RHINO SURVEY IN THE GREATER DANUM VALLEY CONSERVATION AREA

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Final Report

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Report prepared by:

Dr. Alan Rabinowitz
Wildlife Conservation International

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Background

The most comprehensive field research on the Sumatran rhinoceros (Dicerorhinus sumatrensis) has been done primarily in Sumatra (Borner, 1979; van Strien, 1986). The subspecies of rhino in Sabah however, **Dicerorhinus sumatrensis harrissoni**, is considered to be the most endangered of the subspecies and exists in only a few rapidly dwindling pockets in the eastern part of the state. The best assessment of the current distribution and status of the Sumatran rhino in Sabah was done by Payne (1990a). This report points to only two areas which are likely to contain populations of Sumatran rhinoceros that might have prospects for long-term survival: the Tabin Wildlife Reserve and the Ulu Segama-Kuamut area, both in southeastern Sabah. The recent Asian Rhino Action Plan (1989) gives an estimate of 20 individual rhinos in Tabin and 10 individual rhinos in Danum Valley (part of the Ulu Segama population). Both of these areas are considered by the Action Plan to be "reasonably viable for long-term genetic management." Yet there has been very little survey work done in either of these areas, and what has been done has produced evidence of only small numbers of rhinos (Payne, 1990 a&b; Sabah Wildlife Dept. reports). Nearly thirty years ago, Harrison (1965) guessed there were as few as 11-13 rhinos left in all of Sabah; more recent guesstimates by Davies and Payne (1982) range between 15-30 rhinos. In essence, the absence of an on-going survey and monitoring program, and the fact that illegal hunting of rhinos continues in Sabah, means that we are completely in the dark as to the true

status of the rhino in Sabah.

The Greater Danum Valley Conservation Area (GDVCA), within the Ulu Segama Forest Reserve, is part of the largest and most remote forest block left in all of Sabah. The biological richness of the area is well known (Marsh and Greer, 1992) and it has probably the best potential for maintaining a rhino population in Sabah. Presently, the GDVCA is part of the Yayasan Sabah timber concession and consists of primary forest within the Danum Valley Conservation Area (DVCA)(438 km^2), and old (8-10 years), selectively logged forest over most of the proposed contiguous Danum Valley Expansion Area (645 km^2). Due to the recognized biological importance of this entire area, it has recently been proposed that the GDVCA be reclassified and managed as a legally protected area.

Objectives

The primary objective of this survey was to investigate the presence, relative abundance, and distribution of Sabah's most endangered large mammal species, the Sumatran rhinoceros, within the proposed Greater Danum Valley Conservation Area.

The secondary objectives were as follows:

(1) To help standardize the methodology for future rhino surveys.

(2) To initiate a long-term monitoring program for rhino presence and distribution within the GDVCA to be coordinated and supervised by The Sabah Wildlife Department.

(3) To obtain general wildlife information on remote areas within the GDVCA.

(4) To compare rhino and other wildlife presence in areas of primary and old logged forest.

(5) To look for signs of illegal hunting and other human intrusion within the GDVCA.

(6) To initiate a cooperative and on-going working relationship between The Sabah Wildlife Department and Yayasan Sabah Conservation Division.

Methodology

The extreme difficulty of assessing rhino numbers in tropical forest habitat is well known. These animals occur at low densities and are patchy in distribution throughout vast areas of forest. Their numbers and distribution may be limited by factors such as the availability of mineral sources and the availability of high quality browse (Payne, 1990a; van Strien, 1986). In the past, rhino surveys in Sabah involved small teams traversing large areas and looking for tracks along fixed transects or along waterways. This methodology has much potential for missing evidence of rhino presence in an area, and provides a minimum of data based on chance encounters of rhino sign.

Previous research efforts by Borner (1979) and van Strien (1986) in Sumatra suggest that the best way to accurately assess rhino densities is through the thorough patrolling of a single, relatively large study area (100-200 km^2) by experienced individuals. Van Strien (1986) used a single team of five to seven people for two to three weeks in the field, shifting base camps

every three to four days. Several trips were made each year, with a maximum of approximately 200 man-days each trip.

In our survey, factors such as time constraints, the need to investigate a large area, and the uncertainty of when a second survey would be carried out, forced us to intensify van Strien's methodology. The method used in Danum involved a total of seven teams, each of approximately seven people, working out from central base camps for a continuous period of ten days. This allowed for a maximum of 490 man-days during the field survey. Each team was instructed to try and thoroughly cover an area of 30-50 km^2. Four teams surveyed contiguous areas, forming a large central survey block of approximately 180 km^2 (Map 1).

From each base camp, small teams of two to three people made daily patrols, while one person usually remained in camp as cook, watchman, etc. In some cases, base camps were shifted to a more convenient location during the latter part of the survey period; no more than two base camps were established by any one team.

Three days before the field surveys, general instruction on survey techniques, rhino behavior, emergency medical procedures, and data gathering priorities was given to all survey participants. On the fourth day, designated teams (Appendix I) were sent into their assigned survey areas either by helicopter or by foot, whichever allowed the setting up of base camps that same day. A full ten days was spent conducting field surveys, except for team seven which only spent seven days in the field. Upon return from the field surveys, all the data was compiled and teams were de-

briefed.

A detailed schedule of the survey agenda and a synopsis of survey methodology are given in Appendices II and III respectively.

Base camps - Map 1

Three of the teams, Team 1 (the Operation Raleigh cabin site), Team 4 (the Sungai Perut site) and Team 5 (the Jungle Lodge site) were based in primary forest, inside the boundaries of the Danum Valley Conservation Area. Team 7 (the Danum Valley Research Center site) was based on the border of the DVCA in an area of mostly primary forest with some areas of old logged forest. These four teams surveyed areas which were contiguous along at least a portion of their perimeter.

The three remaining teams surveyed areas that bordered DVCA and the proposed Danum Valley Expansion Area. Team 6 (the Sungai Beruang site) surveyed an area along the eastern border of the DVCA, consisting primarily of old logged forest. Team 3 (the Sungai Katangen site) surveyed along the western perimeter of the DVCA, in an area of primarily old logged forest, with patches of virgin montane forest. Team 2 (the Sungai Beatrice site) surveyed along the southern border of the DVCA in remote, mostly virgin forest. A small portion of this survey area crossed the boundary of the Conservation Area into old logged forest.

Survey patrols

Behavioral data from field studies in Sumatra (Borner, 1979; van Strien, 1986) indicate that if rhinos inhabit an area, patrols along ridges and waterways have the greatest chance of finding evidence of the animals. Rhinos often make trails along major ridges. Salt licks or mineral springs, important areas for rhinos, are close to waterways or streams. All patrols were instructed to concentrate their activities primarily along ridges and waterways, using available game trails.

Patrols that traversed sloping terrain, or followed tributaries and small streams to their source were also emphasized, once the main ridges and waterways were patrolled. Well used animal routes or trails were walked as often as time and circumstances permitted. On the other hand, a complete absence of a possible rhino trail along a ridge where the vegetation would have insured such evidence, was considered a strong indication that rhinos were not resident in the area. Such areas were only covered once.

Identifying and recording rhino evidence

The study of indirect evidence is the most practical procedure for assessing rhino presence (Strickland, 1967; van Strien, 1986). The best evidence is the presence of tracks which may allow for the identification of individual rhinos, and may indicate when the animal was present. Other evidence of rhino presence includes wallows or bathing holes, rhino dung, broken and twisted saplings

that result from feeding or marking behavior, mud on trees from rubbing of the flanks, and trampling of the undergrowth around much used feeding areas. The following paragraphs detail specific kinds of Sumatran rhino sign that has been found elsewhere.

If a rhino regularly moves within an area, there should be wallows along the ridges, in flat areas on mountaintops or saddles, in muddy patches by the river, or in small streams. Wallows in Sumatra were usually oval, about 2 meters wide by 2.5 meters long, filled with a clay "broth" of 20-50 cm deep (Borner, 1979). In wallows on a slope, there is sometimes a vertical overhanging wall which shows traces of a rhino having rubbed its' flanks. Wallows are more often used in dry season, and may be passed up in rainy season. After leaving wallows, rhinos often remain in the immediate area rubbing their head and body on trees and shrubs. Depending on the height of the rhino, mud smears are usually found at a height of 50-100 cm above the ground.

Rhino feces is unlike that of other ungulates in the area. Dung heaps usually consist of 10 or more roundish balls, 7-9 cm in diameter, together weighing about 2-6 kg. Rhino dung is generally less compact and polished than elephant dung and has a greater tendency to fragment. Rhino feces generally contains coarse plant remains and fragments of leaf stalks and twigs. There is no strong smell to rhino dung and old dung heaps are common along main trails where there has been rhino activity.

