the limit of the carrying capacity of the environment), and that a group of rhinos from Ujung Kulon should be translocated to another reserve in order to start a new population there.

Protection

One of the most effective conservation measures to increase population size is the protection of a species. Experience has shown that efficient protective measures lead to positive results within a short time. After the improvement of the guard system in 1967 poaching, which apparently constituted a serious mortality factor before 1967, was virtually eliminated. As a result the population increased considerably after 1967. Every effort should therefore be undertaken to protect the rhinos in Ujung Kulon from poaching in the future, in order to avoid any serious decrease of the number of rhinos.

Javan rhinos should also be protected to a certain extent from disturbances by humans. Because of a long history of poaching pressure, rhinos have become highly sensitive to human scent. Fresh human scent elicits flight reactions in rhinos and repeated contacts may cause them to leave the area (4.6.4). Although there is very little evidence, still it seems that the rhino's reaction to man has diminished somewhat in recent years. Especially notable is the fact that rhinos do not avoid fixed human installations such as buildings or trails. It is possible, however, that females with calves avoid areas frequented by humans. It was observed in 1978 that a cow/calf pair left the area east of Kalijetan after it had been visited repeatedly by humans during one week and the pair never returned again during the period of

this study. Human presence might also disrupt matings by causing male/female pairs to separate during the pre-mating phase (but cf. 5.5. case A). Human disturbance should therefore be reduced to a minimum to avoid rendering areas unsuitable for rhino reproduction. This pertains principally to tourism which should be restricted to trails and areas of lesser importance to rhinos such as the grazing grounds or the coast. Minor intrusions on the other hand — patrols by the guards or the presence of researchers — will have little influence. Measures in this direction, namely the establishment of different zones with various degrees of access, have been proposed in the FAD management plan for Ujung Kulon (Blower and van der Zee 1977). If future observations should indicate that the Javan rhinos have become accustomed and are not disturbed by the presence of humans, restrictions on access could be revised.

Monitoring

Protection alone, however, is not sufficient. It is necessary that the future development of the rhino population and its environment be monitored regularly in order to evaluate the effect of conservation measures and also to detect negative developments at an early stage. Monitoring should be carried out by a trained biologist, preferably someone who has some knowledge of the Javan rhino or at least of Ujung Kulon. Visits to the reserve should be made at least once a year; a census of the population should be carried out at least once every two years. It is suggested that different census methods be used in order to evaluate their efficiency through comparison. One possibility has been shown in this study (see chapter 2).

Research

It is highly recommended that further research be carried out in Ujung Kulon. Two environmental factors have been suggested

to be responsible for the decline of population growth since 1975: vegetational changes and competition by banteng for foodplants. Research on vegetation patterns and dynamics is necessary. It needs to be known, for example, how large the area of shrubland available to rhinos is. Practically no information on the direction and speed of successional development is available. Research on the feeding ecology of the banteng, so that its role as a food competitor of the Javan rhino can be judged more accurately, has been postulated above (see 4.3.1). This research should not only aim at obtaining a list of plants eaten by banteng but also of their proportion in the diet and the banteng's preference for them. Habitat use by banteng should also be investigated. Answers to these questions are required so that the influence of these factors can be assessed correctly. If they are indeed found to limit the size of the rhino population then conservation measures aimed at limiting their influence, and thus allowing an increase of population size, should be taken into consideration.

Translocation

The second aim of conservation measures should be, as mentioned, the establishment of further local populations of the Javan rhino. For this purpose rhinos should be translocated from Ujung Kulon to other reserves lying within their historical range of distribution. This would eliminate the possibility of the extinction of the species through a single catastrophic event in Ujung Kulon and simultaneously provide the space for further population increase. Suitable reserves appear to be available in the southern part of Sumatra. The translocation will have to be prepared carefully and the suitability of any reserve under consideration assessed regarding the types of vegetation occurring there as well as the availability of water and wallowing facilities. Preparations should also include the setting up of an

efficient guard system so that the rhinos will benefit from the same standard of protection as in Ujung Kulon.

A group of 6 - 10 rhinos should be transferred and released within a short time period, in the most suitable area of the reserve. This procedure will presumably minimize the risk that the rhinos will drift apart and lose contact, as it is assumed that the quality of the area and the presence of conspecifics will be attractive to each individual. The transferred group should be composed of 2 - 3 males and 4 - 7 females. Most of the transferred rhinos should be in the reproductive age; the group should not include too large a proportion of old or subadult rhinos. The removal of rhinos from Ujung Kulon requires that the population there must increase to at least 80 - 100 individuals before translocation can be undertaken. Should the population in Ujung Kulon stagnate around its present size it will possibly be necessary to alter the environmental conditions in Ujung Kulon artificially for a limited time so that the population will increase to a size where it is safe to remove a number of individuals for translocation (e. g. by increasing the food supply through manipulation of the habitat (see below), or by reducing the population size of food competitors if it can be shown that these are a factor limiting the size of the rhino population).

