POPULATION ESTIMATION, FORAGING ECOLOGY AND NUTRITION OF THE FREE RANGING SUMATRAN RHINOCEROS (*Dicerorhinus sumatrensis harrissoni*, Groves 1965) IN THE TABIN WILDLIFE RESERVE, LAHAD DATU, SABAH, MALAYSIA.

PERPUSTAKAAN
UNIVERSITI MALAYSIA SABAH

SIVAPIRAGASAM THAYAPARAN

INSTITUTE FOR TROPICAL BIOLOGY AND CONSERVATION
UNIVERSITI MALAYSIA SABAH
2006

UMS
UNIVERSITI MALAYSIA SABAH

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS THESIS@

JUDUL: ANGGARAN POPULASI, KAJIAN EKOLOGI PEMAKAN DAN KAJIAN KEPERLUAN NUTRISI BADAK SUMATRA (*Dicerorhinus sumatrensis harrissoni*, Groves 1965) DI PUSAT HUTAN SIMPANAN DI TABIN, LAHAD DATU, SABAH, MALAYSIA

IJAZAH: SARJANA SAINS (BIOLOGI PEMULIHARAN)

SESI PENGAJIAN : 2004-2006

Saya, SIVAPIRAGASAM THAYAPARAN mengaku membenarkan tesis Sarjana ini disimpaN di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:

1. Thesis adalah hakmilik Universiti Malaysia Sabah
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian saya.
3. Perpustakaan dibenerkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pangajian tinggi
4. TIDAK TERHAD

Disahkan oleh

M. Sthayaparan

(Penulis: SIVAPIRAGASAM THAYAPARAN)

(TANDATANGAN PUSTAKAWAN)

Alamat:
18/2, Hamers Avenue,
Colombo- 06,
SRILANKA
Phone: +94 11 2 361048,
+60 16 8154842
Email: thaya@sosrhino.org

(Penyelia: Prof.Madya Dr.Abdul Hamid Ahmad)

Tarikh: 20 Mac 2006

Tarikh: 18/4/07

CATATAN : @Tesis dimaksudkan sebagai tesis Ijazah Dockter Falsafah dan Sarjana secara penyelidikan atau disertassi bagi pengajian secara kerja kursus dan penyelidikan, atau laporan Project Sarjana Muda (LPSM)

UMS
UNIVERSITI MALAYSIA SABAH

DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries, each of which has been fully acknowledged.

July 2006

M. S Thayaparan .
S. THAYAPARAN.

UMS
UNIVERSITI MALAYSIA SABAH

ACKNOLEDGEMENTS

I would like to express my sincere gratitude to my supervisors, Prof. Dr. Datin Maryati Mohamed and Assoc. Prof. Dr. Abdul Hamid Ahmad, and my former supervisor Prof. Dr. Mashitah Yusof (Currently serving as a professor at KUTPM) for their guidance, support, effort, and ideas during the progress up to the completion of this study.

I wish to express my appreciation to Prof. Datin. Dr. Maryati Mohamed, Director of the Institute for Tropical Biology and Conservation for giving her full support.

I would also like to thank Dr. Nan Schaffer, the President of SOS Rhino for providing the funds which has enabled a smooth progress throughout this study.

Secondly I would like to thank my external adviser Dr. Edwin Bosi (Former Program officer SOS Rhino) for his valuable advice, suggestions and comments. Thank you for your guidance, information and for your patience and tolerance.

I am also grateful to the following individuals who have kindly given their ideas, assistance, co-operation and support.

- Director of Sabah Wildlife Department for the permission to conduct the study in TWR
- Dr. Homathevi Rahman for her valuable comments on writing.
- Mr. Berhaman Ahmad for his assistance in plant specimen identification.
- Ms. Noridah, Mr. Jonny Gisil, and Ms. Julianah for their supportive assistance in the UMS's Laboratory.
- SOS Rhino Field staff, specially the late Hayro Nuvin

Lastly, I would like to express my sincere gratitude to family, my special friends' and especially to my mother, sister and brother-in-law for their undivided support. To the Almighty BaBa, with your blessings, this thesis has been finished successfully, thanks.

