A REVIEW OF THE SUMATRAN RHINOCEROS CONSERVATION PROGRAMME AND ASSESSMENT OF MANAGEMENT ALTERNATIVES FOR THE FUTURE

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EVOLUTIONARY AND HISTORICAL ASPECTS

The evolutionary history of the Rhinocerotidae is known in considerable detail beginning during the Tertiary period (Rhodes *et al.* 1962). The early rhinoceros evolved with primary changes in body size, dental characteristics, feeding habits and horn structure and perhaps became extinct due to climatic changes and competition during the geologic times (Zeuner 1957, Rhodes *et al.* 1962). Approximately 36 million years ago (in the Oligocene epoch), primitive and giant-sized rhinoceros such as Baluchitherium which stood about 6 meters and colonised North America and Europe. Later, smaller primitive rhinoceros which were forest dwelling browsers, Diceratherium, evolved between the Miocene and Pliocene (about 25 to 12 million years B.C.) (Rhodes *et al.* 1962, Laurie and Oliver 1977). After the last Ice Age, about 11,000 years ago, woolly rhinoceros, *Coelodonta antiquitatis* which stood up to 2 meters, ranged across North America, Europe, and Asia.

The parentage Dicerorhinae, distinguished by the anterior and posterior horns in tandem and ossification of the nasal septum is related to the tapir-sized *Dicerorhinus tagicus* of the Oligocene (Owen-Smith 1973, Laurie 1978). From a lineage of *Coelodonta,* with incisors and canines entirely reduced, molars that were hypsodont and a lengthened skull, a primitive species *D. kirchbergensis* emerged and became adapted to the tropical rainforest which is now represented by the Sumatran rhinoceros *(D. sumatrensis)* (Laurie 1978).

The first Sumatran rhinoceros made known to the scientific community was described by Bell in 1793 from an animal killed in Sumatra (Prater 1939). In 1820, Raffles described the same species killed in Malacca. Historically, the distribution of the Sumatran rhinoceros included the hills of Chittagong, Tippera and Assam and Brahmaputra valley in the Indian subcontinent, the entire of Burma, hilly country in Thailand, Indo-China, Malay Peninsula, Sumatra and Borneo (Talbot 1960, Groves and Kurt 1972, Prater 1980). By 1960, the species was extinct in the Indian region, Laos, Cambodia and Vietnam and considered rare in Thailand and Malaysia. There is insufficient information of its status in Burma which holds the subspecies *D.S. lasiotis* (Khan 1987). The subspecies *D. S. sumatrensis* is represented in Thailand, Peninsular Malaysia, and Sumatra while *D. S. harrisoni* now remains in dwindling pockets in eastern Sabah and western Sarawak.

In recent years, the Sumatran rhinoceros has attracted our curiosity in many ways. In the last century, Westerners had trapped and acquired more than 60 known animals of this species and exported them to Europe and North America for exhibition in menageries and circuses, or skeletons and skins collected by hunters and naturalists for European museums (Sclater 1872, Prater 1939, Reynolds 1960). The introduction of firearms during that time had also brought many big game hunters who massacred the species for sport or trophy hunting (Thom 1935, Groves and Chakraborty 1983). The locals hunted the animal for the Orient population who traditionally believed that rhinoceros body parts possess certain medicinal

and supernatural value. Rhinoceros hunting was so rampant that the Javan rhinoceros *(Rhinoceros sondaicus)* became extinct in Peninsular Malaysia in 1932 (Loch 1937) and the Sumatran rhinoceros was vulnerable to perish. Coupled with habitat disturbances, rhinoceros populations have been in distress through years of persecution and could be extinct by the next century.

This paper reports on the present population and habitat status in Peninsular Malaysia and highlights the recent captive breeding and conservation problems of the Sumatran rhinoceros in this region and in other non-rhino producing countries.

POPULATION AND HABITAT PROBLEMS

Population estimates and existing problems

Although there are no comprehensive historical records, the population trend of the Sumatran rhinoceros in Malaysia has always been low. In 1854, tracks of rhinoceros were still found in Malacca (Wallace 1962). Hubback (1939), a game warden and an ardent big game hunter, observed that despite enacting a wildlife law in 1896, there was widespread killing of the Sumatran rhinoceros population in Pahang at the turn of the century. The irony was that game wardens, Strait Settlement officers, and private collectors were allowed rhinoceros sport hunting knowing that the population of the species was exceptionally low. Talbot (1960) speculated that a few rhinoceros existed in northern Malay Peninsula but the numbers of the species were unknown. Milton (1963) and Stevens (1968) estimated the remaining population found in Johore, Pahang, Selangor, Perak, Trengganu, Kelantan, Kedah, and Taman Negara to be between 20 and 47 individuals.

