Standardization of Animal Diets in Indian Zoos

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New Delhi
&
Indian Veterinary Research Institute
Izatnagar - 243 122 (U.P.)

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Disclaimer: Every possible effort has been made in the collection and presentation of facts and figures related to captive animal nutrition. However, these recommendations are based on experiments conducted under certain specific conditions. These guidelines may be better used as general guidelines. Specific case may be dealt with its merit. Either authors or CZA or IVRI assumes no liability for any loss, injury or untoward incidence.

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Contents

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सत्यमेव जयते

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MINISTER OF STATE (INDEPENDENT CHARGE)
ENVIRONMENT & FORESTS
GOVERNMENT OF INDIA
NEW DELHI-110 003

MESSAGE

I am happy to learn that the team of Scientists at the Indian Veterinary Research Institute (IVRI) Bareilly, have undertaken the task of "Standardization of Animal Diets in Indian Zoos" under the sponsorship of the Central Zoo Authority (CZA). I congratulate the team of the Central Zoo Authority (CZA) and Indian Veterinary Research Institute (IVRI), Bareilly for meticulous accomplishment of this important task. It is also useful that the book provides guidelines for feeding of captive animals in Indian zoos.

The findings of the project have been documented in the form of a book for the benefit of Zoo Managers, Zoo Veterinarians, Research Workers, Student and Conservationists. These new guidelines published by Central Zoo Authority (CZA) will ensure standard practices to provide proper and balanced nutrition to the animals in the zoo and will improve their health, reproduction and longevity.

I am sure that this publication will be useful for Zoo Managers, Zoo Veterinarians, Research Workers and Conservationists.

Jayanthi Natarajan
(Jayanthi Natarajan)

जहाँ है हरियाली।
वहाँ है खुशहाली।

सत्यमेव जयते

CENTRAL ZOO AUTHORITY

केन्द्रीय चिड़ियाघर प्राधिकरण

(Statutory Body under the Ministry of Environment and Forests)

B.S. Bonal
Member Secretary
बी. एस. बोनल
सदस्य सचिव

MESSAGE

India is one of the biodiversity rich countries in the world, standing 6th in the list of 12 mega biodiversity countries. However, wildlife fauna of India is constantly under the threat of being extinct due to various types of anthropogenic activities which lead to habitat loss and fragmentation. The main goals of the Indian zoos are to complement and strengthen conservation of endangered species. For many species, *ex-situ* conservation is the only string of hope. Consequently, a blue print of "Conservation Breeding Programme" was finalized in July, 2007. Nevertheless, there is no doubt that no captive breeding programme could be successful if proper nutrition is not provided to the animals.

The role of nutrition in improving health, immunity, reproduction, and lifespan is well established but very little information is available in literature regarding feeding and nutrition of captive animals. Most of the available literatures are based on research works conducted in Western zoos on animals fed with commercially manufactured diets.

In India, however, the feeding situation is completely different where animals are fed mostly on raw ingredients, with little or no processing. Most zoos have been feeding their animals empirically on the basis of natural feeding behaviour and from the experience of keepers in that particular or other zoos. Consequently, there are large variations in the amount and the type of food being offered to an animal species in different zoos and reproductive performance is not often up to the expectation. It was felt that better nutrition is not only required to improve reproduction, health and longevity, but is also fundamental to reduce stress and boredom in zoo animals. In this perspective, the project entitled "Standardization of Animal Diets in Indian Zoos" was assigned to IVRI to generate basic data on nutrient composition of different foodstuffs as well as feed consumption and nutrient utilization potential of selected species of animals. The IVRI team was also requested to test the dietary adequacy of existing feeding schedule of these selected species practiced in different zoos and to suggest suitable guidelines for feeding so as to improve nutritional status, reproduction and health.

Indian Veterinary Research Institute has contributed immensely to different aspects of wildlife management. As the "National Referral Centre on Wildlife Healthcare", IVRI has been providing diagnostic and therapeutic services to all the zoos, organizing training programmes for zoo personnel, and also providing consultancy services to different zoos as per requirements. The team of Scientists at IVRI has already developed "Standards, Guidelines and Protocol on Disease Diagnosis and Cure of Wild Animals in Indian Zoos". It was, therefore, anticipated that the team of scientists would come up with excellent findings under this programme, which would be both scientifically valuable and practically useful. The team of scientists including Drs A. Das and M. Saini under the leadership of Dr A.K. Sharma has done a commendable job to accomplish the goal envisaged by CZA.

I am happy to learn that the present work generates baseline data on feed consumption, diet digestibility and utilization of major nutrients in different species across 34 zoos across the country. The team has also tested the dietary adequacies of feeding schedules currently being followed in different zoos. Finally, guidelines have been provided for feeding of selected species which would not only ensure proper and balanced nutrition but would also improve health, reproduction and longevity. I hope that this publication will be useful to the Zoo Veterinarians, Zoo Managers and Animal Keepers.