UMS
UNIVERSITI MALAYSIA SABAH

ABSTRACT

The distribution and abundance of the Sumatran rhinoceros in the Tabin Wildlife Reserve (TWR) Core Area were studied from July 2004 to February 2005. Nine rhinoceros trials were followed in different locations and their browsed plants were collected along the trails for analysis. An estimated minimum number of three rhinoceros are living in the study area (48sq km). This study has reconfirmed that individual rhinoceros to be differentiated based on statistical analysis of the median of the footprint measurements. A total of 65 species of plants from 33 families were collected and identified as the food plants of the rhinoceros in TWR. The majority of the plants were from the family of Euphorbiaceae (10), Annonaceae (7), Meliaceae (4), Dipterocarpaceae (4) and Rubiaceae (4). The findings of the food plants were compared with other studies and 24 species from 15 families matched. Samples of browsed plants were analysed for minerals (Ca, K, Na, Mg, Fe, and Cu) and crude protein content. All the plant samples contained an average of 5.55±2.39 Ca % Dry Matter basis (DM), 2.22±1.11 K % DM, 0.10±.04 Na % DM, 0.30±0.10 Mg % DM, 208.07 Fe mg/kg, 34.92±18.21 Cu mg/kg and crude protein 8.39±2.22 % DM. The minerals and protein were compared to a standard requirement of a horse and the values were found to have adequate amount to their needs. Results showed that the plants consumed were high in nutrition, adequate and sufficient to cater for the Sumatran rhinoceros dietary needs.

UMS
UNIVERSITI MALAYSIA SABAH

ABSTRAK

ANGGARAN POPULASI, KAJIAN EKOLOGI PEMAKAN DANKAJIAN KEPERLUAN NUTRISI BADAK SUMATRA (Dicerorhinus sumatrensis harrissoni, Groves 1965) DI PUSAT HUTAN SIMPANAN DI TABIN, LAHAD DATU,SABAH, MALAYSIA.

Kajian berkaitan taburan populasi dan status nutrisi badak Sumatera di Hutan Simpan Hidupan Liar Tabin, Sabah telah dijalankan dari Julai 2004 hingga Februari 2005. Sejumlah sembilan denai laluan badak Sumatera telah ditemui, di pelbagai lokasi dalam kawasan seluas 48 km^2. Ukuran bekas tapak kaki badak yang ditemui direkodkan, dan tumbuhan yang di makan oleh badak sepanjang denai telah dikumpulkan bagi tujuan analisis mineral dan nutrisi. Keputusan kajian telah berjaya mengenalpasti sekurang-kurangnya tiga badak Sumatera berdasarkan pada bacaan nilai median lebar tapak kaki, jarak antara denai dan persamaan ukuran tapak kaki. Sejumlah 65 spesies tumbuhan daripada 33 famili dikenalpasti sebagai tumbuhan yang telah dimakan oleh badak Sumatera. Kebanyakkan spesies tumbuhan terdiri daripada famili Euphorbiaceae (10), Annonaceae (7), Meliaceae (4), Dipterocarpaceae (4) and Rubiaceae (4). Didapati 24 spesies daripada 15 famili yang dikenalpasti telah pun disenaraikan oleh penyelidik lain dalam kajian berasingan. Analisis kandungan mineral (K, Na, Mg, Fe, Cu) dan protein telah dijalankan pada sampel tumbuhan yang dikumpulkan. Semua sampel tumbuhan mengandungi purata 5.55±2.39 Ca % berdasarkan Berat Kering (BK), 2.22±1.11 K % BK, 0.10±.04 Na % BK, 0.30±.10 Mg % BK 208.07 Fe mg/Kg, 34.92±18.21 Cu mg/Kg dan protein 8.39±2.22 % BK. Melalui kajian ini dapat disimpulkan bahawa kandungan nutrisi dan mineral dalam tumbuhan yang di makan oleh badak Sumatera di kawasan hutan simpan Hidupan Liar Tabin adalah memadai dan pada kadar yang mencukupi mengikut keperluannya.

UMS
UNIVERSITI MALAYSIA SABAH

CONTENTS

UMS
UNIVERSITI MALAYSIA SABAH

UMS
UNIVERSITI MALAYSIA SABAH

UMS
UNIVERSITI MALAYSIA SABAH

UMS
UNIVERSITI MALAYSIA SABAH

LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance.
µg	:	microgram.
Ca	:	Calcium.
cm	:	Centimetre.
Cu	:	Copper.
Fe	:	Iron.
g	:	gram.
K	:	Potassium.
km	:	Kilometre.
Mg	:	Magnesium.
Na	:	Sodium.
TWR	:	Tabin Wildlife Reserve.
DVCA	:	Danum Valley Conservation Area.
GPS	:	Global Positioning System.
SRBC	:	Sepilok Rhinoceros Breeding Centre.
IUCN	:	International Union for the Conservation of Nature and Natural Resources
AsRsG	:	Asian Rhino Specialist Group.
SPSS	:	Statistical Package for Social Science.
UMS	:	Universiti Malaysia Sabah.