Rhinos are browsers that feed on leaves, stems, and twigs of a great number of trees and shrubs, or on readily available

herbaceous undergrowth (van Strien, 1986). When rhinos feed, much of the undergrowth in the area is flattened and trampled and the devastation may be visible for many weeks. Estimated height of saplings and small trees used by rhinos in Sumatra ranged from 2-12 m with an average of 4.5 m (van Strien, 1986); stem diameter ranged from 1-6 cm (Borner, 1979), with the thickest being 8 cm in diameter. During feeding behavior, trees are usually broken between ground level and 40 cm above the ground (Borner, 1979). Rhinos also exhibit behavior in which they twist saplings, possibly as a means of marking or communication. Twisted saplings are generally an average of 2 cm in diameter (range 2-4 cm), stand 2-4 m high, and are twisted at about 80 cm above the ground (Borner, 1979).

Rhino tracks are relatively easy to identify, but need careful measurement and interpretation. Since rhino tracks from the same animal can vary greatly in their dimensions, the best comparable track measurements were considered to be from animals on level ground moving calmly in a straight line. The best areas to look for prints are near salt licks, wallows, or on worn out sections of the trail. Since the hind foot print usually overlaps the fore foot print almost completely, one must be careful of overlapping imprints that can lead to erroneously wide measurements. Van Strien (1986) determined that the most useful combination of measurements is the width of the front hoof from a plaster cast, together with the width (measured between the tips of the side hoofs) and the length of the print. In addition to track

measurements, at least several plaster casts of right and left feet from the same set of tracks should be taken if possible.

All rhino evidence was recorded on special rhino data sheets (Appendix IV), and plaster of paris was provided for making partial casts of rhino tracks.

Other wildlife data

The recording of other wildlife present in the survey areas was a secondary but important priority of this survey. Records were restricted primarily to sign or sightings of terrestrial mammals and primates in order to keep the major emphasis on the search for rhino evidence. Birds and nocturnal mammals were recorded when the opportunity arose. General wildlife survey data sheets were provided in addition to the rhino data sheets (Appendix V).

Results

Rhino presence

The seven teams surveyed a combined area of approximately 300 km^2, nearly one-third of the proposed GDVCA. Teams 1,4,5 and 7, incorporating the Sungai Danum, Sungai Purut, and Sungai Langam drainages covered areas of 50 km2, 48 km2, 39 km2, and 38 km2 respectively, creating a contiguous forest block of approximately 175 km^2, mostly of primary forest (Map 1). Teams 2,3, and 6 covered areas of 40 km2, 53 km2, and 29 km2 respectively.

Rhino tracks were found by two teams, Team 2 and Team 7 (Table

1, Map 2). The location and measurements of the fresh tracks found by Team 2 indicate at least two and possibly three different rhinos in the area. The obvious lack of other rhino evidence in the area, such as feces and broken and twisted saplings, leads to speculation that rhino density is very low in the area, and there may not be any more rhinos than the tracks indicate.

Fresh tracks from Team 7 also indicate at least two and possibly three different rhinos. Here however, an abundance of relatively widespread secondary evidence such as heavily trampled ground, twisted stems, chewed vegetation, and browsed shrubs indicate substantial rhino activity in the area. Based upon what van Strien (1986) considers a moderate rhino density of 10 rhinos/100 km^2, it is speculated that there may be as many as four rhinos in the survey area of Team 7.

Secondary rhino sign

Although only two teams found definite evidence of rhino presence in the form of tracks, all seven teams found other sign in their areas that potentially came from rhinos. The most distinctive types of sign were large wallows and saplings, broken or twisted at particular heights above the ground (Table 2, Map 2). No rhino dung was found by any survey team.

The difficulty in verifying old rhino sign was compounded by large scale pig activity throughout the survey area, as well as the presence of elephants and, in some areas, banteng. However, based on previous reports, it was assumed that although several other

ungulate species use available wallows, only rhinos actively dig out and shape larger wallows. In the case of Team 4, numerous large wallows which were visited were known to have been used by rhinos in the recent past (Ahmad, 1987). Food preferences of the different ungulates species are also somewhat different, particularly elephants which prefer soft secondary growth plant species while rhinos prefer saplings and shrubs (Borner, 1979). Elephants also feed much higher on vegetation than rhinos (up to 3 m), will sometimes tackle much thicker stems (up to 6 cm), and will cause greater destruction of the immediate feeding area.

During debriefing, all teams expressed the feeling that the intensive coverage of their surveys areas was such that a significant rhino presence was not overlooked. The abundance of secondary sign indicated that most areas were probably used by rhinos in the past, or were parts of a rhino's range which was not occupied at the time of the survey. That is not to say that sign of an individual rhino passing through or exploring the area may not have been overlooked. However, if several rhinos were active in an area, tracks or evidence of fresh rhino sign would likely have been found.

Human disturbance

Each of the seven teams found indications of recent (<1 yr) or old (1-2 years) human intrusion into their areas (Appendix VI, Map 2). In the case of Teams 4 and 7, there was sign of hunting in the survey area, in the form of animal remains at old campsites and

a shotgun shell. In the case of Team 2, a group of illegal intruders was possibly chased from the scene by the survey team's arrival in the area, leaving behind a fresh cache of food, clothes and other items. The size of the cache and the distance travelled into the site indicated extensive planning and an extended stay in the area. The presence of one large camp (up to 25 beds) that showed repeated use, and several smaller camps further into the area indicated that such intrusion has been going on for a long time. The active camps located by the survey team were centered within the area of fresh rhino sign. A barking deer was also sighted by this team with what appeared to be fresh gunshot wounds. In the survey areas of Teams 1,3,5 and 6, old campsites and parang cuts on the vegetation were found. The reasons for these human activities are unknown and, at least in some of the survey areas, may have been from sanctioned activities.

Mineral sources

Five of the seven groups came upon what appeared to be salt licks or mineral sources (Appendix VII). These sites all showed a great deal of by activity by ungulates: elephants, deer, and pigs. Such chance encounters, as well as the relative abundance of ungulate species that depend on such sites, indicate that mineral sources are probably not uncommon throughout the area.

Other wildlife

Forty-one species of mainly terrestrial mammals and primates (Table 3), as well as 91 species of birds (Appendix VIII) were noted during the course of this survey. Four teams observed Bulwer's Pheasant, a Bornean endemic now considered rare throughout much of its range. Two other Bornean endemics, the Bornean Bristlehead and the Bornean Blue Flycatcher were also noted. Other bird species noted that are considered increasingly rare or unusual included the Malaysian Honeyguide, Storm's Stork and Helmeted Hornbill.

Signs and sightings of elephants, sun bears, and orangutans, all species which are becoming increasingly rare throughout Sabah, were found by all groups and appeared relatively abundant throughout the GDVCA. Proboscis monkeys were observed in two survey areas. Tracks of the clouded leopard, an uncommon species and the largest extant felid in Borneo, were found by five of the seven survey teams. Tracks of the banteng, the second most endangered large ungulate in Sabah after the rhino, were found in four survey areas. Several individuals of what appeared to be a light (white) phase of the red leaf monkey were seen by Teams 1 and 2. Eleven of the 22 medium-large mammal species that were seen during the survey, were observed with juveniles or young.

Due to large differences in effort and field observation skills between individuals and teams, it is difficult to compare the wildlife data in great depth. Survey areas were grouped into general habitat categories of primary and secondary forest (Table

4). In survey areas with mixed patches of forest types, the area was categorized according to whether the forest was mostly primary or secondary, and where the patrols put in the most time and effort.

A better perspective is achieved when the data is standardized using an index of abundance. This figure was obtained by dividing the number of observations of a particular species, by the total area size covered by each team, and by the total number of team-days during the survey (one team-day equals one eight-hour day in the field by a single team, regardless of team size) (Table 5). Abundance figures were based on either sightings of the animal or by quantifying of some sign of the animal (ie. tracks, feces, etc.). Data from team 7 was not used in this comparison because much of their work was along or close to active roads, causing too large a bias in the data.

Sign of all the larger mammal species that were easily noted was found in both the primary forest and in the old logged forest areas. A closer comparison of the data was difficult due to small sample sizes and large standard deviations from the mean (Table 5). However certain apparent trends are worth further investigation.

Sambar deer was somewhat more abundant in secondary forest than primary (t test, prob.=.0135), while there were no obvious differences in the relative abundance of barking deer and mouse deer (t test, prob. =.6734 & .9560 respectively) between forest types. Sign of banteng was found primarily in secondary forest or in secondary forest portions of survey areas (Table 4). Bearded

pig and sun bear, both relatively abundant in the area, appeared equally as abundant in old logged secondary areas as in the primary areas. The red leaf monkey appeared to be relatively common throughout most of the survey areas but was virtually restricted to primary forest areas or primary forest portions of survey areas. On the other hand, only one group of four gray leaf monkeys were observed by Team 6, in an area of secondary forest. Other primate species also appeared relatively common in both forest types.

