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The Husbandry and Veterinary Care of Captive Sumatran Rhinoceros at Zoo Melaka, Malaysia

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Abstract: The husbandry, adaptation to captivity, nutrition, biological data and medical problems of the rare and endangered Sumatran rhinoceros *(Dicerorhinus sumatrensis)* at Zoo Melaka, Peninsular Malaysia, are described. The clinical management focuses on problems of the captive Sumatran rhinoceros in this region. Currently, 42% of the world's captive Sumatran rhinoceros populations is located in Zoo Melaka. A female Sumatran rhinoceros, suspected pregnant prior to her capture, gave birth after 469 days in captivity at Zoo Melaka. The average daily weight gain of the rhinoceros calf was 0.86 kg for the first 12 months. Problems of the skin, adnexa, sensory organs, genitalia, and digestive system are common in the captive Sumatran rhinoceros. A severe necrotizing enteritis suggestive of Salmonellosis *(Salmonella blockley)* claimed a female Sumatran rhinoceros. The first mating of captive Sumatran rhinoceros was observed in 1987. However, intromission was unsuccessful due to a chronic and severe foot problem in the male.

INTRODUCTION

The Sumatran rhinoceros, *Dicerorhinus sumatrensis,* is the smallest of the five living rhinoceros and one of the most rare and endangered species of large mammals in the world. The Sumatran rhinoceros population once extended from the hilly tracts of Assam on the Eastern borders of India to Burma, Thailand, Indochina, Peninsular Malaysia, Sumatra and Borneo. Now the species is confined to a few island habitats in Thailand, Peninsular Malaysia, Borneo and Sumatra. Little is known of its status in Burma which holds the subspecies *D. s. lasiotis* (Khan 1987). The subspecies *D. s. sumatrensis* is present in Thailand, Peninsular Malaysia and Sumatra, while *D. s. harrisoni* now exists in dwindling pockets in eastern Sabah and Western Sarawak. The rhinoceros populations are threatened by heavy poaching pressure, inadequate protection and insufficient land area which is decreasing long-term population viability.

In Peninsular Malaysia, the number of Sumatran rhinoceros is estimated at 50 to 75 individuals with the Endau-Rompin (20-25 animals) and Taman

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Negara (8-12) areas containing the largest populations (Flynn & Mohd-Tajuddin 1983, 1984). This species is categorized as a totally protected animal under the Malaysian Wildlife Protection Act 76/72 (Anon 1972). Habitat devastation and poaching pressure have threatened the small and segregated populations throughout Malaysia (Mohd-Tajuddin, 1985; Mohd-Tajuddin *et. al.* 1989). Hence in 1985, the Department of Wildlife and National Parks (PERHILITAN) began an intensive effort to conserve those rhinoceros found in threatened areas with negligible prospect for long-term survival (Mohd-Tajuddin, 1987a). Within a three-year period (1985-1988), five rhinoceros were captured in Pahang, Johore and Selangor using pit traps, two were roped and a female was caught using a corral trap (Mohd-Tajuddin *pers. notes;* Mohd-Tajuddin, 1988). Unlike trapping in Indonesia and Borneo which resulted in three losses (Parkinson and Nardelli, 1986; Mohd-Tajuddin, 1987b), the capture techniques used in Peninsular Malaysia are very effective with zero mortality. The wild-caught rhinoceros are to be used for the captive breeding programme at the captive facilities in Zoo Melaka and in the Sungai Dusun Wildlife Reserve, Selangor.

Currently, there are 19 Sumatran rhinoceroses (Table 1) kept at eight captive facilities throughout the world (Zoo Melaka, Peninsular Malaysia; Sepilok, Sabah; Ragunan Zoo, Bogor Safari Park, and Surabaya Zoo, Indonesia; Howletts and Port Lymphne Zoo, Britain; San Diego and Cincinnitti Zoo, U.S.A.). Eight of these rhinoceros representing 44% of the world captive population are found at Zoo Melaka. The accomplishment of the captive management and breeding of this rare Sumatran rhinoceros at Zoo Melaka aims to contribute to the long-term conservation objectives of the species in the Southeast Asian region.

The management and breeding of this species is often discouraged by the deficiency of up-to-date information on the captive management of the rhinoceros. All of the Sumatran rhinoceros kept by western zoos in the last century or early of this century were mainly utilized for display purposes (Reynolds, 1960) and produced scarcely any information on their management in captivity. However, detailed information for the Black, White and Indian species were reported by Jones (1979), Silberman and Fulton (1979) and Fowler (1986). The lack of knowledge on the physiology, anatomy, nutrition, husbandry, medical problems and reproduction of the Sumatran rhinoceros should be considered seriously by zoo biologists or authorities before embarking on a captive propagation programme.

This paper reports the recent captive management experience of the Sumatran rhinoceros at Zoo Melaka, Malaysia.