At later stages the transfer of individuals between populations, for the purpose of genetic exchange, should be considered. The populations of rhinos in other reserves should be monitored in the same manner as suggested above for the population in Ujung Kulon.

Manipulation of the habitat

Schenkel and Schenkel-Hulliger (1969a) were apprehensive that a growing rhino population might not find a sufficient food supply in Ujung Kulon because the climax vegetation in many

access does not allow foodplants to grow. In a pilot study they showed that the removal of the light absorbing layer of palm leaves (esp. Arenga palms) in small plots stimulated the growth of saplings (Schenkel et al. 1978). They suggested that the food supply for rhinos could be increased in this manner. The method in fact simulates the creation of gaps in closed canopy forest through treefall. The results of the pilot study showed that rhinos fed there. In this study it was demonstrated that gaps opened by falling trees are strongly preferred by rhinos as feeding habitat (see 4.1.3.2).

What possible reasons are there for increasing the food supply? Conceivably this would be done to (a) avoid a crash of the population as a result of overpopulation and overexploitation of food resources, (b) counteract vegetational changes leading to a reduction of the area of vegetation types which are suitable as rhino feeding habitat, or (c) increase the carrying capacity of Ujung Kulon for rhinos.

At present it is not known what the carrying capacity of Ujung Kulon is. A population crash could therefore, only be predicted if signs of an overexploitation of food resources could be observed. However, at that point it might already be too late to avoid a population crash since, it takes at least two years before a freshly cut plot will provide an adequate food supply. Moreover, an increase of food supply alone will not solve the problem of overpopulation. It is possible that Javan rhinos can regulate their population density through their behaviour, changes of the age at which they reach sexual maturity or of the intercalving interval near the limit imposed by food supply and thus avoid the detrimental effects of overpopulation.

Hommel (1983) as a result of his study was of the opinion that there is no need to fear that vegetational changes will

lead to a decrease of the supply of rhino food in the near future.

An attempt to increase the food supply would appear indicated in two cases: If the food supply would limit the population to a size at which the risk of extinction through demographic instability or genetic deterioration is serious. Or, if it were considered necessary to artificially induce an increase of population size in order to remove a number of rhinos for translocation elsewhere without risk for the remaining population.

When thinking of interfering with the environment the conservational value of Ujung Kulon as a whole must be kept in mind and the pros and cons of such an action carefully weighed. Large scale changes by man are clearly not desirable (Schenkel et al. 1978, Honnel 1963). Nevertheless, should an emergency arise or the population stagnate around the present level then habitat manipulation will probably have to be considered.

Captive breeding

Three rhino species (black, white and Indian rhino) have been successfully bred in zoos. Presumably this would also be possible with Javan rhinos. Why should not, therefore, some Javan rhinos be caught and transferred to zoos with the aim of later releasing some of the offspring into their natural habitat, especially since with some animal species (e. g. European bison, Arabian oryx) such programmes of establishing wild populations from captive-bred stock have proved successful? A number of problems are inherent to this approach:

- 1) Because there are presently no Javan rhinos in zoos, the founding members of a captive population would have to be taken from the only remaining population in the wild.

- 2) It may not be possible for captive-bred animals to survive in the wild in those cases where young animals learn from their mothers how to survive (e. g. how to orient in space, what food to eat, how to avoid predators, how to react to seasonal changes of the environment etc.). How important this point is where rhinos are concerned is open to question, however.
- 3) Conservation cannot be viewed as the preservation of species alone. Species must be preserved together with the habitat to which they are adapted.

At present it is urgent to preserve areas of suitable rhino habitat which are large enough to sustain a viable population, as long as such areas are still available. Javan rhinos taken from Ujung Kulon should be translocated directly to these areas rather than to zoos from where they will have to be relocated again later.

Recommendations

1. The protection of the rhino population in Ujung Kulon should be continued, so that human disturbance will not interfere with the development of the population.
2. The situation in Ujung Kulon should be monitored regularly by a trained biologist.
3. Further research on the vegetation and the feeding ecology of the banteng is needed. It should be known, whether and how these factors limit the size of the rhino population.
4. The translocation of a group of rhinos to another reserve should be projected and the first steps implemented. These include a careful feasibility study regarding the suitability of the envisaged area as well as the setting up of a guard system before the transfer of the rhinos. Because of the small size of the population in Ujung Kulon the actual transfer is not recommended at present. However, it can be expected that after recuperating from the losses caused by a disease in 1981/2 the population will reach a size that will permit the removal of some individuals without risk, within a few years.
5. Habitat manipulation with the aim of increasing the food supply for rhinos is advised against at present.
6. The transfer of rhinos to zoos for breeding is not recommended.