Discussion

Rhino presence

Where fresh rhino evidence was found, an estimate of four to seven rhinos was made for the nearly 80 km^2 of combined survey areas. If we assume that the lack of apparent rhino tracks in the other surveyed areas indicates no rhino activity in those areas at the time of the survey, then a conservative estimate is that there are two groups of four to seven rhinos in the 300 km^2 of surveyed forest in the GDVCA. If we extrapolate this information and speculate that there are other small groups of rhinos that are similarly distributed, this would lead to an estimate of 13 to 23 rhinos in the approximately 1000 km^2 of the GDVCA. If we assume however, that the remaining rhino population exists primarily within the approximately 170 km^2 of forest within the legally protected Danum Valley Conservation area and the area around the Danum Valley Research Center, then the survey indicates a possible 9-16 rhinos within the Danum Valley Conservation Area itself.

In either case, the figures albeit seemingly low, are at least double the estimate of 10 rhinos for a 2000 km^2 area around Danum by the recent Asian Rhino Action Plan. This is by no means an indication that the population is growing or even stable, only that there has been inadequate survey data on which to base any reliable figures.

Virtually all the rhino tracks were found in primary forest. However, primary forest habitat was surveyed much more extensively than old logged forest areas. Furthermore, the fact that rhinos are known to live in other secondary areas such as Tabin Wildlife Sanctuary and that a rhino was recently sighted in old logged forest along the entrance road to Danum, implies that they are capable of finding food and surviving in secondary forest areas. The mineral sources that were encountered by most of the survey teams also indicates that mineral availability is probably not a limiting factor for the rhino in this area. The abundant sign of hunting camps and human intrusion in the survey areas, and the fact that the best fresh rhino evidence was in the vicinity of the Research Center where the animals are safest, implies that rhino distribution patterns in Sabah may be determined simply by where the animal can be relatively free of human disturbance and stay alive the longest.

Sources of error in estimating rhino presence

Van Strien (1986) states that an experienced observer can determine in a few days whether rhino have been in an area or not.

This statement has two implications. Rhinos leave obvious and sometimes abundant sign of their passing or use of an area. Because some rhino evidence may stay around for months (feces) or even more than a year (broken and twisted saplings) this species is, in some ways, easier to survey than other large mammals. If an area was continually patrolled over a period of time, it is unlikely that one would miss evidence of resident rhino activity. However, an observer still must know what he is looking for. The best evidence of rhinos, their tracks, are often very difficult to find in the rainforest. Rhino tracks can get overrun by the tracks of other, more abundant animals such as pigs and elephants, and tracks are often only around until the next rain. Other sign, such as recent browsing, the breaking or twisting of twigs, and mud rubs on trees, is characteristic of rhinos if you know exactly what to look for, but may be confused with the behavior of other large ungulates and even some primates.

In a survey such as this one where circumstances demanded a large number of people divided into numerous teams, it is inevitable that there are also large sources of error. Some of this error can be eliminated in future surveys. Many of the survey team members were inexperienced, in that they had never knowingly seen rhino sign before to use as a basis of comparison. Also, there were individual observer differences which were sometimes compounded by how daily patrol teams were routinely divided. There were also differences in the amount of time spent in the field each day by different teams, the size of daily patrol teams, and a

patrol team's ability to walk quietly and unobtrusively in the forest. This led to variations in total area covered by any one survey team and the thoroughness with which an area was covered.

Despite standardized data sheets that were meant to minimize differences in data collection and note taking, data sheets were often filled out incompletely. Important observations, such as possible secondary sign of possible rhino presence, were noted haphazardly by some and ignored by others. Some data regarding rhino sign were not accompanied by measurements which could have eliminated the sign being potentially attributed to other species.

The measurements of rhino tracks themselves were often incomplete and came from only a single track or part of a track. This was due to weather and ground conditions and was often not the fault of the observer. However, it created difficulties in trying to assign tracks to individual rhinos. When more than one track of a particular rhino was available, track measurements indicated that there could be large differences within the same animal for virtually all track measurements except that of the middle toe (Table 1). Still, our scant track data supports van Strien's (1986) conclusion that the middle toe measurement is the most consistent of all the measurements as a means of identifying individuals.

A major difficulty that every group encountered was the overwhelming presence and disturbance by wild pigs. The Danum Valley area was in the final phase of a major fruiting period which was the likely cause for such pig numbers. Most wallows

encountered were being used by the pigs and their tracks were so omnipresent that they often obscured all other tracks. This contributed to the difficulty in finding and spotting rhino tracks. However, despite this difficulty, tracks of other ungulates such as elephant, banteng, sambar deer, barking deer, and mouse deer, could occasionally be seen along trails and at mineral deposits, so it seems unlikely that all rhino track sign could have been overlooked in areas where they were active at the time of the survey.

Conservation and management of the Sumatran rhino in Sabah

Protection and management of the Sumatran rhino in the wild cannot even begin to be addressed until there is better data on the presence and distribution of rhino in the remaining forest blocks of Sabah. As a first priority, the areas that have been targeted as possibly the best remaining rhino areas in Sabah, the Ulu Segama-Kuamut and Tabin Wildlife Sanctuary, need to be surveyed using the methodology put forth in this report and the techniques emphasized by van Strien (1986). It is crucial that a standardized methodology be established so that data can be validly compared between different areas and over time.

A few long term monitoring sites with established patrol routes should be set up and monitored yearly by trained Wildlife Department personnel. This would help the Wildlife Department assess changes in rhino numbers and/or distribution patterns in key areas. Optimally, one or more rhino field teams which are trained, experienced, and work well together should be assigned by the

department to do these surveys.

In the long term, a few large areas where survey data indicate that rhino populations still exist, need to be legally protected. As of now, only Tabin Wildlife Reserve is protected, while the future of the Danum Valley Conservation Area remains in doubt. Immediate efforts need to be made to legally protect the combined areas of the Danum Valley Conservation Area and the proposed expansion area as a wildlife sanctuary.

An important ramification of this survey is the clarification that, when potentially large monetary gain is involved, no place is left untouched by hunters, regardless of location, terrain, and legal status. The survey area we believed to be the most remote (Team 2), was the most heavily disturbed by recent illegal human intrusion and has been a long term access site into the Conservation Area. The survey area of Team 4, which had rhinos in the recent past (Ahmed, 1987), had numerous old and new hunting camps and no sign of recent rhino activity. Wallows known to have been used by rhinos in this area were now no longer in use. It is also interesting to note that no survey teams found rhino dung even though such sign can stay around for months at a time (Borner, 1974; van Strien, 1986). This is especially peculiar in the areas of fresh rhino tracks since rhinos defecate often (van Strien, 1986) and usually deposit it along their main routes of travel (Borner, 1979). A possible explanation may be that rhino feces is sought after for medicinal use (Borner, 1979), even in Sabah (Payne, pers. comm.). A lack of rhino dung may be a further

indication of on-going illegal human intrusion into the area.

The Asian rhino situation is dire. It is reported that Taiwan, a known outlet for rhino horn from Borneo, now prefers Asian rhino horn, believing it to be superior to African horn in medicinal properties (Bradley Martin, 1991). While trade in African rhino horn has decreased drastically, new supplies of Asian rhino horn are still coming into Taiwan through Hong Kong, Indonesia and India. Since it is known that the price will escalate as rhinos decline in numbers, some people are now paying as much as $US 45000/kg for rhino horn (Bradley Martin, 1991).

Without real protection and enforcement, the future rhino situation in areas like Danum is not only bleak, but may be changing radically as this report is read. Given the most optimistic scenario, there are relatively few rhinos left in Sabah and they are only in a few remaining areas, most of which are legally unprotected. The death of a single rhino in the Danum Valley Conservation Area alone could mean a 10% decline in the remaining numbers based on this survey's estimates.

There has been much talk and money spent on the Sumatran rhino. Yet we still know very little about this animal in the wild in Sabah. This rhino survey can be seen as a positive step in obtaining data and information that can be acted upon for the protection and management of this species. An important next step would be to immediately shut down the point of access currently being used to get into the southern part of Danum Valley Conservation Area. Along with this, a schedule of patrols needs to

be immediately initiated in areas where rhinos are known to still exist, particularly the Tabin and Danum areas. . This can be combined with opening up permanent patrol routes.

Although an area's remoteness and "wildness" is often gauged by lack of access, this does not appear to effectively deter hunters if the prize is big enough. In the case of the rhino, it seems logical that access in the form of roads and trails in key rhino areas needs to be increased so that Wildlife Department staff can patrol more effectively both on foot and by vehicle.

It is common knowledge that rhino hunting has been taking place for many years in Sabah and that rhino products are still sold openly. If there continues to be only talk about protecting the rhino in Sabah and no effective action is taken at this point, than any future surveys to assess the status of this species is doing little more than documenting the species' demise.