UMS
UNIVERSITI MALAYSIA SABAH

LIST OF APPENDICES

UMS
UNIVERSITI MALAYSIA SABAH

LIST OF FIGURES

UMS
UNIVERSITI MALAYSIA SABAH

UMS
UNIVERSITI MALAYSIA SABAH

LIST OF TABLES

UMS
UNIVERSITI MALAYSIA SABAH

CHAPTER 1

INTRODUCTION

1.1. Initiation of the study

Asian rhinoceros are pre-historic, majestic looking creatures that have wallowed in swamps and wandered in forests for tens of millions of years. They are the world's most endangered species. The most critically endangered Sumatran rhinoceros has declined from an estimated number of 600 animals in 1994 to around only 300 today (Foose and Van strien, 1987). At present the total human population of the world increase tremendously. Because of this rapid population explosion, the land area they occupy and production for their daily consume cannot cope up with this pressure on space and natural resources. Over exploitation of forests are disturbing the natural habitat to a great extent. As a result, the loss of wild animals has become a significant problem, making some species to become endangered and near extinction.

Many of the wild animals would reach to the level of extinction if prompt actions are not taken. Such endangered species are hunted for their body parts that have very high commercial value. The Sumatran rhinoceros is one of such animals that are in top of the list (Ambu, 1995). For thousands of years rhinoceros horn has been used in traditional Asian medicine to treat a wide range of illnesses (Van strien, 1974). Human activities such as logging and agriculture have reduced the wild population size of the Sumatran rhinoceros. Now, the populations are suffered in

UMS
UNIVERSITI MALAYSIA SABAH

Sumatra, Peninsular Malaysia, and Sabah (Foose and Van strien, 1987). The unknown populations may or may not exist in Sarawak, Thailand, Myanmar, and Laos but their existence is unconfirmed. The Sumatran rhinoceros can only be saved from extinction if effective measures are taken to combat both the persistent demands of traditional Asian medicine and habitat loss. In the short term, rhinoceros habitat needs to be studied and safeguarded immediately against any further fragmentation and degradation.

The subspecies *Dicerorhinus sumatrensis harrissoni* that can be found in Borneo is possibly the most endangered (Khan, 1989). The precarious situation of this species is well illustrated in Figure 1.1. It shows the known historical and present distributions of the Sumatran rhinoceros. Now they can only be found in small numbers in a few remote and isolated locations in the rainforest. There are some additional measures that will be able to protect the rhinoceros in the reserve areas; such measures would be *in-situ* studies on the distribution pattern and feeding ecology. This will determine whether proper diet is maintained from the consumption of currently available plants to ensure healthy growth. This *in-situ* knowledge on feeding ecology will help to improve on *ex-situ* studies on rhinoceros.

1.2. Previous studies on Sumatran rhinoceros food plants

There is only limited research available on food plants of the Sumatran rhinoceros and their nutritional content. In Endau Rompin, Peninsular Malaysia, there was a total of 156 recorded species of plant from 49 families have been identified as rhinoceros food plants. These have been analysed for mineral content (Flynn, 1983). In a separate study, 33 plant species have been recorded from Danum Valley, Conservation Area, Sabah (Ahmad, 1991) and their mineral contents were also

UMS
UNIVERSITI MALAYSIA SABAH

analysed (Lee *et al.*, 1993). There is no record thus far of similar studies have been conducted in Tabin Wildlife Reserve.