A study on the rhinoceros population in a regenerated forest was conducted by Strickland (1967) at Sungai Dusun, Selangor. Since 1974, the Department of Wildlife and National Parks (DWNP) started a nation-wide survey on the rhinoceros population and an ecological study of a population in a primary forest at Endau-Rompin region (Flynn and Mohd-Tajuddin 1983 and 1984). At the same time, Sumatran rhinoceros management teams were set up in states known to sustain certain numbers of the rhinoceros population. These rhinoceros teams are instrumental in population monitoring, patrolling, surveying of new areas, furnishing reports, and updating records on the animals distribution. They also carried out trapping for a captive breeding programme in Peninsular Malaysia. The rhinoceros team reports from 1975 to 1989 and our investigation of the habitats and observation of the tracks become the basis of estimating the present numbers of the Sumatran rhinoceros in Peninsular Malaysia.

The present population estimate is 85 animals found in 26 areas of different habitat types (Table 1). Out of these animals 47% is found in Taman Negara and the proposed Endau-Rompin state park, 1% in game reserves, and the remaining 52% inhabit unsecured or isolated forest islands. Generally, 53% of the total population is found in disturbed, isolated, or unsecured habitats and has negligible opportunity to propagate in their natural ranges. Khan *et al* (1982) estimated that the rhinoceros population in Peninsular Malaysia had produced three young during the period 1975-1981. We believe that between 1975-1989, the Sumatran rhinoceros population in Peninsular Malaysia had stabilized below 100 individuals. This situation may be due to an equilibrium between a critically low growth rate of the population against a relatively high mortality rate and rapid habitat reduction.

The difficulties of rhinoceros population and habitat preservation and protection are due to numerous factors. Ecologically, the Sumatran rhinoceros is a solitary animal which requires about 10 to 40 sq km of secondary or primary forest habitat. In regenerated forest, once the animal discovers a feeding site, it stays in the area between one to two weeks. With minimal disturbances and slight improvision of the feeding area the animal can be captured or killed within 24 hours to a week. For large habitats such as Taman Negara and Endau-Rompin, constant patrolling along the perimeter and in specific localities is impossible and

can only serve as a deterrent against poachers. In small fragmented habitats the rhinoceros are more susceptible to hunting due to accessibility by old logging roads or because the areas are close to human settlements. The vulnerability of the rhino population in habitats with extremely low numbers of individuals would reduce the probability of random mating and population fitness.Under such circumstances and without disturbances the population could be naturally extinct over the next few years.

Habitat Problems

Irreversible damage to the habitat and degradation of environmental quality are also causes of the rapid extermination of the Sumatran rhinoceros and its reduction as an endangered species to insignificant relict populations in Peninsular Malaysia. For almost 32 years after Malaysia achieved independence from the British administration, agro-forestry based economics, human settlement, and industrial progress have dominated the government policy in terms of land utilization. Land set aside for wildlife and nature conservation accounted for less than 5% of the total area of Peninsular Malaysia. Except for the Sungai Dusun Game Reserve, the other reserves for wildlife and nature conservation were enacted during the British colonial administration.

In 1964, a small portion (10,000 acres) of the Sungai Dusun habitat was established as a reserve of rhinoceros protection. Attempts to enlarge the Sungai Dusun Reserve to include the adjacent forest along the canal which constitutes part of the known rhinoceros range, were unsuccessful. Other areas known to have rhinoceros, such as Ulu Selama and Endau-Rompin, had been severely damaged in certain parts by logging activities in 1976 and 1986 respectively. Gradually, oil palm plantations are encroaching into Tenggaroh and Kambau in Johore, Endau-Rompin, Bukit Gebok, and Lepar in Pahang. The Temenggor Dam built in 1975 and Kenyir Dam in 1984 have forced the rhinoceros in the Belum District (Jabatan Mergastua 1975) and the Ulu Trengganu area to seek refuge in the highlands. A similar fate will be experienced by the animals in Sungai Yong when the Pergau Dam, Kelantan, is inundated.

Flushing and mortality rate

We believe that the incidence of rhinoceros appearing in secondary forests, rice fields, oil palm plantations, rubber plots, and kampongs (Table 2) is closely related to the habitat encroachment or irreversible changes in their natural environment.

Currently, the yard stick of progress in socio-economic and industrial development in the states of Johore, Selangor, Perak, and Pahang is invariably related to the rate of deforestation. Prime lowland forest which is suitable for wildlife is consistently the target of land conversion for agriculture, new human settlements, and industries. Active logging, low habitat quality, low food quantity, and hunting pressure could flush out rhinoceros form their natural ranges to wander aimlessly and migrate into other territories of unfamiliar habitat.