Suggestions for future rhino surveys

The survey methodology proposed by Borner (1979) and van Strien (1986) and adapted for this survey worked extremely well, given the time constraints. It is suggested that this methodology, which emphasizes a defined survey area and repeated patrols along key rhino travel routes, be used for future rhino surveys in Sabah. This technique appears to work better than random transects or surveys which simply walk across large areas. Two random straight line transects traversing approximately six kilometers of forest were tried by Team 7. Neither transect uncovered any rhino

evidence, even though one transect passed within approximately 1.5 km of a waterway where fresh rhino tracks were later discovered. A recent elephant census in Tabin Wildlife Reserve (Dawson, 1992) covered approximately 120 km of transects scattered throughout the 1200 km^2 reserve and uncovered spoor of only one rhino. Rhino surveys using such techniques have uncovered very little rhino sign due to the species' low density, secretive nature, and the low probability of encountering the animal's spoor.

The technique developed by Van Strien (1986) of taking plaster casts of rhino tracks, at least of the front toe, also proved to be very useful in this survey and should be continued on future surveys. An analysis of the plaster casts of front toes allowed us to recognize a misidentified rhino track as an elephant track.

There were several training objectives accomplished in this survey that augment other basic training given to most of the Wildlife Department staff. These should be considered for future surveys and include the following:

(a) Use of standardized data collection sheets for both general wildlife data and specific rhino data.

(b) Use of a standardized survey technique based on a species' known behavior patterns and literature research.

(c) Extensive use of map, compass, and altimeter.

(d) Appointment of senior staff as team leaders and assistant leaders to manage teams and to organize and plan daily survey routines.

(e) Joint cooperation between Sabah Wildlife Department staff and

the staff of other organziations such as Yayasan Sabah, The Sabah Museum, and Danum Valley Research Center.

Some specific suggestions for future surveys:

(a) Continued use of the rhino data sheets and general wildlife data sheets developed for this survey (Appendices IV & V).

(b) Greater emphasis and instruction on data collection (ie. measurements of wallows, broken saplings, etc.) and note taking.

(c) The purchase and distribution of altimeters to all teams.

(d) The use of well-trained teams of seven to eight individuals to extensively patrol contiguous survey areas totalling approximately 150-200 km^2 over a two to four week period. No less than two weeks should be used for a survey.

(e) Pre-survey training on rhino behavior and what rhino sign looks like. This could be carried out the captive rhinos at Sepilok.

(f) Training in how to make proper plaster casts, and a continued emphasis on taking plaster casts of good rhino tracks or the front toes of rhino tracks.

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Table 1. Rhino tracks and other fresh rhino sign observed during survey.

Team 2 - Sungai Beatrice

Track 1: Primary forest. Tracks found in dry soil/loam along a trail on the north facing slope of a mountain. Almost no erosion of track and a leaf pressed into the track is still green. Estimated age less than 1 week old. Measurements of three tracks taken.

	(a)	(b)	(c)
Partial length:	14.5 cm	13.5 cm	-
Track width:	22.8 cm	19.0 cm	17.5 cm
Front toe width:	7.0 cm	7.0 cm	7.0 cm
Track span:	18.0 cm	-	-

Note: Track (b) about 20 m from track (a).
Track (c) in clay substrate about 30 m from track (b).

Track 2: Primary forest. Track in damp leaf and loam on game trail along a relatively level portion of a SSW-facing slope. Old tracks along with the new suggest repeated use by one or more individuals. Older tracks impossible to measure. Green leaf impressed into the newer track suggests recent use of trail.

Track length: 20 cm
Partial track length: 14.5 cm
Track width: 19 cm
Front toe width: 8.0 cm
Track span: c. 15 cm

Track 3: Primary forest. Five tracks (all hind feet) found in sand and gravel on flat land along waterway. Movement by rhino is upstream. Accurate measurements in wet gravel/sand were difficult.

	(a)	(b)	(c)	(d)	(e)
Left/Right foot	Left	Right	Left	Right	Left
Track length:	22.0 cm	-	21.0 cm	-	22.0 cm
Partial length:	14.5 cm	12.5 cm	15.0 cm	15.5 cm	13.5 cm
Track width:	11.5 cm	16.0 cm	19.5 cm	18.0 cm	21.5 cm
Front toe width:	7.5 cm	-	7.5 cm	-	7.5 cm
Track span:	16.0 cm	15.0 cm	14.5 cm	-	17.0 cm

Note: Distance between steps: 61 cm, 66 cm, 80 cm, 76.5 cm
Track (a) was the most distinct track; track (d) was the worst track.

Track 4: Primary forest. Track of hind front foot found in mud along game trail on ridgetop. Associated with a wallow. Other tracks obscured by fresh pig tracks but can tell it is rhino. Tracks about 3-4 days old. Old (>1yr) and fresh (1-2 months) sign of humans in the area.

Track width: 22.5 cm
Front toe width: 7.5 cm

Team 7 - Danum Valley Research Center (DVRC)

Track 1: Primary forest. Track in dry soil/leaf litter on ridgetop along East Trail of DVRC. Chewed vegetation with trampled ground at base of plants. Twisted over ginger stems. Signs of fresh (c. 3 days) feeding on shrubs (0-136 cm above ground). Many twigs chewed off and lying on the ground, still bearing green leaves. Heavily trampled ground, broken branches (live and dead). Excessive disturbance of vegetation indicates rhino. No elephant sign around.

Front toe width: 8.5 cm

Track 2: Primary forest. Track in mud on ridgetop along rhino trail, 3 m to right of main East Trail. Signs of other less distinct tracks along with ginger plants bent over from feeding activity.

Track width: 18 cm

Sign 1: Primary forest, along East Trail, downslope. No clear tracks but numerous indistinct "depressions" in leaf litter. Estimated about 3-7 days old. Chewed vegetation nearby.

Sign 2: Primary forest, along South Ridge Trail, upslope. Numerous evidence of rhino approx. 1 km from DVRC. Indistinct tracks consisting of sequential depressions in leaf litter. Shrubs eaten off about 0.5 m from ground, some bent over/broken. One small area of extensive feeing. Twigs chewed through; green leaves/ twigs with leaves scattered or ground heavily trampled. In same area, mud rub against tree trunk: side of body at 85 cm high, head or horn rubbed at 145 cm.

Track 3: Old logged forest. Track in leaf litter along Sapat Kalison River, about 50 m from Segama River. Twisted and chewed vegetation (ginger) found for about 500 m along the waterway, approx. 1 m from the ground. Sign looks to be more than 1-2 weeks old.

Track length: 29 cm
Partial length: 18.5 cm
Track width: 17 cm
Track span: 14 cm
Front toe width: 7 cm

Note: Above tracks and sign all in relatively close proximity.

Track 4: Old logged forest. Tracks in mud/leaf litter along waterway. Tracks are indistinct and not new (>1 week). Partial measurements of 3 tracks taken.

Track length: 29 cm/29 cm/28.5 cm
Track width: 19.5 cm/20 cm/20 cm

Track 5: Primary forest. Track in leaf litter on ridgetop along Elephant Ridge Trail. Much fresh trampling of area - rotten branches, twigs on ground and numerous plants with rhino feeding sign. Branches broken 55 and 65 cm from ground with footprint at base of plant. Mud on tree trunk 1.5 cm from ground. No elephant sign in area.

Track length: 25 cm
Track width: 21 cm
Front toe width: 7 cm/8.5 cm

Track 6: Primary forest. Track in sand along left bank of Segama River. Old track with edges eroded so track appears larger than original.

Track length: 35.5 cm
Track width: 29 cm
Track span: 22 cm
Front toe width: 7 cm

Table 2. Possible secondary rhino sign observed during survey.

Team 1 - Operation Raleigh Cabin site. Primary forest.

Numerous large wallows in area. Two very distinctive:

(1) About 3 meters long, on slope. Overhanging vertical wall about 130 cm high. Mud marks on roots from the roof at 124 cm. Very large open trail approximately 1 m wide leading to the wallow.

(2) About 2.5 m long, almost 2 m high, at 1050 ft on slope.

(3) Wallow at 1900 ft, shaped like rhino. 2.5 m long x 2 m at widest point, narrowing to 1 m.

Team 4 - Sungai Purut site. Primary forest.

Numerous large wallows in the area. Known to have been previously used by rhino (Ahmad, 1987), but no sign of recent rhino use. Much pig activity at the wallows.

Team 5 - Jungle Lodge site. Primary forest.

Some distinctive looking wallows and sapling damage:

(1) Large wallow - looks typical of rhino, but grassed over and not recently used. Many palms, ginger, and saplings broken over at 90 degree angle.

(2) Two large wallows - halfway up ridge and crossing ridge.

Team 6 - Sungai Beruang site. Old logged forest

Some distinctive wallows and sapling damage:

(1) Wallow - old, disused, near browsed damage. 3x2 m, with 1 m wall.