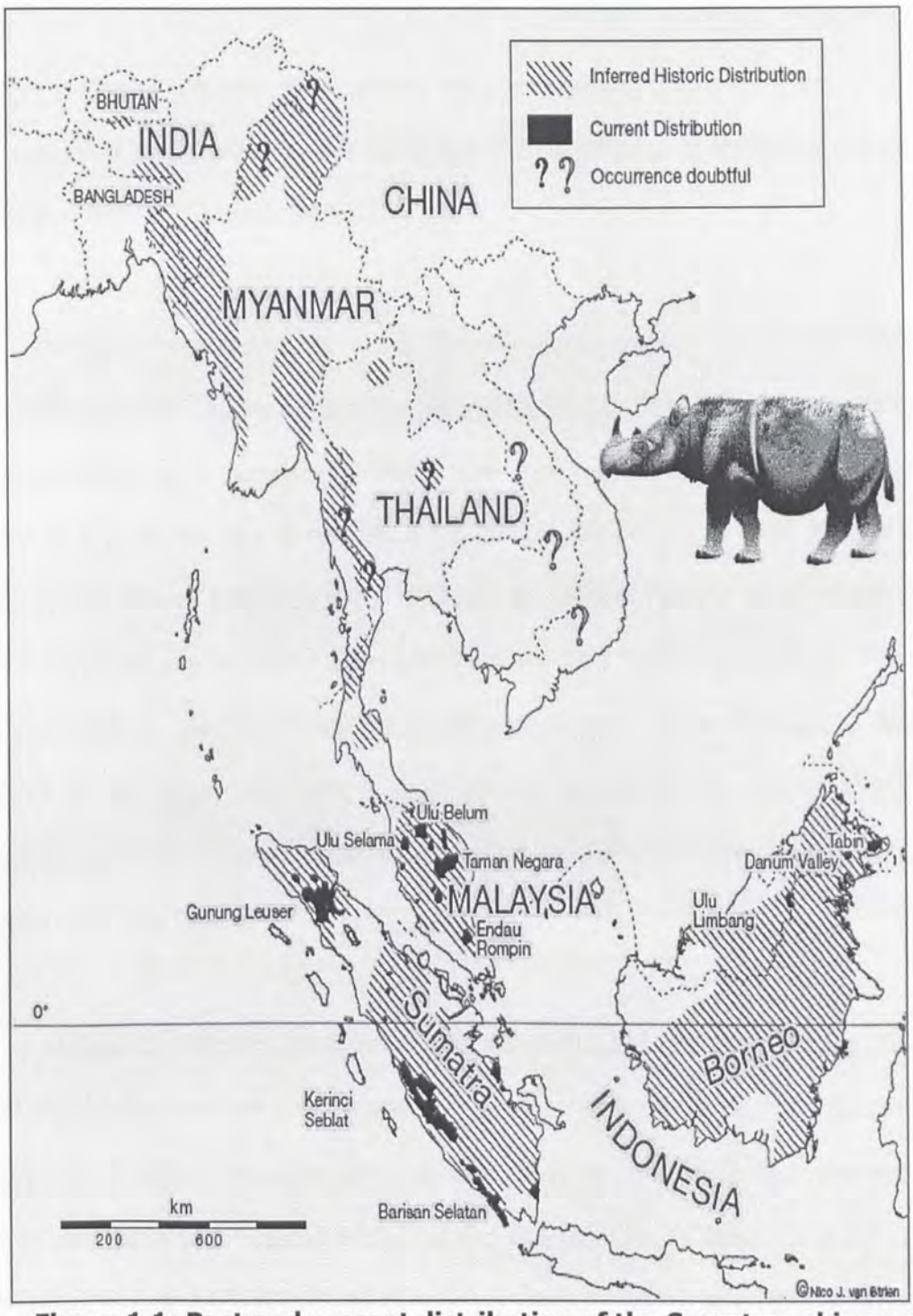

Figure 1.1: Past and present distribution of the Sumatran rhinoceros Source: AsRsG Asia rhino action plan.

UMS
UNIVERSITI MALAYSIA SABAH

1.3. Aims of the study

The study on Sumatran rhinoceros's habitat and feeding ecology is very important to make sure their future survival, preventing them from extinction. Tabin Wildlife Reserve is one of the few places where the subspecies of Sumatran rhinoceros can be found. One of the aims of this study is to follow rhinoceros trails and collect the browsed plants for nutrition analysis.

Sumatran rhinoceros are mainly found in dense forests, usually near streams (Van Strien, 1974). They are typical browsers; feeding on leaves, twigs, wild gingers, bamboo shoots, and occasionally fruits. The food plants as far as are recorded, consist of a great number of species and a combination of many plant families (Van Strien, 1974; Flynn, 1983; Ahmad 1991; Lee *et al.*, 1993). It is extraordinary that only a very few species have been identified as food plants recorded by different researchers. It is clear that it will be possible to discover many more plants species included in the rhinoceros diet if more intense effort can be made. The more knowledge on the rhinoceros food plants can be helpful to relocate them in different places in the near future.

Metabolic disorders linked to inappropriate or nutritionally imbalanced diet can affect the Sumatran rhinoceros health and cause problems in its reproduction system (Paglia *et al.*, 2001). Another focus of this study is to analyse the minerals and protein content in the rhinoceros food plants. This will help to identify the sufficiency of the nutritional content. Through observation of the health of the Sumatran rhinoceros in captivity, it clearly indicates the strong link to dietary husbandry (Dierenfeld, 1995). Several diseases and syndromes have been linked to inadequate

UMS
UNIVERSITI MALAYSIA SABAH

captivity diet. Excess or deficiencies in several feeding components like protein, calcium, phosphorus, ferrous, and copper are also linked to diseases in browsing rhinoceros (Paglia *et al.*, 2001). Every major nutrient category appears to be involved with some aspects of diseases.

The starting point for investigating nutrition of the browsing rhinoceros comes from analysing the chemical composition of naturally consumed foods. Rhinoceros consumes a large number of plant species from diverse array of physical characteristics and nutrition content. This study will provide an outline of current food plants information, basic mineral and crude protein content of plants browsed by Sumatran rhinoceros in Tabin Wildlife Reserve Core Area. The outcome of this study will provide and act as a major reliable nutrition reference. It can be used in the future for feeding captive rhinoceros in breeding programmes.