Appendix I: List of rhino foodplants

FAMILY Species (local name)	Growth form	Feeding events			Q1	Notes
		A	B	Total		
<u>M E G N O C O T Y L E D O N E S</u>						
FLAGELLARIACEAE						
Flagellaria indica (Duar)	c		1	1	2	
MUSACEAE						
Musa sp. (Pisang kole)	h	2	7	9	35	
ZINGIBERACEAE						
Amomum sp. (Tepus)	h	80	257	337	257	
?? (Sayar)	h	1		1		
MAGNOLIACEAE						
Dorax cannaefolia (Bangban)	h		1	1	1	
SMILIACACEAE						
Smilax macrocarpa (Canar bokor)	c	1		1		
DIOSCOREACEAE						
Dioscorea sp. (Canar bedul)	c	1	2	3	5	

FAMILY Species (local name)	Growth form	Feeding events			Q1	Notes
		A	B	Total		
MURCACEAE						
<i>Aranga pinnata</i> (Kawung)	p	1		1		
<i>Calamus</i> sp. (Botan)	p	1	1	2	1	
PANDANACEAE						
(<i>Pandanus caricosus</i> ?) (Harasbas)	x	1		1		
(<i>Pandanus furcatus</i> ?) (Cangkosing)	x	1		1		
<u>DICOTYLEDONES</u>						
SCHISANDRACEAE						
<i>Kadsura scandens</i> (Hunyer wuit)	c		2	2	9	
ANNONACEAE						
<i>Annona muricata</i> (Mangka walanda)	s	1		1		
<i>Cananga odorata</i> (Kembang)	s*	1		1		
<i>Desmos chinensis</i>	c	1	1	2		
<i>Friesodielsia cuneiformis</i>	s		1	1	1	
<i>Mitrospora obtusa</i>	s*		1	1	9	
<i>Papawia piceocarpa</i>	s	1	2	3	16	
<i>Pseuduvaria reticulata</i> (Kilojo)	s*	5	7	12	14	

FAMILY Species (local name)	Growth form	Feeding events			Q:	Notes
		A	B	Total		
<i>Scaevola</i> <i>horstfieldii</i>	s*	2	7	9	34	
<i>Uvaria littoralis</i> (Arey kilaja)	c	1	1	2	1	
LAURACEAE						
<i>Cinnamomum iners</i> (Kiteja)	s*	1		1		
<i>Litsea noronhai</i> (Huru)	s	1	5	6	11	
<i>Litsea</i> sp. (Huru putih)	c		1	1	0	
<i>Litsea</i> sp. (Huru hitam)	s		1	1	15	
MYRISTICACEAE						
<i>Knema cinerea</i>	s*		1	1	3	
PIPERACEAE						
<i>Piper majusculum</i>	c		1	1	4	
<i>Piper</i> sp. (Seureuh)	c		1	1	1	
<i>Potamoerpha subpeltata</i>	h		5	5	5	
LYTHRACEAE						
<i>Lagerstroemia flos-reginae</i> (Bunga)	s*	3	12	15	50	
<i>Lagerstroemia ovalifolia</i>	s*		2	2		

FAMILY Species (local name)	Growth form	Feeding events			QI	Notes
		A	B	Total		
NYCTAGINACEAE						
Bougainvillea spectabilis. (Kukcheulang hitam)	c		4	4	11	
DILLENIACEAE						
Dillenia excelea (Kisagel)	c*	6	49	55	109	
Dillenia obovata (Sempur bstu)	s*	5		5		
Tetracera scandens (Asahac)	c	1	4	5	3	
FLACOURTIACEAE						
Casuaria grewiaeetolia	s		2	2	4	
CUCURBITACEAE						
Trichosanthes sp.	c		1	1	1	
MYRTACEAE						
Syzygium polyanthum (Balam)	s*	8	14	22	19	
Syzygium pycnanthum	s		2	2	1	
Syzygium racemosum	s*	1		1		
Syzygium sp. (Peutag)	s	1		1		