(2) Browsed saplings - stem broken off c. 10 cm., dia=0.5 1.5 cm. Banteng and elephant in area.

(3) Browsed saplings - stem broken, .4-.6 cm, dia=.3-1.5 cm

(4) Wallow - 3x3m, 1.5 m deep, dry but used recently

(5) Saplings broken off at 40-50 cm, .5-1.5 dia, >20, old

TABLE 3

TERRESTRIAL MAMMALS AND PRIMATES FOUND DURING THE SURVEY

Taxonomic group - Species name	Common name	Sign[1]
Order Insectivora		
Family Erinaceidae		
Echinosorex gymnurus	Moonrat	1
Order Dermoptera		
Family Cynocephalidae		
Cynocephalus variegatus	Colugo	1
Order Primates		
Family Cercopithecidae		
Macaca fascicularis	Long-tailed macaque	1
Macaca nemestrina	Pig-tailed macaque	1
Nasalis larvatus	Proboscis monkey	1
Presbytis rubicunda	Red leaf monkey	1
Prebytis hosei	Grey leaf monkey	1
Family Hylobatidae		
Hylobates muelleri	Borneon gibbon	1
Family Pongidae		
Pongo pygmaeus	Orang-utan	1
Order Pholidota		
Family Manidae		
Manis javanica	Pangolin	5
Order Rodentia		
Family Sciuridae		
Sundasciurus hippurus	Horse-tailed squirrel	1
Callosciurus prevostii	Prevost's squirrel	1
Exilisciurus exilis	Plain pygmy squirrel	1
Rheithrosciurus macrotis	Tufted ground squirrel	1
Petaurista petaurista	Red giant flying squirrel	1
Ratufa affinis	Giant squirrel	1
Rhinosciurus laticaudatus	Shrew-faced ground squirrel	1
Family Hystricidae		
Hystrix brachyura	Common porcupine	5
Thecurus crassipinis	Thick-spined porcupine	1
Order Carnivora		
Family Ursidae		
Helarctos malayanus	Sun bear	1

Family Mustelidae		
Mydaus javanensis	Malay badger	4
Martes flavigula	Yellow-throated marten	1
Aonyx cinerea	Small-clawed otter	1
Lutra sp.	Otter species	1
Family Viverridae		
Viverra tangalunga	Malay civet	1
Paguma larvata	Masked palm civet	1
Cynogale bennettii	Otter-civet	2
Hemigalus derbyanus	Banded palm civet	1
Paradoxurus hermaphroditus	Common palm civet	1
Herpestes brachyurus	Short-tailed mongoose	1
Family Felidae		
Neofelis nebulosa	Clouded leopard	2
Felis bengalensis	Leopard cat	2
Felis sp. (maybe planiceps)	Cat (Flat-headed)	2
Order Proboscidea		
Family Elephantidae		
Elephas maximus	Asian elephant	1
Order Perissodactyla		
Family Rhinocerotidae		
Dicerorhinus sumatrensis	Sumatran rhinoceros	2
Order Artiodactyla		
Family Suidae		
Sus barbatus	Bearded pig	1
Family Tragulidae		
Tragulus napu	Greater mouse deer	1
Tragulus javanicus	Lesser mouse deer	1
Family Cervidae		
Muntiacus sp.	Barking deer	1
Cervus unicolor	Sambar deer	1
Family Bovidae		
Bos javanicus	Banteng	2,3

[1] 1=visual; 2=track; 3=feces; 4=scent; 5=spines or scales. If animal was seen, no other sign of the species was noted here.

Table 4. Relative abundance of select mammal species in the survey areas. Numbers are based on individual sightings or on the type of sign in parentheses.

SPECIES	FOREST TYPE[1]						
	Primary Forest					Secondary Forest	
TEAM	1	2	4	5	7	3	6
Sambar Deer	6	12(6)	7	4	1	27(12)	11
Barking Deer	11	6	9	5	8(3)	1(4)	8
Mouse Deer	17	4(5)	3	0	1	0(2)	6
Banteng (tracks)	0	0(2)	0	2	0(2)	1	5
Bearded pig	59	18	42	34	11	24(16)	11
Elephant (feces+tracks)[2]	19	10(3)	10	10	2(16)	4(2)	36(1)
Gibbon	46	20(13)	8	2	3(8)	11(5)	1
Orangutan (nests)[3]	10 (5)	9(0) (6/4)	3 (15)	6 (2)	1 (3/5)	8(2) (10/3)	0 (18/1)
Red leaf monkey	73	23	26	22	9	0(12)	1(5)
Gray leaf monkey	0	0	0	0	0	0	1
Long-tailed macaque	4	3(2)	0	12	0	0(6)	10
Pig-tailed macaque	0	8	3	0	1	1	2
Proboscis monkey	0	0(5)	0	24	0	0	0
Small-clawed otter	2	4	6	0	7	0(10)	4
Clouded leopard	2	1	0	0	1	1	2
Sun bear (claws)[4]	1 (3)	4 (5)	0 (5)	0 (1)	0 (1/2)	1 (1/4)	0 (2)

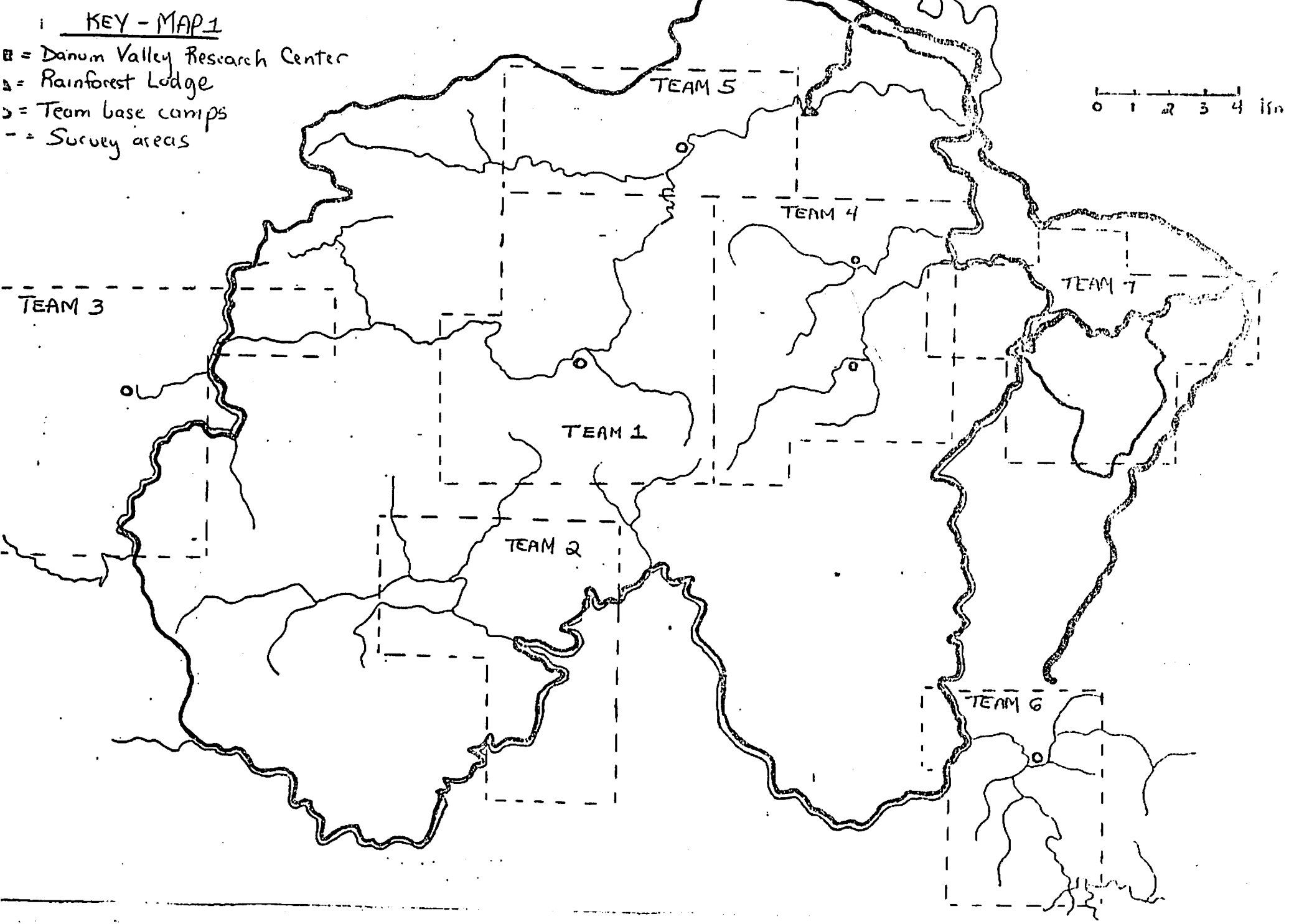
[1] Numbers in parentheses indicate sightings or sign from another habitat type - either secondary forest components of the mostly primary forest, or primary forest components of the mostly secondary forest.
[2] Totals of track and feces together. Numbers represent areas of occurrance not total numbers of every track and fecal deposit observed.
[3] Nests are areas of occurrance, not counts of individual nests.
[4] Distinctive bear claw marks or scratchings on trees, logs, etc.

le 5. Species abundance indices for select species in the survey area. (Numbers indicate # observations/km2/team-days[1]; S.D.=stardard deviation.