The population density can be found using the individual foot prints. The rhinoceros trails were followed and browsed plant samples were collected based on feeding signs. The collected plant specimens were used for minerals and crude protein analysis to determine their nutritional content. The outcome of the analysis is used to calculate the nutrition needed by the rhinoceros, to determine whether the rhinoceros is getting its necessary diet needs.

UMS
UNIVERSITI MALAYSIA SABAH

1.4. Research objectives

The objectives of the study are as follows.

1. To estimate the population density of rhinoceros in the study area, using fresh footprint analysis.
2. To identify the food plants of Sumatran rhinoceros in Tabin Wildlife Reserve and to compare them with available list of food plants elsewhere.
3. To study the feeding behaviour of the Sumatran rhinoceros.
4. To analyse the nutritional content of food plants browsed by the Sumatran rhinoceros.

UMS
UNIVERSITI MALAYSIA SABAH

CHAPTER 2

LITERATURE REVIEW

2.1. BACKGROUND

The rhinoceros is a large, primitive-looking mammal that in fact dates from the Miocene era millions of years ago. Since 1970 the world rhinoceros population has declined significantly by 90% (Khan, 1989), with only five species remaining in the world today, all of which are classified as critically endangered animals. Today's living species are the only remnants in the family of Rhinocerotidae; either is native to Africa or Asia. They are characterised by one or two nasal horns originating from the skin, without any connection to the skull bone. The horns are formed from closely matted hair fibres that are densely keratinised (Van Strien, 1974).

Two rhinoceros species, the black rhinoceros (*Diceros bicornis*) and the white rhinoceros (*Ceratotherium simum*), are found in Africa while the other three, the Javan rhinoceros (*Rhinoceros sonadicus*), the Indian rhinoceros (*Rhinoceros unicornis*) and the Sumatran rhinoceros (*Dicerorhinus sumatrensis*) are found in Asia. The white, black and Sumatran rhinoceros have two horns, while the Javan and Indian rhinoceros have only one horn.

The Asian species are the rarest mammals in the world with the Javan and the Sumatran being in imminent danger of extinction (Flynn, 1978). The decline of

UMS
UNIVERSITI MALAYSIA SABAH

the Sumatran and Javan rhinoceros has been ongoing for centuries. If this trend continues, soon they will reach the final phase of extinction, to a point when the wild and/or captive population will no longer be viable for the survival of the species. For example the Javan rhinoceros was eliminated from its historic range in the 1930's (Rabinowitz, 1994). The species was once widespread throughout the Oriental realm from Bengal eastward to include Myanmar, Thailand, Cambodia, Laos, Vietnam and southwards to the Malay Peninsula and the Islands of Sumatra and Java. But currently the only surviving population of the Javan rhinoceros is located in the Ujung Kulon peninsula of the Island of Java (Choudhury, 1997).

There are three different sub species of Sumatran rhinoceros living in the sub continents of Sumatra, Peninsular Malaysia, Thailand (*D. s. sumatrensis*), Borneo (*D. s. harrissoni*) and Myanmar (*D. s. lasiotis*) (Foose & Van Strien, 1997). Only two sub species, which are *D. s. harrissoni* and *D. s. sumatrensis* are known to exist today.

Over the past 15 years, the population of the Sumatran rhinoceros has declined drastically - more than 50 % during the 1980s and 1990s (Foose & Van Strien, 1997). It was mainly caused by over exploitation due to poaching. These threats caused the population to be fragmented and the wild population of Sumatran rhinoceros today is estimated to be less than 400 (Foose & Van Strien, 1997). The fragmented populations are known to exist in Sumatra, Peninsular Malaysia, and Borneo. The remaining population may exist in Thailand, Myanmar, and Laos but their existence is unconfirmed and the viability of any populations are doubtful.

The Sumatran rhinoceros is the descendant of the woolly rhinoceros which is the oldest living rhinoceros species today. It is the only species found in Malaysia.

UMS
UNIVERSITI MALAYSIA SABAH

The wild population of the Sumatran rhinoceros in Malaysia is estimated to be 100-150 in 2001 (Zainal *et al.*, 2001; Zainal, 1995). Since the Sumatran rhinoceros is on the verge of extinction, the Sabah Wildlife Department is conducting a long-term study on the species aimed at conserving the species in Sabah (Ambu, 1995). One of the adopted strategies is to breed this animal *ex situ*. However, before achieving a successful captive breeding program, it is imperatively necessary to study as many aspects of its biology such as possible including the nutrition requirements, health and the feeding habits.

2.2. The physical characteristics of the Sumatran rhinoceros

Sumatran rhinoceros are hairy; two horned with distinctive odd-toed ungulate feet. Adult animals measure between 1.2 m to 1.4 m at shoulder height and has a head and body length between 2.2 m to 2.6 m (Hubback, 1939; Van Strien, 1974) weighing between 900kg to 1000kg (Van Strien, 1974). Compare to other all rhinoceros Sumatran rhinoceros are the smallest and the most primitive of the species existing in the world (Van Strien, 1974; Borner, 1979).