FAMILY Species (local name)	Growth form	Feeding events			QI	Notes
		A	B	Total		
LECYDITHACEAE						
<i>Barringtonia macrocarpa</i> (Senggom)	s	1	9	10	9	
<i>Barringtonia</i> sp. (Cangkudu)	s		1	1	8	
<i>Planchonia valida</i> (Putat)	s*		4	4	33	
MELASTOMATACEAE						
<i>Melastoma affine</i> (Harendong)	s	2	2	4	9	
<i>Mesecylon oleacefolium</i>	s		1	1	8	(L)
COMBRETACEAE						
<i>Conocretum latifolium</i> (Jaha)	s	2	4	7	6	
<i>Conocretum tetralophum</i>	s	1		1		
RHIZOPHORACEAE						
<i>Carallia brachiata</i> (Kikukuran)	s*		1	1	8	
HYPERICACEAE						
<i>Cratoxylum sumatranum</i>	s*		1	1	8	
<i>Cratoxylum recensum</i>	s*	1		1		
CLUSIACEAE						
<i>Garcinia parvifolia</i> (Ceuri)	s	1	3	4	3	

FAMILY Species (local name)	Growth form	Feeding events			Q1	Notes
		A	B	Total		
TILIACAEAE						
<i>Pentace polyantha</i> (Sigung)	s*	1	3	4	10	
STERCULIACEAE						
<i>Kleinhovia hospita</i> (Tangkole)	s*	4	5	9	66	
<i>Pterospermum javanicum</i> (Bayur)	s*		2	2	9	
<i>Sterculia urceolata</i>	s*		2	2	21	
<i>Sterculia</i> sp. (Hantap hitam)	s		0	0	3	
<i>Sterculia</i> sp. (Hantap)	s	2		2		
BOMBACACEAE						
<i>Salmelia valeronii</i> (Kidangdeur)	s*		3	3	24	
MALVACEAE						
<i>Hibiscus tiliaceus</i> (Waru)	s	9	4	13	38	
EUPHORBIACEAE						
<i>Alchornea javanensis</i>	s*	1		1		
<i>Antidesma bunius</i> (Muni)	s*		1	1	3	
<i>Antidesma velutinocum</i>	s	1		1		
<i>Aporosa aurita</i> (Peculis)	s*	2	1	3	9	
<i>Beccourea javanica</i> (Heudit)	s*	2	2	4		

FAMILY Species (local name)	Growth form	Feeding events			Q1	Notes
		A	B	Total		
<i>Bischofia javanica</i> (Gadeg)	s*		1	1	0	
<i>Bischofia</i> sp. (Sariawan)	s		1	1	1	
<i>Bridelia monoica</i> (Kanyere)	s*	3	3	6		
<i>Bridelia stipularis</i> (Kanyere badak)	s	2	6	8	18	
<i>Croton acyrratus</i>	c	2	1	3	8	
<i>Croton caudatus</i>	c		2	2	4	
<i>Drypetes microsphyllum</i>	s	1		1		1)
<i>Excoecaria virgata</i> (Kisaroh)	s*	1	1	2		
<i>Gallesia filiformis</i> (Kitako)	s	1		1		
<i>Gelonium glomerulatum</i>	s		1	1		
<i>Glochidion rubrum</i>	s*		3	3	9	
<i>Mallotus dispar</i>	s		1	1	8	
<i>Mallotus floribundus</i> (Waru lot)	s	1	1	2		
<i>Mallotus ricinoides</i>	s*		2	2	8	
<i>Margaritaria indica</i>	s*		2	2	16	
<i>Sumbaviopsis albicans</i> (Kijaho)	s		8	8	43	
ROSACEAE						
<i>Rubus elongatus</i> (Harashas)	c		1	1	8	
CAESALPINIACEAE						
<i>Cassia</i> sp.	e		1	1		

FAMILY Species (local name)	Growth form	Feeding events			Q1	Notes
		A	B	Total		
MIMOGACEAE						
Acacia sp. (Jingjingkulit I)	c		1	1	1	
Acacia sp. (Peupeuteuyan)	s		1	1	1	
Entada phaseoloides (Balang)	c	1	3	4	6	
Leucaena leucocephala (pete dina)	s	1		1		
Pithecellobium sp.	s		1	1	8	
PAPILIONACEAE						
Derris elegans	c		1	1		1)
Derris elliptica (Kowao)	c	7	10	17	33	
Derris thyrsiflora	c		2	2		
Derris sp. (Tua laleur)	c		4	4	7	
Desmodium umbellatum (Kanyere laut)	s	3		3		
Brychnia orientalis (Dadap)	s*	1	1	2	15	
Pongamia pinnata (Malapari)	s	5	3	8	17	
Sophora tomentosa (Tarum)	s	1		1		
Spatholobus ferrugineus (Capulang)	c	1	4	5	7	
FAGACEAE						
Quercus sp. (Kipasang)	s	1		1		