Evidently, a high frequency of flushing of rhinoceroses from their territories are observed in those states with rapid deforestation. The flushing frequency for Johore, Selangor, Perak, and Pahang are 43.7%, 18.7%, 18.7% and 12.5% respectively. Between 1975-1989, 50% (8 rhinoceros) of the known flushed animals were killed and 37% were rescued by the DWNP. In the state of Johore, between 1988-1989, 100% of the flushed rhinoceros were killed by poachers. Thus in about a decade if the rhinoceros population in unsecured areas were flushed out due to pressures on their habitat about 18 animals would be killed. These figures only relate to known and reported cases of animals being flushed and killed. The actual number of animals killed is not known but we believe that it is possible that as many as five animals are killed for every reported mortality. The high occurrence of females found in such situations apparently associated with the small home range of the animals.

Apparently, the female rhinoceros are highly vulnerable to poachers during the stage of aimless wandering into aberrant habitats. It was also discovered recently that such animals could be caught without much effort or without any elaborate trapping techniques. Conside-

ring the factors such as a high annual mortality rate (5%), that 50% of the wandering population are mature females, the slow movement pattern of the species, that females have smaller ranges, and the rapid habitat reduction, it is highly probable that a significant number of the adult or breeding females could be lost in the near future.

Between 1975 to 1989, there were nine cases involving rhinoceros poaching in Johore, Kelantan, and Selangor (Table 3). In all cases the skull or some parts of the rhinoceros carcass and skeleton were recovered from the killing sites. About 88% of the mortality is mainly due to poachers. A poacher brought to court in 1985 was convicted and fined M$400. This low penalty imposed by the court will not discourage poachers who can risk the high reward of between M$20,000 to M$30,000 for selling the rhinoceros horn on the black market.

If we assume that the population remains constant since 1975, then the mortality due to poaching is 9.4% of the estimated population size. The number of illegal kills represents a significant part of the total population and this could contribute to the present decline of the species. We hypothesize that the present population could be seriously threatened with extinction if the current conservation problems remain unchecked. Based on the 1989 poaching record, the mortality rate is 2.3%. This coupled with the long gestation period and calving interval, the high rate of habitat destruction, and the fact that most of the animals are living in isolated forests, means that the Sumatran rhinoceros population could be extinct in 96% of its present localities by the year 2010.

MEDICAL PROBLEMS OF CAPTIVE SUMATRAN RHINOCEROS

A common and severe problem in wild Sumatran rhinoceros are snare wounds, both cable and nylon snares. In five reported cases, 60% were associated with cable snares and subsequent exostosis. In Indonesia, 3 cases of cable snares were reported while a case of nylon snare was reported from Sabah. Two of the Sumatran rhinoceros with cable snare injuries died, one from acute colic and the other from Klebsiella pneumonia. The remaining one animal, a male in Surabaya, still has a recurring problem of the affected foot. A male Sumatran rhinoceros with previous cable snare injuries could not mate successfully. Frequent slipping of the forelimbs during "rowing" movement was observed. Due to the timely erection of the penis with a subsequent erection of the cornu on the body of the penis, any delay in mounting will prevent a successful intromission.

Another common foot problem is foot pad ulceration with underrunning of the sole and subsequent excoriation. The cause of this is still unknown, but a tentative diagnosis of laminitis was suggested. Two cases of foot pad ulceration were observed in newly acquired wild caught Sumatran rhinoceros. Laceration of the foot pad is always related to crating and paddock utilization.

In captivity, it was observed that the rapid rate of keratinization and hair growth resulted in hyperkeratinization and pyoderma. The main contributiing factors are lack of abrasive surfaces (horizontal and vertical) and mud wallows. The availibility of angular panellings resulted in severe irregular abrasion of the horns. Excessive wallowing will result in the flaking of the skin and coronary cracks of the hooves (Zainal Zahari 1988).

Sterile skin abscesses were observed in several animals, particularly after previous administration of antibiotics and anabolic steroids. One abscess on the hind limb of a Sumatran rhinoceros at Zoo Melaka was due to a puncture wound. Myiasis were observed in three cases in captive Sumatran rhinoceros.

Unilateral and bilateral corneal opacity were observed in several captive Sumatran rhinoceros. This problem was associated with traumatic causes, particularly dust, contaminated wallows, and cut forage stems. At Ragunan Zoo, the corneal opacity terminated in ulceration and scarring of the cornea. Blindness was observed in a Sumatran rhinoceros female at Zoo Melaka as a result of trauma during handling by plantation workers in an estate.

Phimosis in a subadult male was observed at Zoo Melaka. The problem was associated with age. Observation of the condition showed a remarkable improvement as the animal matured.

Diarrhoea and associated enteritis were observed in captive rhinoceros. The death of the animal due to a severe necrotizing enteritis and the isolation of Salmonella blockley from the paddock provide a tentative diagnosis of Salmonellosis. Endoparasites were the other cause of diarrhoea. Strongyles, Strongyloides, and Crossocephalus spp were previously identified.