The anterior horn of a male rhinoceros measures an average of 19 cm and rarely exceeds 30 cm in length, while the posterior horn averages about 7.6 cm. The anterior horns of females average 7.6 cm, while the posterior ones are small knob-like structures. The species is also characterised by two distinct folds on its body, which renders the look to be as being segmented into three parts. The first segment is encircling the trunk just behind the front-legs and the second part over the belly and flank (Van Strien, 1974). The skin structure is rough.

The general colouration of the Sumatran rhinoceros varies from light buff to brown to dark brown (Hubback, 1939), but in the field the colouration of the skin is

UMS
UNIVERSITI MALAYSIA SABAH

REFERENCES

Abdullah, M.T., 1985, A Sumatran rhinoceros conservation plan for the Endau-Rompin National Park, Malaysia. Problem report submitted to Division of Forestry of West Virginia University, MSc Thesis.

Ahmad, A.H., 1991, Kajian Kelimpahan Semasa dan Beberapa aspek EkologiPemakanan bagi Badak Sumatera (*Dicerorhinus sumatrensis harrissoni* Groves, 1965) di Kawasan Pusat Luar Lembah Danum, Lahad Datu, Sabah. Tesis Sarjana Muda Sains dengan Kepujian, Universiti Kebangsan Malaysia (Sabah).

Ambu, L.N., 1995, The status of the Asian two- horned rhinoceros (*Dicerorhinus sumatrensis harrissoni*) in Sabah, Malaysia, Report for the Malaysian population and habitat viability analysis (PHVA) Conference (27-28 November 1995) Sandakan, Sabah.

AOAC, 2000, Official methods of analysis of AOAC international, 17th Edition. Gaithersburg: Association of official Analytical Chemists International

Bernard, H., Kimsui, L., Sukor, J.A and Soffian, M.A., 1999, A check list of Non-Volant Small Mammals in Tabin Wildlife Reserve, Tabin Wildlife Expedition, pp 145-151.

Boonratana, R., 1997, A state-wide survey to estimate the distribution and density of the Sumatran rhinoceros, Asian Elephant and Banteng in Sabah, Malaysia, New York: WCS.

Borner, M., 1979, A field study of the Sumatran rhinoceros *Dicerorhinus sumatrensis* Fischer 1814: Ecology and Behaviour Conservation Situation in Sumatra, Zurich, Juris:

Bosi, E., Schaffer, N., Kilbourn, A., and Leni, T., 2005, Presence, distribution and population denisity of Sumatran rhinoceroses (*Dicerorhinus sumatrensis harrissoni*) in Tabin Wildlife Reserve, Lahad Datu, Sabah, Malaysia. Submitted to *Pachyderm*.

Bosi, E., 2005, Sumatran rhinoceros hoof print and measurements, SOS Rhino research No 2. (Unpublished)

UMS
UNIVERSITI MALAYSIA SABAH

Bridson, D and Forman, l., 1992, The Herbarium Handbook, Royal Botanic Gardens Key.

Choudhury, A., 1997, The Status of the Sumatran rhinoceros in north-eastern India, J. *Oryx,* **31:**151-152.

Coakes,S.J & Steed L.J.1999. *SPSS. Analysis without Anguish. Version 11.0.* North Sydney : John Wiley & Sons.

Colin, P.G and Kurt, F., 1972, Dicerorhinus sumatrensis, *The American society of Mammalogists, Mammalian species,* **22:** 1-6.

Dalimin, M. N and Ahmad, R., 1999, Mud volcano of Tabin Wildlife Reserve, Lahad Datu, Sabah, Tabin Scientific Expedition, Universiti Malaysia Sabah, pp 7- 18.

Dierenfeld, E.S., Atkinson, S., Craig A.M., Walker, C.K., Streich, W.J and Marcus., 2005, Mineral concentrations in serum/plasma and liver tissue of captive and free-ranging rhinoceros species, J. *Zoo Biology* **24:** 51-72.

Dierenfeld, E.S., Doherty, J.G., Kalk, P and Romo, s., 1994, Feeding the Sumatran rhinoceros (*Dicerorhinus sumatrensis)*: Diet evaluation, adaptation, and suitability, In: Junge, R,Editor. Proc Amer Assoc Zoo Vet. Pittsburg. P.371 (abstract).

Dierenfeld, E.S., Toit, R and Millar, R.E., 1988, Vitamin E in captive and wild black rhinos (*Diceros bicornis*). *J. Wildlife Diseases*, **24:** 547-550.