FAMILY Species (local name)	Growth form	Feeding events			QI	Notes
		A	B	Total		
MORACEAE						
<i>Artocarpus elasticus</i> (Tauzeup)	s*	1	1	2	15	
<i>Ficus ampelas</i> (Hampelas)	s	1		1		
<i>Ficus benjamina</i>	s*	1		1		
<i>Ficus callophylla</i>	s*		1	1	8	
<i>Ficus callosa</i> (Pangser)	s*	1	2	3	2	
<i>Ficus elasticus</i> (Kiara karet)	s*	1		1		
<i>Ficus fistulosa</i> (Benuying)	s		3	3	17	
<i>Ficus</i> sp. (Pisoro)	s	2	1	3		
<i>Ficus obscura</i>	s		1	1	15	
<i>Ficus sagittata</i> (Acety kiara)	c		1	1	1	
<i>Ficus subulata</i>	s		1	1	1	
<i>Ficus tinctoria</i>	s*		2	2	9	
<i>Ficus trichocarpa</i>	c	1		1		
<i>Ficus variegata</i> (Kondang/Sales)	s*	2	4	6	13	
<i>Ficus</i> sp.	s		1	1	1	
<i>Poikilospermum suaveolens</i> (Lauksa)	c	9	21	29	77	
<i>Streblus spinosus</i>	s	2	1	3	1	
URTICACEAE						
<i>Dendrocnide stimulans</i> (Pulus)	c	1	3	3	9	
<i>Villebrunea rubescens</i> (Kinangsi)	c		1	1	13	

FAMILY Species (local name)	Growth form	Feeding events			QI	Notes
		A	B	Total		
Celastraceae						
<i>Lophopetalum javanicum</i>	s*		1	1	17	
Celastraceae						
<i>Stenobolus secundiflorus</i>	s*		1	1	8	
Clusiaceae						
<i>Strobilium javanicum</i>	s*	1	1	2	1	
Rhamnaceae						
<i>Ventilago dichotoma</i>	s	1	1	2		1)
<i>Ziziphus hornefieldii</i> (Jingjingkulit I)	c	1	10	11	3	
<i>Ziziphus rufula</i> (Jingjingkulit III)	c		1	1	3	
Vitaceae						
<i>Cayratia geniculata</i>	c	1	1	2	1	
<i>Cayratia japonica</i>	c		1	1	1	
<i>Cissus discolor</i>	c		1	1	1	
<i>Leea saxbucina</i> (Sulangkar)	s	32	54	86	242	
<i>Tetrastigma lanceolarium</i> (Kibarela)	c	2	1	3	1	

FAMILY Species (local name)	Growth form	Feeding events			Q1	Notes
		A	B	Total		
RUTACEAE						
<i>Eucdia latifolia</i> (Kisampang)	s*	1		1		
<i>Glycosmis pentaphylla</i>	s		1	1	1	
<i>Zanthoxylum rhetsa</i> (Kitanah)	s*	6	2	8		
SIMARUBACEAE						
<i>Harriseetia perforata</i> (Garut)	c	1		1		
BURSERACEAE						
<i>Canarium denticulatum</i>	s*		3	3	17	
MELIACEAE						
<i>Aglaia latifolia</i>	s	2	1	3	8	
<i>Chioscheton nirocarpus</i>	s*		5	5	24	
<i>Didymocheton decandrum</i>	s	1		1		
<i>Dysoxylum arborescens</i>	s		1	1	15	
<i>Dysoxylum caulocetachyum</i>	s*		1	1	8	
SAPINDACEAE						
<i>Erioglossum rubiginosum</i> (Kilalayu)	s		1	1	1	
<i>Lepisanthes tetraphylla</i> (Kilalayu)	s	1	1	2	1	1)
<i>Pometia pinnata</i> (Geungsir)	s*	1		1		

FAMILY Species (local name)	Growth form	Feeding events			QI	Notes
		A	B	Total		
ANACARDIACEAE						
<i>Euchensia arborescens</i> (Kitsanjung)	s*		4	4	1	
<i>Dracontomelum dac</i>	s		2	2	9	
<i>Dracontomelum puberulum</i> (Dahu)	s*	2	4	6	19	
<i>Gluta renghas</i> (Renghas)	s*	3		3		
<i>Spondias pinnata</i> (Kedondong)	s*	15	57	72	519	
CONNARACEAE						
<i>Agelaea macrophylla</i>	c		1	1		
<i>Cornarus</i> sp.	c		1	1	1	
ALANGIACEAE						
<i>Alangium salviifolium</i>	c	1	5	6	16	
ARALIACEAE						
<i>Schefflera elliptica</i>	c		1	1	1	
<i>Schefflera longitolla</i>	s		1	1	15	11
EBENACEAE						
<i>Diospyros cauliflora</i>	c		2	2	16	
<i>Diospyros hermaphroditica</i>	s*	1	1	4	1	
<i>Diospyros macrophylla</i> (Nicalung)	s*	2	6	8	12	