GENERAL HUSBANDRY AND ADAPTATION

Habituation to captivity

The zoo acquired eight wild-caught subadults and adults rhinoceros from

isolated habitats in Johore, Pahang and Selangor between 1985 to 1988 (Table 1). Immediately after capture, the Sumatran rhinoceros was confined in a wooden crate measuring 100 (w) x 225 (l) x 165 (h) cm. A light pick-up truck (1 ton) was used to transport the animal to Zoo Melaka. The animal was confined in the wooden crate for a varying number of days (1-60 days) depending on their response to handfeeding, their temperament, and body condition. During this period of adaptation to the captive environment, the wild rhinoceros were handfed, watered and constantly bathed. Dewor-

Table 1. Sumatran rhinoceros in captivity

No.	House name	Sex	Capture Date/Locality	Captive facility
1.	Jeram	F	30.4.1984/Selangor	Zoo Melaka
2.	Erong*	M	21.5.1984/Perak	Zoo Melaka
3.	Rima	F	10.2.1986/Johore	Zoo Melaka
4.	Julia	F	6.7.1986/Perak	Zoo Melaka
5.	Panjang	F	25.2.1987/Selangor	Zoo Melaka
6.	Minah**	F	23.5.1987/Zoo Melaka	Zoo Melaka
7.	Seri Delima***	F	1.7.1987/Selangor	Zoo Melaka
8.	Napangga*+	M	25.4.1987/Sumatra	Zoo Melaka
9.	Mas Merah	F	26.5.1987/Selangor	Zoo Melaka
10.	Shah	M	26.3.1988/Selangor	Zoo Melaka
11.	Seputih	F	11.7.1988/Pahang	Zoo Melaka
12.	Tenegang	M	15.7.1987/Lahat Datu	Sepilok, Sabah
13.	Long Parai	F	22.4.1989/Lahat Datu	Sepilok, Sabah
14.	Jalu	M	23.3.1986/Sumutra	Ragunan Zoo, Indonesia
15.	Dusun+	F	9.9.1986/Selangor	Ragunan Zoo, Indonesia
16.	Rokan	M	2.2.1986/Sumatra	Surabaya Zoo, Indonesia
17.	Dalu	F	8.7.1988/Sumatra	Bogor, Indonesia
18.	Agustine	F	26.8.1989/Sumatra	Bronx Zoo, New York
19.	Melintang++	F	18.4.1985/Perak	Dusit Zoo, Thailand
20.	Subur+++	F	22.6.1986/Sumatra	Howletts, England
21.	Torgamba	M	25.11.1986/Sumatra	Howletts, England
22.	Meranti	F	9.9.1986/Sumatra	Howletts, England
23.	Mahato	F	22.7.1988/Sumatra	Cincinnati, USA
24.	Kumu	F	24.7.1988/Sumatra	San Diego Zoo, USA
Other rhinoceros that died during capture;				
25.	?	F	23.1.1986/Sumatra	Torgamba, Sumatra
26.	?	M	26.3.1987/Sabah	Limbar, Sabah
27.	?	M	1988/Sabah	Lahat Datu, Sabah

* Calf rescued in clear-fell area, died 10 days later
** Born in captivity
*** Died in captivity on 23 Sep. 1988
*+ Acquired from Sumatra and died in captivity on 6 Aug. 87
\+ Acquired from Zoo Melaka in exchange for Napangga
++ Acquired from Zoo Melaka, died in captivity in Nov. 1986
+++ Died in captivity on 30 Oct. 1986

Plates 1–5. The physical restraint technique for the Sumatran rhinoceros developed at Zoo Melaka.

ming, deticking and treatment of injuries were also carried out. At the same time the animal was handled physically by rubbing, touching or stroking any parts of the body. Once the animals responded to handfeeding and touching, they were released into a night stall measuring 3.25 x 4.65 m.

Handling

In the night stall, handling was intensified to discipline the animal to respond to a physical restraint technique developed at Zoo Melaka. The animal was approached from the rear and the tail was held firmly between the base and the tip (Plate 1). Its rump was then gently stroked forwards and backwards followed by the back and flank (Plate 2). The areas ventral to the anus and vulva or penis were then also stroked, as well as the prepublic region on the median plane. The median thigh area was also stroked occasionally. The animal eventually went into a sitting position, whereupon stroking was increased in intensity and frequency (Plate 3). This was continued until the animal reclined completely in lateral recumbency (Plate 4). If stroking was continued on the median area of the thigh, the animal extended its hindlimbs (Plate 5). This technique was successful on all of the Sumatran rhinoceros in the zoo, including a two-week old female calf (Mohd-Tajuddin *et. al.*, 1987: Zainal-Zahari, 1988a). An adult female responded on the same day she was transferred into a holding pen while two adult female were restrained on the first day they were handled (Mohd-Tajuddin and Zainal-Zahari, 1987; Zainal-Zahari, 1988a). This method of restraint allows simple manipulative procedures to be carried out. Once the animals were manageable, they were allowed into the outdoot compound of the rhinoceros enclosure. It is essential that the handler reinforces handling and restraining procedures on the animals frequently.