PRESENT MANAGEMENT OPTION

Intensive population management

With all these population and habitat constraints on Sumatran rhinoceros conservation discussed earlier, what management options are available to secure the future of this endangered species? Are these management options viable to overcome the threats and problems that could wipe out most of the rhinoceros population in 10 to 20 years from now? We believe that there is no simple answer to this as with any wildlife problem. However, most western zoo administrators, theoretical scientists, and modelers have strongly advocated captive breeding as an ideal model of intensive management, and this could be a viable solution to the problems of endangered species (Soule and Wilcox 1980, du Toit et al 1986, Maguire *et al.* 1987, Foose *et al.* 1987). However, their theoretical judgements for captive breeding are highly subjective and prominently prejudiced against certain aspect of *in-situ* management options.

The DWWP initiatives on a captive breeding programme for the subspecies *D.s. sumatrensis* in Peninsular Malaysia started in 1985 (Mohd-Tajuddin 1986). The wildlife authority in Indonesia entered into agreements for captive breeding projects on the rhinoceros with the Howletts Estates, England, and a consortium of American zoos in 1986 and 1987 respectively. In Sabah, the captive breeding programme began in 1986 for the subspecies *D.s. harrisoni.*

Since 1984, a total of 27 Sumatran rhinoceros were caught and 19 of the living animals are kept in eight captive facilities throughout the world (Table 4). Eight of the rhinoceros or 42% of the world captive population is found at Zoo Melaka. The rest of the rhinoceros are located at Sepilok, Sabah; Ragunan Zoo, Bogor, Surabaya, and a basecamp in Sumatra, Indonesia; Howletts Estates, England; and Cincinnati and San Diego Zoos, USA. Over a six-year period, 29.6% of the Sumatran rhinoceros died without contributing any genetic material towards the species conservation. The combined fatality rate during rhinoceros capture programmes in Malaysia and Indonesia is 11.1% (assuming that all field mortalities have been reported).

As with the captive breeding of the black *(Diceros bicornis)* and Indian *(Rhinoceros unicornis)* rhinoceroses in other modern and sophisticated zoos (Lang 1977, Beehler and Bush 1981, Char et al. 1984, Fowler 1986, Maruska *et al.* 1986), we observed that the Sumatran rhinoceros breeding programmes are facing similar difficulties of high captive mortality (Table 5) and clinical management problems(Table 6) (Kloss and lang 1982, Zainal-Zahari et al, 1989a & 1989b). Diseases accounted for 50% of mortality, with 37.5% from post-capture problems, and 12.5% due to accidents. The Indonesian-British breeding cooperation and Sabah had the highest mortality of 50% respectively, while the Peninsular Malaysia programme encountered a 27% fatality. Comparatively, in North American and European zoos, hemolytic anemia has been reported in 17 black rhinoceros (Fowler 1986) and has claimed several animals. Stillborn calves accounted for 13.8% of the 36 Indian rhinceros calves born during 1956-1975 (Lang 1977). Pneumonia, septicemia, accidents, enteritis, and euthanization have claimed many black rhinoceros worldwise (Maruska *et al.* 1986).

The present captive breeding programmes also suffer from a skewed sex ratio favouring the capture of female rhinoceros which account for as much as 74% of the animals captured.

Eighty percent of the captive population in Malaysia are females, with only one potentially breeding pair established at Sepilok. Unpaired animals are found at Surabaya and Bogor, Indonesia and San Diego and Cincinnati, USA. Out of the five males located at Zoo Melaka, Sepilok, Ragunan, Bogor, and Howletts, only two animals are considered good breeders. At the Zoo Melaka, the male is still immature, while a male at Bogor Safari Park is suffering from a permanently damaged forelimb. In other species (especially domestic animals), it is found that non-breeding females will eventually suffer from the male-effect syndrome, where they ultimately stop cycling and may become permanently useless for breeding purposes.

It is clear that over the last three years there have been sufficient numbers of breeding male and female Sumatran rhinoceros in captivity for a major breeding exercise of the species to have begun, provided the animals were optimally distributed. It is sad comment upon the sectarian sentiments that plague this project that such breeding has not yet started. Rather than cooperation, individual bodies seem to be talking conservation on one had while competing on the other.

The present plan for the conservation of Sumatran rhinoceros envisages the establishment of major captive populations in North America and England in addition to South-east Asia. Dietary and climatic changes, adaptation, and behavioral reformation are major factors that will determine the success of *ex-situ* rhinoceros management in England and North America. Conversely, the progeny born and bred in the temperate zoos might not be suitable for reintroduction into the thick and humid tropical rain forest in the future. A second weakness of captive breeding in temperate areas is the glaring lack of any guarantee that the Sumatran rhinoceros will actually be readily and easily available for re-introduction programmes in the countries of origin. British and American institutions have entered into the programme on a conservation basis, but in practical terms are treating the capture programme as an animal acquiring project, where they measure their financial contribution against a number of rhinoceros to be exported. It would seem that much more could be done for real *in-situ* conservation if the will was there. Apparently, the captive breeding programmes elsewhere have diverted all resources from *in-situ* conservation of the Sumatran rhinoceros population. At this stage when the Peninsular Malaysian average trapping cost is about US$2,500 per rhinoceros, the actual costs of the British and American programmes in Indonesia were exorbitant, ranging from US$150,000 to US$200,000 per animal exported to their zoos. About 30% of this amount has gone into a conservation fund for *in-situ* Sumatran rhinoceros management. However, the wild populations remain neglected and unattended by any of those institutions.