FAMILY Species (local name)	Growth form	Feeding events			Of	Notes
		A	B	Total		
<i>Diospyros pendula</i>	s*		1	1	8	
<i>Diospyros truncata</i>	s*	1		1		
MYRSINACEAE						
<i>Ardisia humilis</i> (Lampeni)	s	2		2		
<i>Ardisia sumatrana</i> (Lampeni leuweung)	s		2	2	9	
<i>Eubella ribes</i> (Kecembang)	c	4	12	16	24	
SYMLOCACEAE						
<i>Symplocos brandisii</i> (Kiwangi)	s*	4	3	7	3	
<i>Symplocos odoratissima</i>	s*	1	1	2	1	
APOCYNACEAE						
<i>Alstonia scholaris</i> (Lame)	s*	1	1	2	1	
<i>Ichocarpus frutescens</i>	c	1		1		
RUBIACEAE						
<i>Anthocephalus chinensis</i> (Banja)	s*		1	1	15	
<i>Mussaenda</i> sp.	c		1	1	4	
<i>Neonauclea calycina</i> (Cangkaratan)	s		1	1	15	1)
<i>Paederia scandens</i>	c		1	1		
<i>Randia</i> sp.	s		1	1		

FAMILY Species (local name)	Growth form	Feeding events			QI	Notes
		A	B	Total		
Tarenna fragrans (Kitano)	s*		1	1	3	
Uncaria sp. (terras?) (Kalebahe)	c	7	24	31	43	
COMPOSITAE (Asteraceae)						
Eupatorium odoratum (Nanpong)	s		3	3	2	
Mikania cordata (Capituheur)	c	2	12	14	43	
BORAGINACEAE						
Cordia sp. (Konal)	s*	3		3		
SOLANACEAE						
Solanum torvum (Takokak)	s	1		1		
CONVOLVULACEAE						
Ipomoea illustris	c	1	6	7	6	
Ipomoea loba (Palungpung putih)	c	1	1	2	1	
Lepistenon binedtaferum (Palungpung putih)	c		1	1	4	
Lepistenon acceolatum	c		7	7	19	11
Lepistenon sp. (Palungpung besar)	c		2	2	2	
Meczenia peltata	c		1	1	1	
Meczenia umbellata (Palungpung biasa)	c	1	7	8	17	

Appendix 11: List of potential rhino foodplants occurring in the sample plots

Species	Number of plants	C ₁	% of total V ₁
<i>Leea sambucina</i>	461	2'607	17.85
<i>Willdenia excelsa</i>	495	2'126	14.56
<i>Harringtonia sacrocarpa</i>	285	583	3.99
<i>Lagerstroemia filoxerinae</i>	89	539	3.69
<i>Syzygium polyanthum</i>	102	514	3.52
<i>Baccaurea javanica</i>	44	444	3.04
<i>Symplocos</i> sp. (Sauhaun)	83	396	2.73
<i>Pseuduvaria reticulata</i>	59	310	2.12
<i>Mikania cordata</i>	181	301	2.06
<i>Diospyros cauliflora</i>	52	264	1.67
<i>Mesecylon oleaeifolium</i>	45	239	1.64
<i>Spondias pinnata</i>	45	201	1.38
<i>Diospyros macrophylla</i>	45	192	1.31
<i>Litsea neronhae</i>	20	158	1.08
<i>Drypetes longifolia</i>	15	147	1.01
<i>Pentace polyantha</i>	24	192	.97
<i>Cardia</i> sp. (Kenal)	18	139	.95
<i>Saccopetalum horsfieldii</i>	89	132	.90
<i>Callicarpa longifolia</i>	13	124	.85
<i>Stelechocarpus burahol</i>	14	106	.73
<i>Glochidion rubrum</i>	9	102	.70
<i>Galeeria filiformis</i>	14	97	.66
<i>Cynometra ramiflora</i>	19	94	.64
<i>Dillenia aurea</i>	7	91	.62
<i>Lepistemon binacteriferus</i>	90	90	.62
<i>Uncaria (terres?)</i> sp.	50	86	.59
<i>Diospyros hemisphaeroides</i>	41	78	.53
<i>Pavona acuminata</i>	11	76	.52
<i>Morremia vitifolia</i>	64	75	.51
<i>Aporosa aurita</i>	5	71	.49
<i>Lepisanthes tetraphylla</i>	40	70	.48
<i>Lagerstroemia ovalifolia</i>	14	69	.47
<i>Embelia ribes</i>	54	63	.43
<i>Putranjiva roxburghii</i>	12	59	.40
<i>Mallotus floribundus</i>	10	57	.39
<i>Garcinia parvifolia</i>	9	56	.38
<i>Mecremia umbellata</i>	55	55	.38
<i>Cinnamomum iners</i>	7	54	.37
<i>Radermachera</i> sp. (Padali)	7	53	.36
<i>Derris elliptica</i>	53	53	.36
<i>Gmelina elliptica</i>	5	52	.36
<i>Hvaria littoralis</i>	40	48	.33
<i>Artocarpus elastica</i>	7	44	.30
<i>Xiziphus horsfieldii</i>	43	42	.29
<i>Ficus callosa</i>	5	32	.22
<i>Xanthophyllum</i> sp. (Kinog)	3	41	.28