Housing and hygiene

At Zoo Melaka, the Sumatran rhinoceros enclosure consists of eight indoor night stalls with a corresponding number of outdoor paddocks. The night stall is equipped with an overhead shower, light, a water trough and a wooden feeding trough (Plate 6). The wedge-shaped outdoor compound is 17.5 m in radius and measures 4.6 m and 23.8 m at the distal and proximal arc respectively. Shade trees (Angsana, *Pterocarpus indicus*) were planted within the paddock and wooden logs line either side of the brick wall. The earth substrate in the outdoor compound was planted with carpet grass (*Axonopus compressus*) (Plate 7). A shaded one-meter deep water pool is located near the dry moat.

The night stall is disinfected daily with Lindores (1:500). Leaf forage, fruits and vegetables are soaked in clean water diluted with Lindores (1:1000–1:2500) before stacking and subsequently feeding to the rhinoceros. In the evening, they are confined to the night stalls.

Plate 6. Weighing Minah using a Trutest electronic scale in the night stall at Zoo Melaka.

Plate 7. The outdoor compound of the captive facility at Zoo Melaka.

NUTRITION

Diet in the wild

The Sumatran rhinoceros is a monogastric herbivore with a relatively large caecum to allow for microbial digestion. In the wild, the animal is a genera-

list herbivore. In the Endau-Rompin region, it feeds in primary rain forest on 181 species representing 102 genera and 49 families (Appendix II). About 75% of the total forage are plants from 30 genera which can be regarded as principal food plants. *Prunus* spp. (15%), *Ficus* spp. (6.4%), *Medusanthera* spp. (3.8%) and *Eugenia* spp. (3.0%) contributed the greatest amount to the diet (Flynn, 1983).

In the secondary forest at Sungai Dusun in Selangor, the food plant species consumed by rhinoceros consisted of *Artocarpus* spp., *Ficus* spp., *Macaranga triloba* (mahang), *Mangifera lagenifera* (lanjut) and *Melastoma* spp. (sendudok) (Strickland, 1967).

Previous reports indicate that fruits constitute an essential part of the diet of the free ranging Sumatran rhinoceros. Fruits of *Mangifera foetida* (bacang) and *M. langenifera* are highly preferred. Other fruits consumed by these rhinoceros include *Calophylium macrocarpum* (bintangor bunut), *Parkia* spp., *Citrus* spp., *Payena* spp. (mengelut), *Garcinia forbesii* (Rose-kandis), *Artocarpus rigidus* (monkey jack) and *Mezzetia leptopoda* (mempisang)(Flynn, 1980, 1983; Hubback, 1939).

Diet in captivity

In captivity, the normal daily diet of a Sumatran rhinoceros consists of 30-40 kg (gross weight) of foliage, 3 kg of fruits (bananas, papayas, oranges and bacang) and vegetables (long beans, bean sprouts, sweet potato vines and sweet potatoes), supplemented with 1.5 kg of Pig Starter and 1.5 kg of Dairy Conditioner (containing 16% crude protein; Cargill, Malacca Sdn. Bhd. Malaysia), vitamins and a mineral mixture (Stresspak, Complex Cambridge, Ontario, Canada). The leafy forage consisted of *Ficus variegata, F. grossulariodes* (Kelempung), *Macaranga triloba, M. gigantea* (Tapak Gajah) and *Artocarpus rigidis*. The concentrated feed (Pig Starter and Dairy Conditioner) were moistened with water and wrapped up in leaves for hand feeding. Occasionally, *Pennisetum purpureum* (Napier grass) was given with the normal foliage. Grazing on grass within the outdoor paddock was observed for two of the Sumatran rhinoceros in the zoo. Water, supplemented with vitamins and minerals, is usually given *ad libitum* in the night stalls.

High levels of crude protein (10-13%) ingested by captive Black *(Diceros bicornis)* and Indian *(Rhinoceros unicornis)* rhinoceros is known to lead to a problem with laminits (Jones, 1979). Analysis of *F. variegata* foliage provided a crude protein value of 11.4% (Zainal-Zahari and Marid-Hassan, 1989). A study on the daily dry matter intake of an adult female Sumatran rhinoceros indicated that the animal ingested 0.95% of its body weight for *Ficus variegara* (Zainal-Zahari and Marid-Hassan, 1989). Comperatively, the Sumatran rhinoceros consumes less forage in terms of dry matter intake than the adult White rhinoceros which has the daily intake of dry matter of 1.1% of body weight (Jones, 1979). During this study, given a

choice, the animal was observed to consume stem and leaves down to about 30 cm from the shoot tips.