It is safe to state that captive breeding within the rhinoceros producing countries stands a better chance in terms of its long-term viability than those management programmes carried out elsewhere in the world. However, given the high rate of fatality in a previous report (Skafte 1961), and the recent trapping fatalities and captive mortality due to diseases as high as 11.1% and 50% respectively, it could take us less than 50 years to exterminate the whole rhinoceros population in the world while implementing the intensive management programmes. This situation is compounded by inadequate knowledge of the captive breeding and management of the Sumatran rhinoceros. Our conservation objectives could easily be defeated, and the future generation could accuse us of accelerating the process of extinction. Such is the reality based on the dismal results of the present captive programmes; the critics were right in questioning the whole captive breeding programme.

On a large-scale, intensive management of the rhinoceros requires a large area with adequate basic facilities. However, in many zoos large space for the animal is a luxury and a costly investment. Unlike the white, black, or Indian rhinoceros which are social animals, the Sumatran rhinoceros is always solitary in its natural environment. In captivity, at Zoo Melaka, 8 rhinoceroses are separated in individual compounds and night stalls. A female, Rima, was known to be extremely fierce and aggressive in behaviour towards other animals

during her pregnancy. On one occasion a female (Jeram) that was in heat was released to a male's (Napangga) paddock for mating purposes. A cow-calf pair (Rima and Minah) was allowed to share a common paddock and two night stalls for more than two years.

The overused outdoor compound suffered erosion during a wet period which caused the exposure of many sharp and angular stones and other objects which were harmful to the rhinoceros. It was also observed that during this period pathogenic bacteria flourished which could cause serious threat to the animals in captivity. When these conditions prevailed, the outdoor paddock was treated and left unused until the soil analysis showed negative presence of the pathogens. During that time the animals were confined to their indoor stalls.

Accordingly, in order to breed a founder population of 20 animals there must be a system of at least 30-40 paddocks and night stalls to accommodate breeding females and cow-calf pairs. It is clear that most zoological gardens will not be able to provide sufficient space to meet these stringent conditions.

Good knowledge of the breeding and clinical management of the endangered species, and a team of dedicated scientists and field workers are prerequisites before embarking on propagation plans on a larger and intensive scale for the Sumatran rhinoceros. However, captive management and propagation of the species is hindered by the scarcity of information on this endangered species. We also observed certain disparity in the present breeding arrangements in Malaysia, Indonesia, England, and North America. Technically, the breeding programmes appear comprehensive on paper, but in practice they are more or less ad hoc and are evolving individually in different directions. This is mainly due to difficulties in administration and financial and political pressures. These human-related problems have long dictated our decisions and could jeopardise the conservation values of the captive breeding programme. For instance, when Zoo Melaka officially or unofficially offered to host scientists for a long-term cooperative research on reproductive biology, behavior, and management there was no institution willing to accept the proposal. However, there are conservationists who would receive the research proposition if only Zoo Melaka played a non-functional role in the cooperation. Realising that we need to develop our skills and experience to an adequate level in handling and preserving this species, we have had to train and educate ourselves to meet these needs.

Indifferent attitudes and the lack of commitment of field workers has resulted in poor husbandary of the Sumatran rhinoceros at certain captive facilities (Mohd-Tajuddin and Zainal-Zahari 1987, Zainal-Zahari 1988, Zainal-Zahari et al. 1989). Such poorly managed animals are useless for breeding purposes, and the captive propagation programme can be defeated in the long-run.

PROPOSED SOLUTIONS

Poaching control

Poaching in Malaysia can be considered as a silent force that seriously threatens our wildlife populations. This problem has kept the rhinoceros population low for many decades. Out of 5000 cases of wildlife act infringement in 1988, about 25% were poaching-related problems involving various types of animals. We have observed on many occasions that wire snares used by poachers for trapping wild pigs have seriously crippled elephant, tiger, and rhinoceros. Too many guns in the wrong hands kill too much precious wildlife almost everyday. Rhinoceros, seladang, and serow have been reported killed by illegal hunters. On many occasions, members of the villagers' auxillary security unit (RELA) went on wildlife shooting sprees on the pretense of enforcement of security law. It is estimated that more than 100,000 guns are issued to RELA members who are mostly living in the villages.