Species	Number of plants	QI ₃	% of total QI ₃
<i>Croton argyrateus</i>	2	40	.27
<i>Tetragera scandens</i>	34	18	.26
<i>Cordia bantamensis</i>	6	14	.23
<i>Dioscorea</i> sp. (Kanan bedul)	32	12	.22
<i>Premna foetida</i>	2	30	.21
<i>Pterospermum diversifolium</i>	1	10	.21
<i>Vitex quinata</i>	1	29	.20
<i>Flagellaria indica</i>	29	28	.19
<i>Smilax leucophylla</i>	27	27	.18
<i>Pterocymbium tinctorium</i>	4	26	.18
<i>Cleistanthus myrianthus</i>	6	25	.17
<i>Mischocarpus sundaicus</i>	5	23	.16
<i>Sarcblus spinosus</i>	5	23	.16
<i>Flacourtia rukem</i>	13	22	.15
<i>Pterospermum suaveolens</i>	21	21	.14
<i>Tricodiella cuneiformis</i>	2	21	.14
<i>Pterospermum javanicum</i>	1	21	.14
<i>Randia parula</i>	2	21	.14
<i>Conetia pinnata</i>	2	20	.14
<i>Cassia timorensis</i>	2	20	.14
<i>Ficus ampelas</i>	1	20	.14
<i>Leptanthes amoena</i>	1	20	.14
<i>Urtica</i> sp. (Tua laleur)	19	19	.13
<i>Anacia</i> sp. (Jingjingkulit II)	10	18	.12
<i>Combretum latifolium</i>	18	18	.12
<i>Villebrunea rubescens</i>	0	17	.12
<i>Spatholobus tetragynus</i>	17	17	.12
<i>Ficus fistulosa</i>	6	15	.10
<i>Popowia pinocarpa</i>	5	14	.10
<i>Neonauclea calycina</i>	5	14	.10
<i>Bridelia stipularis</i>	13	13	.09
<i>Aphania seneqalensis</i>	3	12	.08
<i>Ardisia sumatrensis</i>	3	12	.08
<i>Piper majusculum</i>	11	11	.08
<i>Actinodaphne macroptera</i>	2	11	.08
<i>Capparis acuminata</i>	2	11	.08
<i>Diospyros malabarica</i>	2	11	.08
<i>Dracontomecon puberulum</i>	2	11	.08
<i>Drypetes cumatiana</i>	3	11	.08
<i>Dysoxylum caulestachyum</i>	2	11	.08
<i>Polyalthia subcordata</i>	2	11	.08
<i>Kauvoitia reflexa</i>	2	11	.08
<i>Sumbaviopsis albicans</i>	2	11	.08
<i>Actinodaphne glabra</i>	1	10	.07
<i>Bridelia monoica</i>	1	10	.07
<i>Claoxylon pelet</i>	1	10	.07
<i>Cleistanthus</i> sp.	1	10	.07
<i>Diospyros frutescens</i>	1	10	.07
<i>Ficus obscura</i>	1	10	.07
<i>Ficus sagittata</i>	1	10	.07