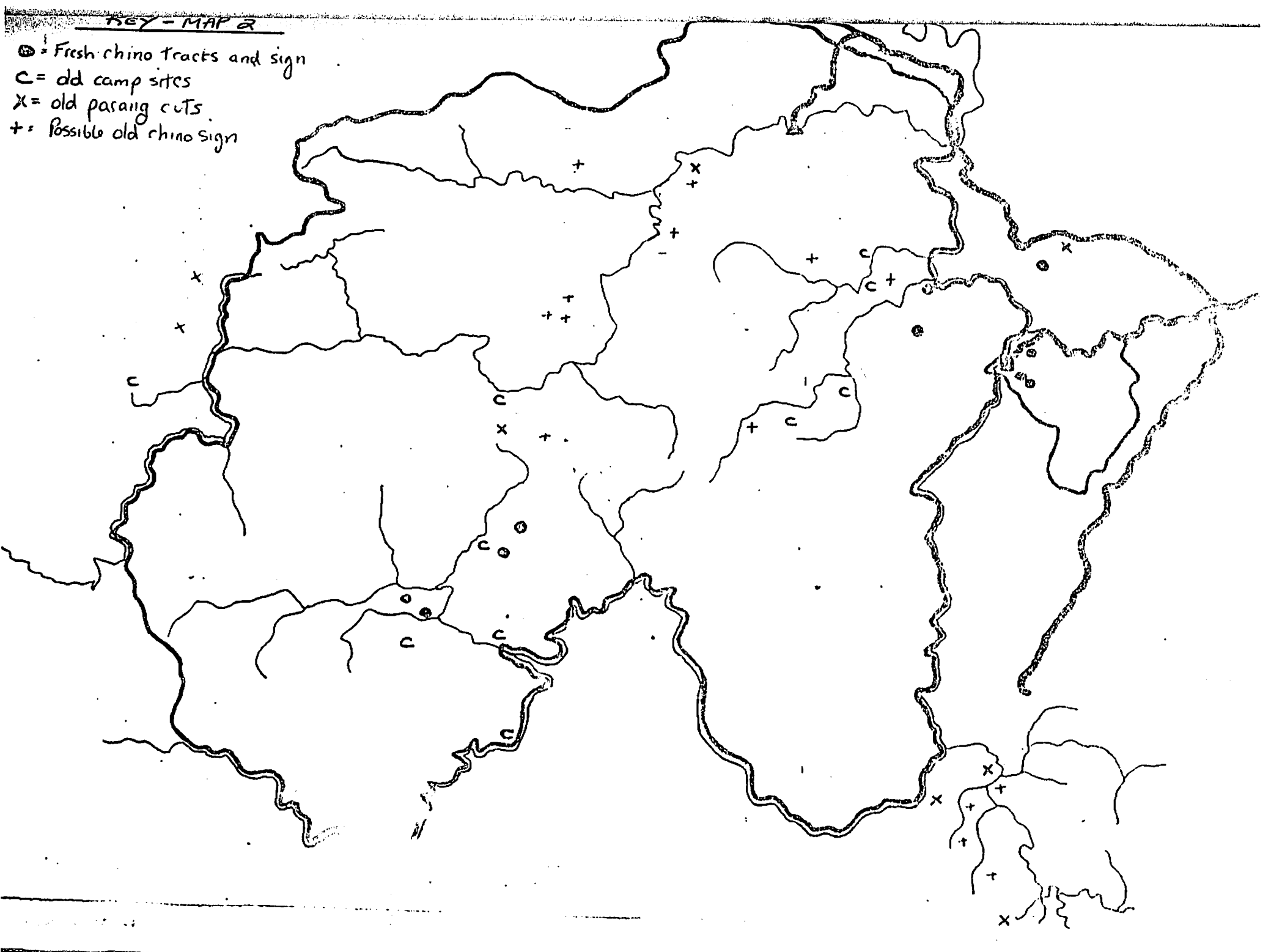
CIES sual unless stated)	FOREST TYPE: Primary Forest 1	2	4	5	MEAN	S.D.	Secondary Forest 3	6	MEAN	S.D.
bar Deer	.0051	.0238	.0076	.0075	.0110	.0086	.0411	.0366	.0388	.0032
king Deer	.0093	.0079	.0098	.0094	.0091	.0008	.0053	.0159	.0106	.0075
se Deer	.0144	.0119	.0033	0	.0074	.0070	.0021	.0120	.0070	.0070
teng (tracks)	0	.0026	0	.0026	.0013	.0015	.0010	.0100	.0055	.0061
rded pig	.0500	.0260	.0460	.0640	.0465	.0157	.0420	.0220	.0320	.0111
phant ces+tracks)	.0160	.0170	.0110	.0190	.0158	.0034	.0060	.0740	.0400	.0181
bon	.0390	.0440	.0090	.0040	.0240	.0201	.0170	.0020	.0095	.0106
ngutan	.0085	.0119	.0033	.0113	.0086	.0039	.0105	0	.0052	.0071
sts)	.0042	.0132	.0164	.0038	.0094	.0061	.0137	.0379	.0258	.0171
langur	.0619	.0304	.0284	.0415	.0406	.0154	.0126	.0120	.0123	.0001
g-tailed aque	.0034	.0066	0	.0226	.0082	.0100	.0063	.0199	.0131	.0096
-tailed aque	0	.0106	.0033	0	.0035	.0050	.0010	.0040	.0025	.0021
bear aws)	.0034	.0066	.0054	.0038	.0048	.0015	.0063	.0040	.0052	.0016

e team-day equals one eight-hour day in the field by a single patrol team, ardless of team size.

MAP 1. SURVEY AREAS AND BASE CAMPS WITHIN THE GDVCA


KEY - MAP 1
= Danum Valley Research Center
= Rainforest Lodge
= Team base camps
= Survey areas
TEAM 5
TEAM 4
TEAM 7
TEAM 3
TEAM 1
TEAM 2
TEAM 6
0 1 2 3 4 km

2. LOCATION OF RHINO SIGN AND HUMAN INTRUSION IN THE SURVEY AREAS


KEY - MAP 2
⊙ = Fresh rhino tracks and sign
C = old camp sites
X = old poaching cuts
+ = Possible old rhino sign

APPENDIX I

SURVEY TEAM PARTICIPANTS

Team (1): Operation Raleigh cabin site - west of DVRC
Virgin forest; center of conservation area
Team coordinator - Christoval Jomitin (JHL)
Field leader - Alan Rabinowitz (WCI)
Other team members:

1. David Anthonius (JHL)
2. Richard Jaikin (JHL)
3. Laingki Bein (RBJ)
4. Sabrianai (RBJ)
5. Phillip Hurrell (RBJ)

Team (2): Sungai Beatrice site
Virgin forest: southern part of core conservation area
Team coordinator - Sampoladon Pilik (JHL)
Field leader - Junaidi Payne (KPPAS)
Other team members:

1. Edward Tangon (JHL)
2. John Taraan (JHL)
3. George Phipps (WCI)
4. Arman Kudau (RBJ)
5. Basri Latif (RBJ)

Team (3): Sungai Katangen site - on old Luasong timber road

Old logged forest; west of conservation area
Team coordinator - Jikos Cordunon (RBJ)
Field leader - Clive Marsh (RBJ)
Other team members:

1. Jerry Gumpil (JHL)
2. Jaffit Majuakim (MZ)
3. Sabran Ali (RBJ)
4. Lee Chainsaw (RBJ)
5. Gani Juni (RBJ)

Team (4): Sungai Purut site - west of Danum Valley Field Station.
Virgin forest; site of previous rhino survey
Team coordinator - Augustine Tunga (JHL)
Field leader - Hamid (RBJ)
Other team members:

1. Jefte Sompud (JHL)
2. Adrianus Onong (JHL)
3. Sylvester Simon (JHL)
4. Alin Cheen Hong (RBJ)
5. Raymond Goh (Mz)

Team (5): Jungle Lodge site - on Sungai Danum
Virgin forest; good access
Team coordinator - Jumarafiah Abd. Shukor (JHL)
Field leader - Joseph Gasis (RBJ)
Other team members:

1. Nilofer Chaffar (RBJ)
2. Yakoob Abdullah (JHL)
3. Jimli Perijin (JHL)
4. Albert Lo (MZ)
5. John Rees (Whitewater Expeditions)

Team (6): Sungai Beruang site - on Sungai Segama
Logged forest - old logging in south, current logging in north; east of conservation area
Team coordinator - Laurentius Ambu (JHL)
Field leader - Matt Hayden (RBJ)
Other team members:

1. Rashid Saburi (JHL)
2. Joseph Kindingam (JHL)
3. Bidi Buit (JHL)
4. Marayu Palanus (JHL)
5. Anthony Pius (JHL)

Team (7): Danum Valley Field Center
Primary forest/some old logged forest.
Team coordinator - John Sale (JHL)

1. Rika Akahatsu (JHL)
2. Cede Prudente (Wildlife Expeditions)
3. Gunik Gunsalam (JHL)
4. Syarudin Mohammad (RBJ)
5. Simon Ambi (RBJ)

APPENDIX II

SCHEDULE OF RHINO SURVEY

14 September - Arrival and initial briefing at Danum Valley Research Station.

15 September - Training on census techniques and inventory methodology. Discussion of specific techniques for rhino survey.