BIOLOGICAL DATA

Early authors, who were big game hunters, often made inaccurate and exaggerated measurements of the Sumatran rhinoceros (van Strien, 1974). For instance the weight of this species was cited as up to 2000 kg and the gestation period of between 7-8 months. At Zoo Melaka, data of individuals of various age groups were constantly monitored and recorded. A female, Rima, suspected to have mated in the wild prior to her capture, gave birth after 469 days in captivity (Mohd-Tajuddin *et. al.* 1987). This is considered consistent with data of captive Indian rhinoceros where the gestation period ranged between 462-489 days (Lang, 1977). Adult female Sumatran rhinoceros weigh between 529 and 747 kg. The calf, Minah, (Plate 8) weighed 24 kg at birth and had a body length, heart girth and height of withers of 92 cm, 75 cm, 45 cm respectively (Table 2). Comparatively, the Sumatran rhinoceros calf is about three times smaller than captive-born female Indian rhinoceros which averaged 68.5 kg (Lang, 1977). The average daily weight gain of Minah was 0.86 kg until the age of 12 months.

Rectal temperature, pulse and respiration are 36.6–37.9°C, 56-68 per minute and 12-32 per minute respectively, recorded at an ambient temperature of 22–31°C and relative humidity of 58-98% (Zainal-Zahari & Shukor, *in prep*). At Zoo Melaka, the Sumatran rhinoceros preferred the mud wallow to the water pool.

In the wild, the body hair of the rhinoceros measures 0.2–2.0 cm

Plate 8. Minah at Zoo Melaka, the first captive-born Sumatran rhinoceros this century.

long, however, once in captivity, they grow very rapidly and reach 4–5 cm within three months. The skin is slatey grey in colour, smooth and ranged in thickness from 5.2–14.0 mm in the medial thigh and abdomen respectively. Contrary to a previous report by Furley (1987), sweet glands are present and located deeply in a skin sample from the adbomen (M.K. Vidyadaran, *pers. comm.*).

Venipuncture can be carried out from the auricular coccygeal and cephalic veins. The cephalic vein is the most practical in terms of ease and volume of blood obtained (Zainal-Zahari & Shukor, *in prep.*) Table 3 shows parameters of the Sumatran rhinoceros. A preliminary study on a female blood sample found that the chromosome number of the Sumatran rhinoceros is 80.

MEDICAL PROBLEMS

Skin and adnexa

Snare wounds from steel cable and nylon rope were observed to be the most common problem in wild-caught Sumatran rhinoceros. A total of five such cases were recorded from the rhinoceros captured in Malaysia and Indonesia. Sixty per cent of the cases were from steel cable snare and the remaining from nylon snares. Sunsequently, exostosis was confirmed in at least three animals. Severe snare injury causes fibrosis and stiffness of the affected limbs. In addition, the mobility of the animals was markedly

Table 2. Morphological data on the Sumatran rhinoceros at Zoo Melaka

PARAMETER	AGE				
	Day-old	6 mth.	12 mth.	S/adult	Adult
n	1	1	1	3	3
Weight (kg)	24	183	338	446–451	529–747
Total length (cm)	92	173	207	237–244	242–250
Shoulder height (cm)	45	85	103	110–115	118–123
Hearth girth (cm)	75	129	155	177–187	194–214

Table 3. Normal blood parameters of the Sumatran rhinoceros at Zoo Melaka.

Parameters	Range
R.B.C. (/cmm x 10^6)	5.37–5.45
W.B.C. (/cmm x 10^3)	7.80–11.0
PVC (%)	34.0–45.0
Hb (g%)	13.0–14.1
MCV (u3)	62.0–84.0
MCHC (%)	31.0–38.0
Plasma protein (g%)	7.2–8.0

reduced. From an observation in 1987 of the mating of a snared male, it was obvious that stiffness of the affected limb prevented successful mounting and intromission. Thus, this condition interfered with breeding by natural means. Snare wounds are a long standing problem with a poor prognosis.

A nylon snare was successfully removed from a Sumatran rhinoceros in Sabah under local anesthetic, Lignocaine HCl (Zainal-Zahari, 1987). In Torgamba base camp, Sumatra, a cable snare was removed from a male Sumatran rhinoceros using an immobilizing drug, Immobilon (D.A. Parkinson, *pers. comm.*).

In Indonesia, a male Sumatran rhinoceros, Rokan, still had an oozing wound on the snared foot even two years after treatment. In another Sumatran rhinoceros acquired from Indonesia, it was observed that the area around the site of the snare wound was markedly congested and showed severe fibrosis (Zainal-Zahari *et. al.*, 1988). There was a complete fracture of the second metacarpus. The exostosis extended to the carpus, radius-ulna and the radius-ulna-humerus joint. The surface of the joint was irregular.