Species	Number of plants	Q1 _a	% of total Q1 _a
<i>Neliosma lanceolata</i>	1	10	.07
<i>Nitrophora obtusa</i>	1	10	.07
<i>Quercus</i> sp.	1	10	.07
<i>Polyalthia lateriflora</i>	1	10	.07
<i>Scelopora spinosa</i>	1	10	.07
<i>Planchonia valida</i>	9	9	.06
<i>Tetrastigma lanceolatum</i>	8	8	.05
<i>Suchanania arborescens</i>	7	7	.05
<i>Lepistemon</i> sp. (Palungpung besar)	6	6	.04
<i>Caederia scandens</i>	5	5	.03
<i>Cissus discolor</i>	5	5	.03
<i>Abrus laevigatus</i>	4	4	.03
<i>Fagara rhetsa</i>	4	4	.03
<i>Kadsura scandens</i>	4	4	.03
<i>Melastoma affine</i>	4	4	.03
<i>Enilax zeylanica</i>	4	4	.03
<i>Strombosia javanica</i>	4	4	.03
<i>Ziziphus rotula</i>	4	4	.03
<i>Himendendron bokbrai</i>	3	3	.02
<i>Casuaria flavo-virens</i>	3	3	.02
<i>Cayratia geniculata</i>	3	3	.02
<i>Cayratia japonica</i>	3	3	.02
<i>Cissus repens</i>	3	3	.02
<i>Entada phaseolides</i>	3	3	.02
<i>Hydrocarpus heterophylla</i>	3	3	.02
<i>Pectocampylus glaucus</i>	3	3	.02
<i>Uvaria hirsuta</i>	3	3	.02
<i>Cissus nodosa</i>	2	2	.01
<i>Ficus</i> sp. (Anisnata)	2	2	.01
<i>Heteronia peltata</i>	2	2	.01
<i>Myrsopyrum nervosum</i>	2	2	.01
<i>Piper bantamense</i>	2	2	.01
<i>Selagin Koithalsiensis</i>	2	2	.01
<i>Semecarpus heterophyllus</i>	2	2	.01
<i>Syzygium racemosum</i>	2	2	.01
<i>Adina heterophylla</i>	1	1	.01
<i>Aglaiola macrophylla</i>	1	1	.01
<i>Aglais argentea</i>	1	1	.01
<i>Aglais</i> sp.	1	1	.01
<i>Alseodum selvitifolium</i>	1	1	.01
<i>Alseodum</i> sp.	1	1	.01
<i>Albizzia chinensis</i>	1	1	.01
<i>Alstonia scholaris</i>	1	1	.01
<i>Raphelocissus atachnaidea</i>	1	1	.01
<i>Anodendrum tenuiflorum</i>	1	1	.01
<i>Anthocephalus chinensis</i>	1	1	.01
<i>Ardisia humilis</i>	1	1	.01
<i>Balaicnemia</i> sp.	1	1	.01
<i>Breynia</i> sp.	1	1	.01
<i>Bryonopsis laciniata</i>	1	1	.01

Species	Number of plants	Q ₁	% of total Q ₁
Casearia brachiata	1	1	.01
Casearia greviaefolia	1	1	.01
Clematis smilacifolia	1	1	.01
Clerodendrum disperifolium	1	1	.01
Clerodendrum villosum	1	1	.01
Combretum sp.	1	1	.01
Croton candelatus	1	1	.01
Cyclea barbata	1	1	.01
Dalbergia sp.	1	1	.01
Dendrocnide strigulans	1	1	.01
Derris elegans	1	1	.01
Desmos chinensis	1	1	.01
Drypetes neglecta	1	1	.01
Eubelia javanica	1	1	.01
Excoecaria virgata	1	1	.01
Ficus variegata	1	1	.01
Glochidion sp.	1	1	.01
Hemalanthus populneus	1	1	.01
Illicium pulchrum	1	1	.01
Iponoea tuba	1	1	.01
Kleinhovia hospita	1	1	.01
Litsea elliptica	1	1	.01
Madhuca macrophylla	1	1	.01
Melalasia scandens	1	1	.01
Melilotus dispar	1	1	.01
Melothria perpusilla	1	1	.01
Micromelum minutum	1	1	.01
Parinari sumatrensis	1	1	.01
Piper minutum	1	1	.01
Piper sp.	1	1	.01
Rourea minor	1	1	.01
Symplocos tubiginosa	1	1	.01
Trichosanthes bracteata	1	1	.01
Trichosanthes sp.	1	1	.01

Plants (belonging to several species) identified only to the genus level:

Syzygium sp.	102	545	1.73
Sterculia sp.	57	305	2.09
Litsea sp.	23	115	.79
Aprosa sp.	9	75	.51
Diospyros sp.	4	41	.28
Nectophaebe sp.	2	16	.11
Dysoxylum sp.	5	5	.03
Canarium sp.	4	4	.03
Phaseolus sp.	2	2	.01

Species	Number of plants	QI _a	% of total QI _a
Unidentified plants:			
(Taritih beutit)*	78	320	2.19
(Kloensi)	35	288	1.97
(Sizih)	2	2	.01
other	72	372	2.54

* Plants which were only known by their local name but which were not identified by their scientific name for various reasons.

Appendix III: List of Indonesian geographic terms

Indonesian	Abbreviation	English
Ci....		denotes a stream/ river or a village (in this thesis always streams unless noted otherwise)
Gunung	G.	mountain
Pulau	P.	island
Tanjung	Tg.	cape

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