Dierenfeld, E.S., Robert, E.C., Wildman and Steve R., 2000, Feed intake, diet utilization, and composition of browses consumed by the Sumatran rhino (*Dicerorhinus sumatrensis*) in a North American Zoo, J.*Zoo Biology* ,**19:**169-180.

Dierenfeld, E.S., Toit R and Braselton, W.E., 1995, Nutrition composition of selected browses consumed by black rhinoceros (*Diceros bicornis*) in the Zambezi Valley, Zimbabwe, *J. Zoo Wildlife Med* , **26:** 220-230.

Dierenfeld, E.S., 1993, SSP Nutrition Advisers: Roles and responsibilities, Proc. Amer. Assoc. Zoo Vet., St, Louis, MO, Pp.333-336.

Dierenfeld, E.S., 1995, Rhinoceros nutrition: an overview with special reference to browsers, *VERHANLUNGSBERICHT ERKRANKUNGEN ZOOTIERE,* **37:**7-14.

UMS
UNIVERSITI MALAYSIA SABAH

Dierenfeld, E.S., 1996, In AZA RHINOCEROS HUSBANDARY RESOURCE MANUAL. Fouraker, M.; Wagener, T. eds. Fort Worth Zoological Park. Pp52-55.

Dierenfeld, E.S and Colleen, M. M., 1999, Nutrient composition of selected plant species consumed by semi free-ranging lion-tailed macaques (*Macaca silenus*) and ring-tailed lemurs (*Lemur catta*) on St. Catherines Island, Georgia, USA, J.*Zoo Biology* **18:**481-494.

Flynn, R and Abdullah, M.T., 1983, Distribution and number of Sumatran rhinoceros in the Endau-Rompin region of Peninsular Malaysia, *Malay Nat. J.* **36:**219-247.

Flynn, R and Abdullah, M.T., 1984, Distribution and status of the Sumatran rhinoceros in Peninsular Malaysia, *Biological Conservation,* **28:** 253-273.

Flynn, R., 1976, Distribution and ecology of sumatran rhinos (*Dicerorhinus sumatrensis*) in Peninsular Malaysia, Progress report to the Federal Game Department.

Flynn, R., 1978, The Sumatran rhinoceros in the Endau-Rombin National Park of Peninsular Malaysia, *J.Malay. Nat*, **4:**5-12

Flynn, R., 1983, Distribution status and feeding ecology of the Sumatran rhinoceros in Malaysia, Msc Thesis, University of Montana.

Flynn, R., 1980, Endau- Rombin National Park management plan, Kuala Lumpur, Malaysia, Department of Wildlife and national parks.

Foose, T.J and Van Strien., (editors) 1987 Asian Rhinos- Status Survey and Conservation Action Plan. IUCN. Gland, Switzerland and Cambridge, UK.

Fujii, T., Takahashi, A., Ishida, H., Magintan, D and Maryati, M., 1999, Preliminary list of seeds plants in Tabin Wildlife Reserve. Tabin Scientific Expedition, Universiti Malaysia, Sabah. Pp:49-59.

Groves, C. P., 1964, Description of a new subspecies of rhinoceros from Borneo. augetierkundliche Mitteilungen, **13 (3)**: 128-131.

Sadjudin, H.R., Zainal, Z. Z and Charles Santiapillai (Editors), 1995, SUARA BADAK, newsletter of the UNDP/GEF Project for the conservation of Rhinos in South East Asia (Indonesia and Malaysia).

UMS
UNIVERSITI MALAYSIA SABAH

Hubback, T., 1939, The Asiatic two- horned rhinoceros, *J.Mamm.* **20:** 1-20.

Jewell, Z.C., Alibhai, S.K and Law P.R., 2001, Censusing and monitoring black rhino (*Diceros bicornis*) using objective spoor (footprint) identification technique, *J. Zool.* **254:** 1-16.

Jomitin, C. 1999, Notes on the birds and mammals of Tabin Wildlife Reserve, Tabin Scientific Expedition, Universiti Malaysia, Sabah Pp-153-163.

Khan, M., Foose, T.J and Van Strien N., 1995, Asian rhino in action plan for their conservation, IUCN SSC Asian rhino Spezialist group.

Khan, M., 1989, Asian Rhinos: An Action Plan for their Conservation. IUCN, Gland, Switzerland.

Kilbourn, A., Dierenfeld, E.S., Bosi, E.J., Andau, M., Alsisto, S and Karesh, W., 2005, Intake, utilization and composition of browses consumed by the rhinoceros (*Dicerohinus sumatrensis harrisoni*) in captivity in Sabah, Malaysia. Submitted to *J. Zoo and wildlife.*

Lee, Y.H., Stuebing, R.B and Ahmad A.H., 1993, The mineral content of food plants of the Sumatran rhinoceros (*Dicerorhinus sumatrensis*) in Danum Valley, Sabah, Malaysia, *Biotropica* 25:352-355.