Ulcerations of the footpad were observed in wild and captive Sumatran rhinoceros. In captive animals, the lesion starts as a single vesicle, 2–3 cm in diameter and spreads throughout the sole. Focal areas of erythema or hematoma then develop in the next few days. Within a week, excoriations and under running of the soles is apparent. No signs of pain are observed in the animal. A culture of the swab made from the lesion revealed no significant finding. The condition was treated with an antiseptic wash, hydrogen peroxide and acriflavine solution. An 8 mm thick rubber mat was provided as padding on the hard cament floor for the animal.

Two Sumatran rhinoceros captured from a swampy area showed a severe excoriation of the soles of all four feet. However, the condition dried and does not cause problems to the animal. This problem was resolved in one to two months without any treatment.

Lacerations of the foot pad are frequent in captive Sumatran rhinoceros. The condition is particularly prevalent when the animal is confined in the wooden crate. The use of rubber mats as flooring material helped to relieve this problem. Injuries to the flank were common whenever there were protruding surfaces in the enclosure.

Hyperkeratosis was observed in most of the Sumatran rhinoceros several months after being brought into captivity. This problem was further aggravated by the rapid growth of hair under captive conditions. The hair tends to provide a matrix or base for the keratin, particularly on the dorsum due to little or no abrasive action on these surfaces. Apparently, hyperkeratosis was rarely found on the flank which was constantly being rubbed against the wall panelling or tree stumps within the paddock. Thus by providing abrasive surfaces such as logs, both horizontal and vertical, within the paddock helped to overcome the problem of hyperkeratosis occurring on the dorsum and abdomen. For the dorsum, the log should always be 1 cm lower than the height of withers of the animal. Careful consideration

of the choice of log is important as logs such as Gelam *(Melaleuca cajuputi)* can cause severe eye irritation because of its brittle and dusty nature during dry season.

Constant grooming in captive Sumatran rhinoceros is an alternative approach provided a stiff brush is used. The use of the mud wallow was observed to be beneficial especially for the skin. Rhinoceros with a mud wallow in the paddock have a smooth healthy skin. However, excessive wallowing in the unhygienic pond at the Ragunan Zoo, Indonesia, caused flaking of the skin when dry.

Pyoderma was always a consequent problem of hyperkeratosis. The bacteria predominantly isolated is *Escherichia coli.* The pyoderma can be an isolated problem or it may affect an entire section of the animal (dorsum, flank or neck). Treatment involves removing the pus and necrotic tissues, and cleaning the lesion with hydrogen peroxide. Finally Coopex Healing Oil is painted on the lesion. In severe cases, the animal was put on oral broad spectrum antibiotics. At the same time, constant grooming with a stiff brush was found to be helpful in reducing the occurrence of pyoderma.

Abscesses occur mainly due to puncture wounds or occasionally due to intramuscular injections of antibiotic and anabolic steroid. It was observed that some animals were more prone to abscesses caused by injections. These abscesses usually occurred at the region of the rump, shoulder and thigh. Treatment was initially by enhancing the ripening of the abscess and later (with or without local anesthetic) lancing it with a sterile surgical blade. The wound was then flushed with hydrogen peroxide followed by acriflavine solution.

Frequently, the horns of the animal were severely rubbed down and became very irregular and flat. This situation arose when there were hard and angular objects such as feeding troughs, doors and gaps between panelling within the enclosure. Later, abscesses occurred around the base of such deformed horns.

Hoof cracks normally occurred in all the rhinoceros several months after capture. The problem either involved one or several digits. However, there were cases of hoof cracks, particularly the "low crack" occurring in the Sumatran rhinoceros several times in a year. The problem was related to the hard flooring and diet. The cracks were horizontal and spread throughout the whole length of the hoof. Coronary cracks were also observed in these animals. Treatment involves confining the animal to the night stall lined with rubber matting (8.0 mm thick) and removing concentrated feed from the diet. The cracks were cleaned daily with hydrogen peroxide and acriflavine.

Myiasis was observed in two of the Sumatran rhinoceros at the zoo. Some ectoparasite isolated from the wild-caught Sumatran rhinoceros were *Amblyomma* spp., *Aponomma* spp. and *Haemaphysalis* spp. Tabanids were observed in abundance in the area close to the swamp forest where

the animals were kept in a temporary holding pen at Sungai Dusun Reserve (Mohd-Tajuddin & Zainal-Zahari 1988).

Some nematodes isolated from Sumatran rhinoceros were *Strongyle, Strongyloides* and *Crossocephalus* spp. Faecal egg count increased markedly whenever the animals were confined in a crate for a long period.