16 September - A.M. - Training by Yayasan Sabah paramedic on emergency medical procedures.

16 September - P.M. - Final briefing of field assignments, methodology, etc. for the rhino survey.

17-26 September - Field surveys.

27 September - Return and debriefing at Danum Valley Research.

27 September - P.M. - Analysis and wrap-up by executive committee. Party for all participants.

APPENDIX III

SYNOPSIS OF GENERAL METHODOLOGY USED IN THE RHINO SURVEY

(1) Seven teams of seven individuals worked out from base camps situated at a central location in their survey area. Location of base camp changed no more than once during survey period.

(2) From each base camp, small teams of two to three people were sent out on daily patrols. Patrol assignments were given by the team leader after review of the previous day's data.

(3) Teams concentrated their patrolling efforts along waterways and ridges. Any game trails along these topographic features were followed. All daily patrol teams had to be able to locate their position on the map at all times through use of compass and altimeter.

(4) Daily records of progress and observed animal signs were collected from all patrol teams and compiled by the team leader. All teams used the same wildlife survey data sheets.

(5) If rhino tracks were found, the length and width of the entire track were measured as well as the width of the front hoof. At least one plaster cast was made of the front hoof of one of the good rhino tracks. All teams used the same rhino data sheets.

(6) Photographic records were made of the activities of each of the base camp teams and of all rhino evidence found in the field.

SERVER(S): _____ TEAM: _____

TE: _____ TIME: _____

CATION: _____ _____ SUBSTRATE: DRY SOIL / SAND / MUD / OTHER _____

ATHER: _____ _____ FOREST TYPE: OLD LOGGED / NEW LOGGED / VIRGIN /OTHER ___

RCLE APPROPRIATE CATEGORY:

INO SIGN OBSERVED: TRACK / WALLOW / FECES / SCRAPES / URINE

CHEWED VEGETATION / OTHER _____

CATION OF RHINO SIGN: ALONG TRAIL / CROSSING TRAIL / AT SALT LICK / IN FORE

CATION OF RHINO SIGN: ON RIDGETOP / ALONG WATERWAY / ON SLOPE

TRACK, SLOPE/DIRECTION: UPSLOPE / DOWNSLOPE: SLOPE FACING N / S / E / W

ARKS AND/OR MEASUREMENTS: _____

CK MEASURMENTS: TRACK ID NUMBER _____

T FOOT / RIGHT FOOT / UNKNOWN

NT FOOT / REAR FOOT / UNKNOWN

CK LENGTH (L_1-L_2): _____

CK LENGTH (l_1-l_2): _____

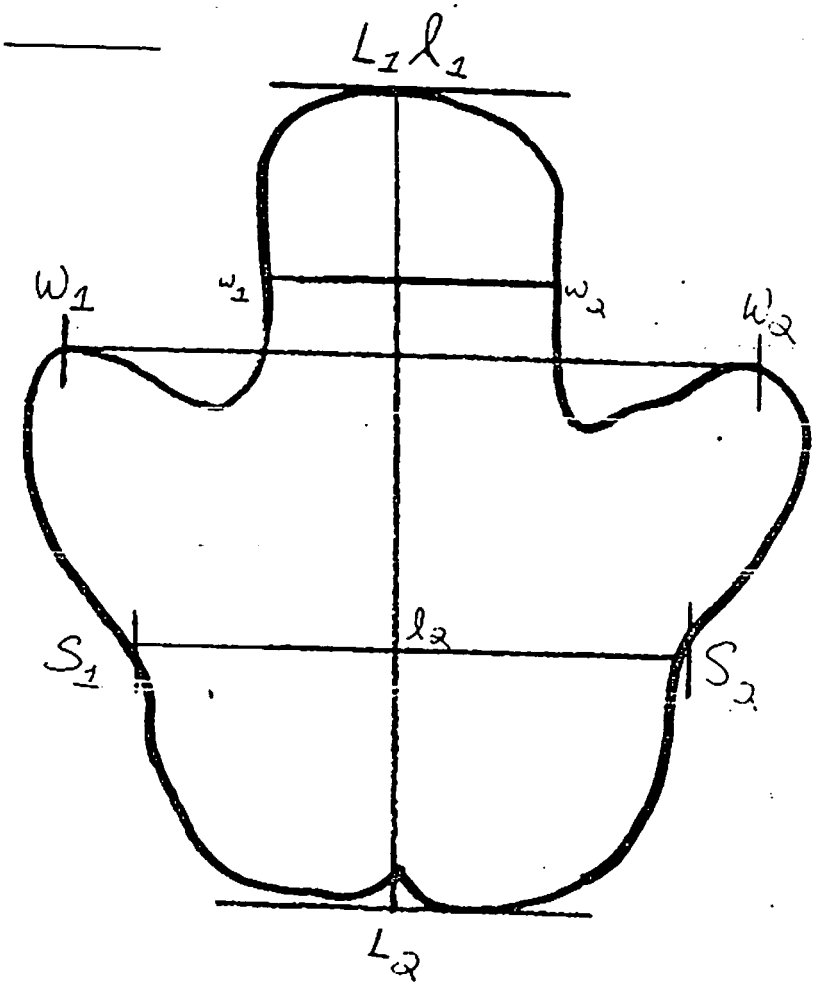
CK WIDTH (W_1-W_2): _____

CK SPAN (S_1-S_2): _____

NT TOE WIDTH (w_1-w_2): _____

T OF FRONT TOI TAKEN: YES / NO

TINCTIVE MARKS ON TRACK
cribe and draw on track)



WILDLIFE DATA SHEET

ER(S): _____ TEAM: _____ DATE: _____

E: _____ TIME START: _____ TIME FINISH: _____ FOREST TYPE: _____

N: _____

S	TIME	NUMBER	SIGN[1]	LOCATION/DIRECTION[2]	HABITAT[3]	MEASUREMENTS[4]	BEHAVIOR	REMARKS[5]

[1] Visual; 2=Vocalization; 3=Feces; 4=Scrapes; 5=Den/Nest (Specify); 6=Claw marks; 7=Other (Specify)

[2] Location: R=ridgetop; V=valley; S=along slope / Direction: North, South, West, East. Compass bearing.

[3] Examples: Salt lick, riverine forest, rock outcrop, open grassy area, scrubby, low second growth, virgin dipterocarp

[4] Examples: Fecal length and diameters, scrape length, distance to sighting.

APPENDIX VI

EVIDENCE OF HUMAN DISTURBANCE IN THE SURVEY AREAS

Group 1:

(1) Parang cuts on ridge west from Gunung Danum Summit at 2260 ft.

(2) Relatively large, very clean camp (12-14 beds) about 50 m up second tributary about 2 km from Raleigh Cabin. Looks like about 1 year old.

Group 2:

(1) Parang marks and camp, 2 1/2 km west of Kuala Beatrice. About 10 days - 1 month old. Four camps, along ridgetop and riverside.

(2) Young barking deer has severe wounds in hindfoot and chest that look to be gunshot.

(3) Hunter's cache: Located at 1500-1600 ft on ridge:

25 kg rice
2 D-size batteries
Iban parang
spoon/string/wire
thin nylon rope
one pair shoes
2 shirts and pants
salt
mirror
coffee
soap
gunny sacks
plastic bags
extra pants and shirt
small knife with bone handle
extra wooden parang handle
socks and leech socks
candles - 3 boxes
white pepper
5 kg sugar

Group 3:

(1) Old camp and area of old parang cuts found on ridge in primary forest.

Group 4:

(1) Evidence of human presence - trail and resting place about 1 month old. South ridge of Sg. Purut.

(2) Hunters camp in Purut tributary. Three person, about 1 month old.