Malim ,T.P and Maryati M., 1999, Tabin Scientific Expedition. Universiti Malaysia Sabah, Sabah.

Marcus, C., Carmen, P., Kienzle, E., Wiesner, H., Baumgartner, K., Houwald, F.V., Juergen Streich., and Dierenfeld E.S., 2005, Energy and mineral nutrition and water intake in the captive Indian rhinoceros (*Rhinoceros unicornis*). *Zoo Biology,* **24:**1-14.

Marcus, C., David, A., Edward, J., Norkus, B., Tai, C. Chen., Hollck, M.C., Juergen, S and Dierenfeld, E.S., 2002, Fat soluble vitamins in blood and tissue of free-ranging and captive rhinoceros.

Maryati, M., Andau, M., Dalimin, M.N and Malim, T.P., 1999, Tabin Scientific Expedition, Universiti Malaysia, Sabah, Pp 1-3.

UMS
UNIVERSITI MALAYSIA SABAH

Mokhtar, M.B., Lee, Y.H., Stuebin, R.B., Maryati, M and Ismail, G., 1990, Elemental composition of rhinoceros wallow soils in Danum Valley, East Malaysia, *Biotropica* **22**: 110-112.

Muya, S.M and Oguge, N.O., 2000, Effects of browse availability and quality on black rhino (*Diceros bicornis* michaeli Groves 1967) diet in Nairobi National Park, Kenya. *East African Wildlife Society. Afr.Jr. Ecol* **38:** 62-71.

National Research Council., 1989, Nutrient requirements of horses, 5th edition, National Academy Press, Washington Pp.65-97.

Paglia, D.E., Kenny, D.E., Dierenfeld, E.S and I-Hsien Tsu., 2001, Role of excessive maternal iron on the pathogenesis of congenital leukoencephalomalacia in captive black rhinoceros (*Diceros bicornis*). *American journal of veterinary research,* **62**: 343-349.

Paglia, D.E and Dennis, P., 1999, Role of chronic Iron overload in multiple disorders of captive black rhinoceros, In Proceedings of the conference of the American Association of Zoo Veterinarians, C.K. Baer (Ed). Columbus, Ohio, Pp. 163-171.

Payne, J., 1987, A Preliminary Management Plan of Tabin Wildlife Reserve, Sabah, Unpublished report prepared by World Wildlife Fund, Malaysia for the Sabah Forestry Department. (IUCN/WWF Project No.3050 and MAL 61), Kuala Lumpur.

Rabinowitz, A., 1994, Helping a Species Go Extinct: The Sumatran rhino in Borneo. *Conservation Biology.* **9**:482-488.

Sale, JB., 1994, Management plan for Tabin Wildlife Reserve 1994, United Nations Development Program, Kota Kinabalu, Sabah, Malaysia.

Strickland, D.L., 1967, Ecology of Rhinoceros in Malaya. *Malay. Nat. J.* 20: (1-7).

Tabachnick,B.G & Fidell, L.S.2001. *Using Multivariate Statistics.* Fourth Edition. Boston: Allyn and Bacon.

Van Strien, N., 1974, *Dicerorhinus sumatrensis* (Fischer) The Sumatran or two-horned Asiatic rhinoceros. A study of literature. Meded. Landbouwhogesschool wageningen. The Netherlands.

Van Strien, N., 1979, On the difference in the foot prints of the Javan and Sumatran rhinoceros. *Tiger paper* **7**: 16-19

UMS
UNIVERSITI MALAYSIA SABAH

Van Strien, N., 1986, The Sumatran Rhinoceros *Dicerorhinus sumatrensis* (Fischer, 1814) in the Gunung Leuser National Park, Sumatra, Indonesia; its Distribution, Ecology and Conservation.

Yahya, B.E., 2000, The use of three insect Groups as Biological Indicators in Three Ecohabitats of sabah. Msc Thesis Universiti Malaysia, Sabah.

Yasuma, S and Andau, M., 2000, Mammals of sabah. Habitat and Ecology. Japan International Co-Operation Agency(JKA) and Sabah Wildlife Department, Ministry of tourism Development, Environment, Science and Technology, Malaysia.

Zainal, Z.Z., Julia, N.S.C., Nasaruddin, O and Ahmad, A.M., 2001, Displacement of Asian elephants *Elephas maximus*, Sumatran rhinoceros *Dicerorhinus sumatrensis* and Malayan tapirs *Tapirus indicus* in Peninsular Malaysia, *J. Wildlife Parks*, **19**: 13–18.

Zainal, Z.Z., 1995, Review of Sumatran rhinoceros, *Dicerorhinus sumatrensis* population in Peninsular Malaysia. *J. Wildlife Parks*, **14**: 1–15.

UMS
UNIVERSITI MALAYSIA SABAH