Sensory problems

Corneal opacity was observed in four Sumatran rhinoceros. The condition normally implicated the center and later the periphery of the cornea. Blepharospasm, lacrimation, periorbital swelling and sometimes ulceration occurred in one or both eyes of these animals (Zainal-Zahari, 1988b; Zainal-Zahari *et. al.*, 1988; Mohd-Tajuddin & Zainal-Zahari, 1988). The primary cause was suspected to be traumatic. At Zoo Melaka, it was observed that during the dry season, the bark of the *gelam* wood panelling within the paddock became very dusty and irritated the eyes of the animals as it rubbed againts it. At Ragunan Zoo, the excessive wallowing in contaminated mud pools within the paddock was found to be one of the contributing factors (Zainal-Zahari, 1988b).

One rhinoceros was blinded by plantation workers in an estate during capture. An eye swab and sensitivity test were necessary to detect the bacteria and to determine which drugs should be used for treatment. The use of fluorescein could determine the extend of damage to the eye (ulceration) and the patency of the lacrimal duct. The affected animal was kept in the shaded night stall and bathed constantly with clean water. Wallowing was usually not allowed during this period. All sharp and angular objects were removed from the enclosure to avoid unnecessary self-inflicted injuries due to poor vision. Depending on the sensitivity test, the treatment normally involved local application of either ointment (Terramycine, Lacribiotic, Chloramphenicol) or aerosol (Terramycine Pink Eye Aerosol) to the infected eye. The latter was always an advantage since there was no physical contact with the diseased eyes. On one occasion, a long acting antibiotic was administered intramuscularly to avoid secondary infection.

Genital problems

A case of phimosis was observed in a subadult male Sumatran rhinoceros. When first observed, only 5 cm of the penis was free. There were four points of attachment of the prepuce to the penis. Warm normal saline and antiseptic was used to clean the areas around the lesion. Glycerine was then applied and massaged into the lesions. The animal showed some tendency to erect and in so doing, freed some of the attachments. After 3-4 months, the condition improved markedly and only several centimeters were left before complete erection was possible.

Digestive system

A case of salmonellosis is reported in the Indian rhinoceros (Char *et. al.*,

1984). In a recent case, a Sumatran rhinoceros died of a severe necrotizing enteritis but the bacteria was not isolated. However, it was speculated that the etiology indicated *Salmonella blockley*, based on the similar symptoms and enteritis from a horse that died a few days later. The disease was manifested by off feed, shooting diarrhoea and extreme pallor (Zainal-Zahari *et. al.,* 1989). An epidemiological study of the soil and water were found to be positive for *Salmonella* in the rhinoceros paddock and horse stable. Measures taken to control the organism involved liming of the rhinoceros paddock, disinfecting the enclosure, monitoring the animals, strict hygiene and regular sampling of soil, faeces and water. The use of Trimethoprim with Sulphadiazine (Tribrissen Boluses, The Wellcome Foundation Ltd. London) orally and Trimethoprim with Sulphamethoxypyridazine (Septotryl 24%. Magny-Vernois, France) intramuscularly was effective in the early treatment.

REPRODUCTION

Oestrus and reproductive behavior

At Zoo Melaka, oestrus detection on the Sumatran rhinoceros was done by direct observation of the vulva. This has to be carried out on a daily basis by an experienced personnel. The signs are normally mucous discharge and moistening of the vulva and pliable texture of the mucosa. On 16th June, 1987, after observing Jeram was in oestrus, the animal was subsequently introduced into Napangga's paddock for mating. The animals engaged into extremely aggressive courtship behavior – fighting, chasing, necking, rubbing, butting, biting, and vocalizing for more than an hour. Gradually, Jeram became receptive to Napangga. Consequently, Napangga made about 15 unsuccessful attempts to mount on Jeram. Later, at about noon, both animals were separated into their own paddocks. They were given abundant food and water and allow to rest and wallow.

In late evening, the animals were reunioned again in Napangga's paddock for mating. Jeram was more receptive and Napangga was observed to make many attempts to mount and copulate. Standing heat was observed 10-12 hours after onset of oestrus. Napangga would place its head on either side of Jeram's rump and mount. Once on the female's dorsum, it would row forward. It was later followed by several thrust to fully erect the penis. Once erection is complete, Napangga would move more forward and attempt intromission. He began thrusting prior to intromission. It was observed that Napangga's effort to move forward was always hindered by the problem of an injured forelimb. Slipping of the forelimb at Jeram's shoulder was frequent. On many occasions, the penis was misdirected to the region of Jeram's sacrum.

In the male Sumatran rhinoceros, the penis consisted of the telescopic glans and an accessory paired structure (cornu) situated dorsally on the body of the penis. During mating, the erection of the penis was followed by erection of the cornu, 10-15 seconds later. It was observed that intro-

mission was impossible after complete erection of the cornu.

In Napangga's case, unsuccessful intromission was mainly due to diseased forelimb and his prolonged "non-mating" period in the wild (Zainal-Zahari *et. al.*, 1988). There was a three-minute assisted intromission but ejaculation was not observed.