(3) Hunters camp about 1 year old at Langum bank. Fireplace on river beach with bones of tortose and shoulder bones of a pig.

(4) Another hunters camp on Langum bank. About 5-6 months old.

Group 5:

(1) About halfway up southeast ridge from camp - many cuttings - sign of old (1 yr) human disturbance.

Group 6:

(1) Parang cuts. Within a year, possibly several months. In residual primary, up towards ridge, following game trails.

(2) Cigarette packet, local. Not badly deteriorated. On old logging road.

(3) Parang cuts - very old. Along game trail on ridge.

Group 7:

(1) 12 guage shotgun shell found on old logging road, east of DVRC (Deer Research Plot) at km 63.

APPENDIX VII

SALT LICKS OR MINERAL SOURCES FOUND DURING SURVEY

Group 1:

(1) Along moderately steep slope - dry dirt area that has been heavily dug at and cleared. Alot of animal activity in dirt.

(2) Near Danum River (200 ft) not far from 3rd main tributary west from Raleigh Cabin. Vegetation is scarce and short. A lot of elephant, sambar, and wild boar tracks in area.

Group 4:

(1) West ridge, down to east tributary of Sg. Purut. End of ridge, evidence of soil (and water) being dug up and licked (perhaps ingested.) No wallow. Two, perhaps 3 springs with many animals trails towards the salt licks. First pot of salt spring found in DVCA.

Group 5:

(1) Looks like large dry wallow - like mineral lick on top of ridge. Under heavy fruiting fig tree.

(2) A wallow with adjacent mineral lick in riverine forest.

Group 6:

(1) Area of 4x4 m of brown wet mud, extensively trampled by pig and sambar but no evidence of wallowing. A lot of tracks leading to this site. Maybe salt deposit.

Group 7:

(1) Mineral Licks on Segama River trail south of DVFC. Tracks of pigs, sambar deer, and mouse deer present.

(2) Small salt lick nearby the Sungai Sapat, Kalison. Tracks of pig, sambar deer, and barking deer found.

APPENDIX VIII

LIST OF BIRDS OBSERVED DURING SURVEY[1]

Alcedinidae: Kingfishers
- Ceyx erithacus / Asian Dwarf Kingfisher
- Alcedo euryzonia / Blue-banded Kingfisher
- Pelargopsis capensis / Stork-billed Kingfisher
- Halcyon chloris / Collared Kingfisher

Oriolidae: Old World Orioles, Fairy-bluebirds
- Irena puella / Asian Fairy Bluebird
- Oriolus xanthonotus / Dark-throated Oriole

Muscicapidae: Old World Flycatchers
- Terpsiphone paradisi / Asian Paradise Flycatcher
- Cyornis superba / Bornean Blue Flycatcher*
- Cyornis caerulata / Large-Billed Blue Flycatcher
- Philentoma velatum / Maroon-breasted Flycatcher
- Ficedula dumetoria / Rufous-chested Flycatcher
- Philentoma pyrhopterum / Rufous-winged Flycatcher
- Rhipidura perlata / Spotted Fantail
- Muscicapa sibirica / Sooty Flycatcher

Pittidae: Pittas
- Pitta guajana / Banded Pitta
- Pitta baudi / Blue-headed Pitta*
- Pitta granatina / Garnet Pitta

Eurylaimidae: Broadbills
- Eurylaimus ochromalus / Black and Yellow Broadbill (Team 7)
- Calyptomena viridis / Green Broadbill

Bucerotidae: Hornbills
- Anthracoceros malayanus / Black Hornbill
- Anorrhinus galeritus / Bushy-crested Hornbill (Team 2)
- Rhinoplax vigil / Helmeted Hornbill (Teams 2,5,6,7)
- Buceros rhinoceros / Rhinoceros Hornbill (Teams 2,5,6,7)
- Berenicornis comatus / White-crowned Hornbill (Team 2)
- Rhyticeros undulatus / Wreathed Hornbill (Teams 2,1,7)

Corvidae: Jays, Magpies, Crows
- Platysmurus leucopterus / Black Magpie
- Platylophus galericulatus / Crested Jay
- Corvus enca / Slender-billed Crow

Timaliidae: Babblers
- Pellorneum capistratum / Black-capped Babbler
- Stachyris erythroptera / Chestnut-winged Babbler
- Pomatorhinus montanus / Chestnut-backed Scimitar-Babbler
- Macronous ptilosus / Fluffy-backed Tit-Babbler
- Stachyris poliocephala / Grey-headed Babbler
- Malacopteron magnum / Rufous-crowned Babbler
- Malacopteron cinereum / Scaly-crowned Babbler
- Trichastoma malaccense / Short-tailed Babbler
- Kenopia striata / Striped Wren-Babbler
- Macronous gularis / Striped Tit-Babbler
- Trichastoma rostratum / White-chested Babbler
- Yuhina zantholeuca / White-bellied Yuhina

Hemiprocnidae: Treeswifts
- Hemiprocne comata / Whiskered Treeswift

Pycnonotidae: Bulbuls
- Pycnonotus atricepts / Black-headed Bulbul
- Hypsipetes charlottae / Buff-vented Bulbul
- Criniger bres / Grey-cheeked Bulbul
- Pycnonotus bruneus / Red-eyed Bulbul
- Pycnonotus erythropthalmos / Spectacled Bulbul
- Pycnonotus striatus / Straw-headed Bulbul
- Hypsipetes malaccensis / Streaked Bulbul

Capitonidae: Barbets
- Megalaima australis / Blue-eared Barbet
- Megalaima chrysopogon / Gold-whiskered Barbet
- Megalaima mystacophanos / Red-throated Barbet

Dicruridae: Drongos
- Dicrurus aeneus / Bronzed Drongo
- Dicrurus paradiseus / Greater Racket-tailed Drongo

Apodidae: Swifts
- Hirundapus giganteus / Brown Needletail
- Rhaphidura leucopygialis / Silver-rumped Swift

Picidae: Woodpeckers
- Meiglyptes tukki / Buff-necked Woodpecker
- Picus mentalis / Checker-throated Woodpecker
- Chrysocolaptes validus / Orange-backed Woodpecker
- Blythipicus rubiginosus / Maroon Woodpecker
- Picus puniceus / Crimson-winged Woodpecker
- Micropternus brachyurus / Rufous Piculet

Phasianidae: Quail, Partridges, Pheasants
Lophura bulweri / Bulwer's Pheasant* (Teams 2,4,5)
Argusianus argus / Great Argus Pheasant (Teams 4,5,6,7)
Arborophila charltonii / Scaly-breasted Partridge
Lophura ignita / Crested Fireback

Turdidae: Thrushes
Enicurus ruficapillus / Chestnut-naped Forktail
Enicurus leschenaulti / White-crowned Forktail
Copsychus pyrropygus / Rufous-tailed Shama
Copsychus malabaricus / White-rumped Shama

Accipitridae: Kites, Hawks, Eagles, Vultures
Spilornis cheela / Crested Serpent Eagle (Team 6)
Icthyophaga nana / Lesser Fish-Eagle

Columbidae: Pigeons, Doves
Chalcophaps indica / Emerald Dove (Team 7)
Ducula aenea / Green Imperial Pigeon

Sylviidae: Old World Warblers
Gerygone sulphurea / Flyeater
Orthotomus sericeus / Rufous-tailed Tailorbird

Ardeidae: Herons, Egrets, Bitterns
Ardea sumatrana / Great-billed Heron
Butorides striatus / Little Green Heron

Motacillidae: Wagtails, Pipits
Motacilla cinerea / Grey Wagtail

Nectariniidae: Sunbirds, Spiderhunters
Arachnothera longirostra / Little Spiderhunter

Psittacidae: Parrots
Loriculus galgulus / Malay Lorikeet

Indicatoridae: Honeyguides
Indicator archipelagicus / Malaysian Honeyguide?

Dicaeidae: Flowerpeckers
Dicaeum trigonostigma / Orange-bellied Flowerpecker

Phalacrocoracidae: Cormorants, Darters
Anhinga melanogaster / Oriental Darter

Hirundinidar: Swallows
Hirundo tahitica / Pacific Swallow

Meropidae: Bee-eaters
Nyctyornis amictus / Red-bearded Bee-Eater

Trogonidae: Trogons
Harpactes kasumba / Red-naped Trogon
Harpactes duvaucelii / Scarlet-rumped Trogon

Cuculidae: Cuckoos
Centropus rectunguis / Short-toed Coucal

Ciconiidae: Storks
Ciconia episcopus / Storm's Stork (Team 6)

Pityriasis gymnocephala /Bornean Bristlehead[2]*

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[1] Unless otherwise noted, all sightings were compiled by Team 1, in the study area around the Operation Raleigh cabin. Teams in parentheses noted the species in addition to Team 1.

[2] Considered a rare bird of Borneo.

* Bornean endemic species