In its efforts to control poaching, Nepal mobilized 500 armed soldiers to guard the Indian rhinoceros in the Chitwan National Park. The result of this massive protection was so overwhelming that the rhinoceros population grew from 160 in 1966 to 375 in eight years (Martin 1984). Efforts at controlling poachers necessitate the service of several teams of experienced,

responsible, and well trained staff and good vehicles and equipment. This can be an expensive excercise, but in a long term it will increase the security for the rhinoceros in the wild. Establishing good rapport with villagers can help the enforcement officers in gaining reliable information on the poachers. We recommend that for any solved poaching cases, financial incentives for the enforcement officers and informers must be provided to encourage them to high work productivity.

Semi-intensive management

Semi-intensive management of the white rhinoceros *(Ceratotherium simum)* has proven to be a useful management option in South Africa (Owen-Smith 1973). In 1965, the 480 sq km Umfolozi Game Reserve was fenced with five strands of heavy duty lift cable supported by heavy duty posts. The extensive fenced wildlife reserve is also protected against poachers, and the white rhinoceros is allowed to range freely in the enclosed habitat. In 1960, the aerial survey produced a total estimate of 705 white rhinoceros. Five years after the fencing, in 1970, there was a 250% population increase to 1,764 white rhinoceros in the enclosed reserve. From 1969-71, the Umfolozi white rhinoceros population was increasing at 9.5% per annum (Owen-Smith 1983). However, this rapid increase in the white rhinoceros population can cause damage to the habitat, or the population could crash due to habitat and population factors. Culling of the white rhinoceros population was proposed (Owen-Smith 1983) and was carried out in order to preserve the habitat and the population.

Considering population and habitat constraints, plus the solitary behavior of the Sumatran rhinoceros, both captive management and habitat manipulation principles can be combined where the rhinoceros can be managed in a semi-intensive state in its natural environment. Minimal disruption of its social behavioural pattern must be strived for at all times during the implementation of the semi-intensive breeding programme. The DWNP will initiate a semi-intensive breeding programme at the 400 hectare Sungai Dusun Wildlife Reserve beginning 1990. Night stalls with spacious outdoor compounds for breeding and an enclosed natural habitat, plus a research facility and staff quarters are under construction at Sungai Dusun. This facility could accommodate 10 breeding animals, and there is enough room for future expansion. The breeding of the Sumatran rhinoceros at Sungai Dusun will be closely monitored. However, the results of the programme can only be realised in the next 10-20 years time.

A constant supply of a large amount of forage to support a large population of the animals is required in this situation. In captivity, the rhinoceros are known to consume between 30-40 kg of foliage per day. Preferred are young leaves and selected foliage 30 cm from the tip of the shoot (Zainal-Zahari *et al.* 1989). In its natural environment, the Sumatran rhinoceros is a destructive and sometimes wasteful feeder. Saplings are usually broken at about two feet from the ground and the animal selectively feeds or rejects the foliage. In the semi-intensive situation at Sungai Dusun, the feeding cannot depend on the saplings available in the enclosed area. Feeding could easily destroy the entire enclosed habitat within a few months. Thus, the rhinoceros must be fed daily prior to release in the enclosed habitat in order to avoid unnecessary damage to the entire area. Cultivation of food plants such as *Macaranga* spp, *Ficus* spp, and *Artocarpus* spp and fruits such as papaya and *Mangifera* spp is necessary in the cut-and-carry feeding system at Sungai Dusun.

Habitat management : manipulation and modification

According to Teague and Decker (1979), viable wildlife populations result from a sufficient quantity and quality of food, cover, and other special requirements, appropriately interspersed. The provision, maintenance, or improvement of these habitat ingredients is essential to the health of the population. Habitat modification techniques have been documented as essential management tools to improve the habitat quality for wildlife such as deer and migratory waterfowl in North America. In Ujung Kulon Nature Reserve, Java, in Indonesia,

Schenkel and Schenkel-Hulliger (1978) studied habitat modification to improve growth of the Javan rhinoceros food plants. In Malaysia, the DWNP has experimented with habitat improvement for the seladang *(Bos gaurus)* populations in Ulu Lepar and Taman Negara. At the seladang captive breeding centre in Jenderak, Pahang, food plots are maintained to provide supplemental forage for the animals.

It has been documented that in old secondary forest, not severely damaged by logging activity, there is abundant secondary browse for seladang and elephants (Conry 1981, Olivier 1978). Strickland (1967) found that the food plants in the regenerated forest of Sungai Dusun can support a population of 4-6 animals. In Endau-Rompin, Flynn (1983) observed that in terms of canopy cover, the rhinoceros preferred old forest gap succession and some new gap and riverine areas for browsing. Feeding sites near stream bottoms and lower slopes made up 60% and 35% respectively of the total feeding sites. In climax forest such as in Taman Negara and the Krau Game Reserve, forest gaps can be created by breaking the closed forest canopy. The gap will increase sunlight intensity and will encourage dormant seeds to germinate and suppressed seedlings to grow. There will be abundant emergence of secondary growth in the area. The saplings from the secondary growth are the main source of food for the free ranging rhinoceros. Thus creating several well distributed gaps in the climax forest can enhance the quantity and quality of food resources for the Sumatran rhinoceros.