On the following day, a thorough physical examination on Jeram and Napangga revealed numerous abrasion and laceration (between 2–15 cm in length) on the head, mandible, neck, shoulder and anterior skin fold. These injuries were sustained during the aggressive courtship behavior. Estrus was still apparent after 24 hours following onset. Her vulva lips were swollen with blood-tinged fluid. Hematoma on the upper part of her vulva might be due to many attempted and abortive penetration. Her left eye was swollen and had excessive discharge. Abrasion was observed on the dorsal and ventral of the penis. During the physical examination, both animals were submissive and appeared exhausted. Few months later, ultrasonography was done using a rectal probe and it was discovered that Jeram did not conceived.

Prepartum behavior was observed in another female, Rima, one week before parturition. Rima was very aggressive and restless. An examination of her vulva revealed slight swelling of the labium. Her udder was not obviously engorged. A serous exudate was expressed from both her mammary glands. The milky exudate, presumed as colostrum, was very high in protein and of yellowish coloration.

Postpartum behaviour was also observed and recorded. Rima was very cooperative and docile. She allows keepers and other personnel to handle the calf. Spray urination was very frequent until several months postpartum. Her milk was collected and analysed for nutrient contents (Table 4). The level of milk fat was 0.99%, two days postpartum and decreases to 0.37% at 4 months. The milk pH was 6.14 and the Total Plate Count (col/ml) was 1.3 x 1000. In Black rhinoceros, milk fat composition was only recorded as trace and the Solids-non-fat was 8.10% (Greed, 1960).

Table 4. Milk composition of the Sumatran rhinoceros at Zoo Melaka

Total Solids (%)	Water (%)	Fat (%)	Protein (%)	Lactose (%)	Solids non-fat (%)
11.24	88.7	0.99	4.17	5.38	10.27

Currently, the use of direct radioimmunoassay for measuring the urinary steroid conjugates is being studied in the Sumatran rhinoceros. This method was very successful in the Indian rhinoceros (Kasman *et. al.*, 1986).

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APPENDIX I Commonly used drugs on the Sumatran rhinoceros at Zoo Melaka.

Drugs	Dosage	Treatment
Ampicillin 20%	20 ml i.m. sid	Salmonellosis and diarrhoea
Trimethoprim and Sulphadiazine	10 gm oral bid	Salmonellosis and diarrhoea
Chloramphenicol 5% Opthalmic oint	qid	Conjunctivitis
Penicillin/Streptomycin	20 ml i.m.	Pyoderma
Lignocaine HCl	2-10 ml subcut	Removing snare and Venipuncture
Lacribiotic (10 gm)	qid	Conjunctivitis
Fenbendazole (20 gm)	single dose	Dewormer
Laurabolin (5)	10 ml. subcut	Chronic emaciation
Terramycin Pink Eye Aerosol	qid	Conjuctivitis
Hydrogen Peroxide (3%)	as wash	Abscess/wound
Acriflavine		Wound
Lindores	as wash	Disinfectant
Coopex Healing Oil	as paint	Abrasion/Laceration and Myiasis
Glycerine	as rub	Phimosis/Skin crackes

APPENDIX II Sumatran rhinoceros food plant list in Peninsular Malaysia

Family	Scientific name	Family	Scientific name
Aceraceae*	*Acer laurinum*		*Shorea leprosula*
Actinidiaceae*	*Saurauia* sp.		*S. maxima*
Alangiaceae	*Alangium ebenaceum*		*S. parvifolia*
Annonaceae	*Goniothalamus* sp.	Ebenaceae*	*Diospyros subrhomboidea*
	Monocarpia marginalis		*D. wallichii*
	Polyalthia glauca		*Diospyros* sp.
Apocynaceae	*Tabernaemontana* sp.		
Aquifoliaceae	*Ilex macrophylla*	Elaeocarpaceae	*Elaeocarpus petiolatus*
Araceae	*Homalomena rubra*		*Elaeocarpus* sp.
Burseraceae	*Dacryodes laxa*	Euphorbiaceae*	*Antidesma cuspidatum*
	D. rugosa		*A. velutinosum*
Celastraceae*	*Bhesa paniculata*		*Antidesma* sp.
	Glyptopetalum fruticosum		*Aporusa* sp.
			Baccaurea lanceolata
	Lophopetalum floribundum		*Croton laevifolius*
			Elateriospermum tapos
Convolvulaceae	*Erycibe* sp.		*Glochidion hypoleucum*
Dichapetalaceae	*Dichapetalum* sp.		*Glochidion* sp.
Dipterocarpaceae*	*Hopea nutans*		*Macaranga hosei*
	Hopea sp.		*M. laciniata*

	M. pruinosa
	M. triloba
	Pimelodendron griffithianum
	Trigonopleura malayana
Fagaceae	*Lithocarpus* sp.
	Quercus oidocarpa
Flacourtiaceae*	*Casearia lobbiana*
	Homalium sp.
	Flacourtia sp.
Gnetaceae	*Gnetum* sp.
Guttiferae	*Calophyllum* sp.
	Garcinia forbesii
	G. griffithii
	Garcinia sp.
Hyperiacaceae	*Cratoxylum formosum*
Icacinaceae*	*Gonocaryum gracile*
	Medusanthera gracilis
	Medusanthera sp.
	Stemonurus secundiflorus
Lauraceae*	*Cinnamomum iners*
	Endiandra kingiana
	Endiandra sp.
	Litsea amara
	L. nidualris
	Litsea sp.
	Nothophoebe sp.
Leeaceae	*Leea indica*
Leguminosae*	*Gynometra cauliflora*
	Pithecellobium clypearia
	P. ellipticum
Loganiaceae*	*Fagraea racemosa*
Melastomataceae	*Melastoma malabathricum*
	Melastoma sp.
	Phyllagathis rotundifolia
Meliaceae*	*Aglaia griffithii*
	A. tenuicaulis
	Aglaia sp.
	Aphanamixis rohituka
	Chisocheton sp.
	Dysoxylum sp.
Menispermaceae	*Tinomiscium petiolare*
Moraceae*	*Artocarpus elasticus*
	A. nitidus
	A. rigidus
	Ficus chartacea
	F. depressa
	F. fistulosa
	F. grossularioides
	F. schwarzii
	F. sinuata
	F. uniglandulosa
	F. vasculosa
	F. vrieseana
	Ficus sp.
	Streblus elongatus
Myristicaceae*	*Gymnacranthera forbesii*
	Knema curtissi
	K. malayana
Myrsinaceae*	*Ardisia colorata*
	A. oxyphylla
	Ardisia sp.
	Maesa ramentacea
Myrtaceae*	*Eugenia anisosepala*
	E. cerasiformis
	E. densiflora
	E. syzygioides
	Eugenia sp.
Oleaceae*	*Chionanthus* sp.
	C. oliganthus
	C. ramiflorus
Palmae	*Calamus* sp.
	Korthalsia sp.
Polygalaceae	*Xanthophyllum* sp.
Rhizophoraceae*	*Anisophyllea grandis*
	Gynotroches axillaris
	Pellacalyx saccardianus
	Pellacalyx sp.
Rosaceae*	*Prunus arborea*
	P. grisea
	P. malayana
	P. odorata
	P. polystachya
	Prunus sp.
Rubiaceae*	*Amaracarpus caudatus*
	Amaracarpus sp.
	Gardenia sp.
	Lasianthus sp.
	Mycetia sp.
	Pavetta indica
	Pavetta sp.
	Randia scortechini
	Randia sp.
	Timonius sp.
	Uncaria sp.
	Urophyllum glabrum
	Urophyllum sp.
Rutaceae*	*Acronychia porteri*
	Atalantia raxburghiana
	Luvunga scandens
	Luvunga sp.

	Tetractomia sp.	Symplocaceae	*Symplocos adenophylla*
Sapindaceae*	*Arytera* sp.	Theaceae*	*Adinandra acuminata*
	Mischocarpus sp.		*Adinandra* sp.
	Pometia pinnata		*Ternstroemia penangiana*
	Xerospermum wallichii	Tiliaceae	*Grewia laurifolia*
Sapotaceae*	*Madhuca korthalsii*		*G. paniculata*
	Palaquim hexandrum		*Grewia* sp.
	P. rostratum	Ulmaceae*	*Gironniera nervosa*
	Palaquim sp.		*G. subaequalis*
	Payena lucida	Verbenaceae*	*Callicarpa* sp.
Simaroubaceae	*Quassia indica*		*Clerodendrum villosum*
Sterculiaceae	*Sterculia* sp.		*Clerodendrum* sp.
Styraceae	*Styrax benzoin*		*Congea forbesii*

From Flynn (1983)
* Principal Sumatran rhinoceros food plants contributing more than 1% of the diet.

APPENDIX III Diet of the Sumatran rhinoceros in captivity at Zoo Melaka.

	Diet	Quantity/Animal
1.	Leafy forage *Artocarpus rigidus* (Nangka) *Ficus variegata* (Ara) *F. glossolariodus* (Kelempung) *Macaranga triloba* (Daun tapai) *M. gigantea* (Tapak gajah) *Pennisetum purpureium* (Napier grass) Sweet potatoes vines	30–50 Kg (gross)
2.	Fruits and vegetables Papaya Banana Long beans Bean sprout Sweet potatoes	3 kg
3.	Concentrated feed Pig starter mesh Dairy conditioner	3 kg
4.	Vitamins and minerals Vitamins Mineral mixture (Stresspak)	As recommended by the manufacturer