Translocation and stocking

Translocation and stocking of wildlife species into their former ranges have long been practised in wildlife management. Between 1984-85, the greater one-horned rhinoceros was transplanted from Assam and Chitwan, Nepal to Dudhwa National Park, in north central India (Singh 1984, Sale 1986, Sale and Samar 1987). Of the nine rhinoceros translocated to Dudhwa National Park, 77.7% (seven animals) survived. The exercise resulted in the development of valuable techniques in capture and handling of the Indian rhinoceros (Sale and Woodford 1981). Excess white rhinoceros have been translocated from South Africa, and several populations have been re-establishe din their former ranges (Owen-Smith 1973).

We recommend the translocation of the Sumatran rhinoceros from threatened habitats to other protected reserves such as Taman Negara and Krau Game Reserve, Pahang. Animals in unsecured areas can be released into these protected reserves to infuse new blood and increase breeding potential in the natural environment of the species. This program can go hand in hand with the present captive breeding plan for the species. Surplus females/males from the breeding centre can be immediately transplanted into Taman Negara and the Krau Game Reserve.

IMMEDIATE ACTION NEEDED

1. Serious attention should be given to centering the Sumatran rhinoceros captive breeding programme within South-east Asia where the present wild population of the species still survives and where the future reintroduction will take place. Technical advantages of breeding animals in the USA and UK are somewhat nullified by the climatic and transport factors as well as by the uncertainty that the animals bred here will be available and adaptable to South-east Asian conditions. The authorities responsible for rhinoceros conservation should seek funds from local and other international bodies with no vested interest in the species other than a desire for its long term *in-situ* survival.
2. Zoo Melaka must be supported to reach its full potential in the research and captive management of the Sumatran rhinoceros. A team of full-time researchers must be commissioned to conduct detailed investigation on the reproductive biology, genetics, husbandry, clinical pathology, and applied biotechnology of captive breeding of the Sumatran rhinoceros. Other research institutions and interested

parties should be invited to participate in this concerted effort to conserve the endangered species in this region.

3. The high rate of trapping and captive mortalities deserves serious consideration in any future attempt for ex-situ rhinoceros management. Biologists and wildlife managers who are involved in the rhinoceros management must be willing to share information to improve trapping, handling, and husbandry techniques. Such knowledge of the Sumatran rhinoceros must be documented to become an accepted standard procedure for any captive breeding facility.

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Table 1: Population estimates of the Sumatran rhinoceros in Peninsular Malaysia

Locality	Minimum number	Habitat type	Status
Johor			
Tenggaroh	2	Lowland; secondary forest	Unsecured
Kambau	2	Lowland; secondary forest	Unsecured
Kuala Sedeli	1	Lowland; secondary forest	Unsecured
Gunong Belumut	1	Hill; primary forest	Unsecured
Endau-Rompin	20	Lowland, hill; primary	State Park
Taman Negara	20	Lowland, hill; primary	Natl Park
Selangor			
Sungai Dusun	2	Lowland; secondary	Unsecured
Pahang			
Raub	2	Lowland; secondary	Unsecured
Kuala Lipis	1	Lowland; secondary	Unsecured
Krau Reserve	1	Lowland, hill; primary	Secured
Bukit Gebok	1	Lowland; secondary	Unsecured
Sungai Lepar	1	Lowland; secondary	Unsecured
Sungai Luit	1	Lowland; secondary	Unsecured
Perak			
Tera, Grik	3	Lowland, hill; primary, secondary	Unsecured
Ulu Selama	6	Lowland, hill; primary, secondary	Unsecured
Ulu Belum	2	Lowland, hill; primary, secondary	Unsecured
Bubu Forest	2	Lowland, hill; primary, secondary	Unsecured
Kedah			
Gunung Inas	2	Lowland, hill; primary, secondary	Unsecured
Kelantan			
Kuala Balah	3	Lowland, hill; primary, secondary	Unsecured
Sungai Depak	3	Hill; secondary	Unsecured
Sungai Pergau	1	Hill; secondary	Unsecured
Sungai Kenerong	1	Lowland; secondary	Unsecured
Sungai Sok	1	Lowland; secondary	Unsecured
Bukit Yong	3	Lowland; secondary	Unsecured
Trengganu			
Sungai Chenana	1	Lowland; primary	Unsecured
Ulu Trengganu (Kenyir Dam)	2	Hill; secondary	Unsecured
TOTAL	85		

Table 2: Incidence of Sumatran rhinoceros emerging in unnatural habitat

Year	Age/Sex	Habitat/State
1976	Adult/?	Sec forest/Kelantan
1984	Calf/M	Sec forest/Perak
1984	Adult/F	Oil palm/Selangor
1984	Adult/F	Oil palm/Perak
1985	Adult/?	Oil palm/Johore
1986	Adult/?	Sec forest/Johore
1986	Adult/F	Sec forest/Selangor
1986	Adult/?	Sec forest/Johore
1986	Adult/?	Rubber plot/Pahang
1986	Adult/F	Oil palm/Perak
1987	Subad/F	Rice field/Selangor
1988	Adult/F	Kampong/Pahang
1988	Adult/F	Sec forest/Johore
1988	Adult/M	Sec forest/Johore
1989	Adult/F	Sec forest/Johore
1989	Calf/M	Sec forest/Johore
	Total : 16	rhinoceros

Table 3: Known mortalities in the wild Sumatran rhinoceros population in Peninsular Malaysia between 1975-1989.

Year	Locality	Cause of death	Number
1975	Endau-Rompin, Johore	Unknown	1
1976	Kuala Krai, Kelantan	Poached; dehorned	1
1985	Bukit Bujang, Johore	Shot; dehorned	1
1986	Kambau, Johore	Snared	1
1986	Sungai Dusun, Selangor	Shot; dehorned	1
1988	Tenggaroh, Johore	Shot; decapitated	1
1988	Tenggaroh, Johore	Shot; dehorned	1
1989	Tenggaroh, Johore	Shot; decapitated	1
1989	Tenggaroh, Johore	Unknown	1
		TOTAL	9

Table 4: Sumatran rhinoceros captured and held in captivity between 1984 - 1989

Year	Name	Age	Sex	Trapping site	Captive facility	
1.	**PENINSULAR MALAYSIA**					
1984	Jeram	Adult	F	Selangor	Zoo Melaka	Not breeding
1984	Erong	Calf	M	Perak	Zoo Melaka	Died
1984	Melintang	Adult	F		Dusit Zoo	Died
1986	Rima	Adult	F	Johore	Zoo Melaka	Not breeding
1986	Dusun	Adult	F	Selangor	Ragunan Zoo	Not breeding
1986	Julia	S/ad	F	Perak	Zoo Melaka	Not breeding
1987	Panjang	S/ad	F	Selangor	Zoo Melaka	Not breeding
1987	Minah	Calf	F	Zoo Melaka	Zoo Melaka	Captive birth
1987	Sri Delima	S/ad	F	Selangor	Zoo Melaka	Died
1987	Mas Merah	Adult	F	Selangor	Zoo Melaka	Not breeding
1988	Shah	S/ad	M	Selangor	Zoo Melaka	Not breeding
1988	Seputih	Adult	F	Pahang	Zoo Melaka	Not breeding
2.	**SABAH, MALAYSIA**					
1987	?	Adult	M	Lahat Datu	Capture	mortality
1987	Tanegang	Adult	M	Lahat Datu	Sepilok	Not breeding
1988	?	Adult	M	Lahat Datu	Capture	mortality
1989	Long Parai	Adult	F	Lahat Datu	Sepilok	Not breeding
3.	**INDONESIA**					
1986	Jalu	S/ad	M	Sumatra	Ragunan Zoo	Not breeding
1986	Napangga	Adult	M	Sumatra	Zoo Melaka	Died
1986	Rokan	Adult	M	Sumatra	Surabaya	Not breeding
1988	Dalu	Adult	F	Sumatra	Bogor	Not breeding
1989	Agustine	Adult	F	Sumatra	Basecamp	Not breeding
4.	**ENGLAND**					
1985	Torgamba	Adult	M	Sumatra	Howletts	Not breeding
1986	Riau	Adult	F	Sumatra	Capture	mortality
1986	Subur	Adult	F	Sumatra	Howletts	Died
1986	Meranti	Adult	F	Sumatra	Howletts	Not breeding
5.	**U.S.A.**					
1988	Mahato	Adult	F	Sumatra	Cincinnati	Not breeding
1988	Kumu	Adult	F	Sumatra	San Diego	Not breeding

DISCUSSION

Dr. S. Vellayan (National Zoo, Malaysia) commented that even though salmonella organism cannot be isolated in the laboratory, the disease should however be at least reported as a clinical case. He added that Salmonellosis is a fatal disease to elephant, rhinoceros and other large hoofstock as reported by many researchers. Since this is the recent experience from the Zoo Melaka, the audience present could obtain this information and be aware of the seriousness and fatality of this organism.

In relation to Dr. Vellayan's comments, Dr. Zainal Zahari (DWNP, Malaysia) replied that the bacteriology laboratory were not able to isolate salmonella but the gross pathology was very suggestive of the disease. He also added that a horse that died during the same day showed similar gross pathology and the laboratory isolated *Salmonella blockley*.

The Chairman asked whether the estimated population of 85 rhinos in 26 localities is a viable population.

Mr. Tajuddin (DWNP, Malaysia) clarified that using the minimum viable population (MUP) by Soule would require 500 individuals for the period of 1000 years. Thus, the population here cannot be considered viable and that this population must be manged in such a way that it is capable to reproduce especially those remote populations that still occur in Taman Negara and Endau Rompin.