(B. S. Bonal)
Member Secretary

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प्रो. गया प्रसाद
Prof. Gaya Prasad
कार्यवाहक निदेशक
Acting Director

Foreword

The main thrust of the Central Zoo Authority (CZA) is to encourage *ex-situ* conservation through its scientifically planned conservation breeding programme. Modern zoos make significant contribution towards conservation of endangered species. For successful breeding of the endangered species in captivity, not only the animals must be in good health but the keeping conditions also need to be optimum. With the support from the CZA, IVRI has already developed guidelines and protocols on wild animal disease diagnosis and treatment in India Zoos. The 'National Referral Centre on Wildlife Healthcare' at IVRI is assisting in conservation breeding efforts of Central Zoo Authority. Nurition in one of the critical components of scientific zoo management as the role of nutition in improvement of health, immunity, reproduction and lifepan is now well established. In recent times, there is growing concern over captive propagation of endangered animals, however, little to none is known about the nutritional needs of these species. Consequently, most of these animals are fed empirically based upon their natural feeding behaviour, domestic animal model or by sharing nutritional information among the zoos; which sometimes results in nutritional imbalance/deficiency leading to poor health and reproduction.

In view of above, the CZA sponsored project "Standardizaion of Animal Diets in Indian Zoos" had been a sincere, timely and earnest effort towards generation of basic data regarding feed/food consumption and nutrient utilization by endangered species. Unlike domestic or laboratory animals, conducting scientific experiments on endangered wild animals is very difficult on many accounts including the difficulty in putting them on rigorous experimental regime. Moreover, the sample collection is difficult and requirement of sufficient number of animals often remains a great limitation. In spite of these difficulties, the team of dedicated Scientists at IVRI has generated basic data on nutrient utilization of 53 species within a short span of time, besides identifying the dietary inadequacies of existing feeding regimes for different species of endangered animals. The IVRI team has also suggested guidelines for improved feeding and nutrition of all these species, which will go a long way in achieving the comprehensive goal of captive animal management in terms of sound health, longevity, reproduction and behavioural stimulation. I congratulate Dr. Asit Das and his team on accomplishment of this arduous book of national importance to cater to the need of scientific nutritional management of wildlife species in Indian scenario.

G. Prasad
Gaya Prasad

Acknowledgements

The project covered more than 50 species of animals across 34 zoos across the country. Fruitful accomplishments of project of this nature require support from a number of organizations and individuals. We are indebted to them all.

It is acknowledged at the very onset that there is no mutual conflict of interests. The scientific contributions of zoo personnel are acknowledged herewith.

The financial support provided by CZA is deeply acknowledged. We are especially thankful to Shri B.S. Bonal, Member Secretary, Central Zoo Authority for his kind support and patronage. Without his active persuasion, proper and timely initiatives and directives, it would have not been possible for us to accomplish the project. Our special thanks are also due to the Former Member Secretary, CZA, Dr. B.R. Sharma. It was his vision to improve the nutritional status of animals in Indian zoos. We express deep sense of gratitude to him for his keen interest and kind support. We are also thankful to the other members and officials of CZA, especially Dr Naim Akhtar, Dr B.K. Gupta, the Scientific Officers and Shri P. C. Negi, the Finance Officer for their valuable support.

The valuable guidance, necessary directives and kind support received from Dr Gaya Prasad, Director IVRI as well as Dr. M.C. Sharma, Dr S.P.S. Ahlawat, Dr Dharmeshwar Das, Dr R.S. Chauhan and Dr M.P.Yadav, the Former Directors of IVRI is deeply acknowledged. We are also thankful to Joint Director (Research) for necessary support.

I am fortunate to have right impetus, infra-structural support and proper guidance from the former and present Heads, Division of Animal Nutrition as well as the Nutrition Faculty. Support received from the Head and Faculties of Medicine, Pathology, Physiology and Climatology and other Divisions are duly acknowledged. Administrative staff of IVRI had been very helpful during the duration of the project. Their timely support is duly acknowledged. Assistance received from Shri Rajendra Kumar, Shri Mohan Bhatt, Shri Raj Kumar and Shri Jitendra Khare is specially acknowledged.

It is time to acknowledge the contribution made by my colleagues Drs. M. Saini, N. Dutta, S.K. Saha and B.C. Das. I would like to thank three of my bosses Drs D. Swarup, K. Sharma and A.K. Sharma for their meticulous guidance, contribution, criticism and motivation. I also thank the members of the team Drs. S.P. Gupta, Puneet Kumar, Mahipal Choubey, Shrikant Katole, Rakesh Ranjan, Rais Ahmad and Vineet Kumar whose sincere efforts, commitment to work and dedication is highly appreciated. The contribution made by S.S. Kullu, PhD. Scholar of the laboratory was invaluable and is duly acknowledged. Help rendered by Drs Shynu, Ramesh and Chandramohan is duly acknowledged. Md. Islam, Shri Hari Gobind, Shri Mohan Bhat and Shri Rajendra Kumar took a lot of pain in typing the manuscript. Their efforts are duly acknowledged. Our sincere thanks are due to Shri Kundan Singh and M/s Printing Palace for meticulous editorial setting and typing the manuscript.

We acknowledge the kind support and necessary impetus provided by the Directors/Authority of different zoos; without their support the project could not have been accomplished. Our deep sense of gratitude is due to the Directors, Veterinary Officers, Zoo Keepers and other staff of all the 34 zoos where we have visited and conducted experiments. We wish to mention the name of following individuals whose support was crucial for the accomplishment of the project: Dr. Sudarshan Panda, Director, Nandankanan Biological Park, Shri R.K. Raj, DFO, HNP, Kufri; Shri Dharminder Sharma, Director, MCZP, Chattbir; Shri A.K. Agnihotri, Director, NZP, New Delhi; Ms. Iva Sharma (ex), Ms. Renu Singh, Director, Lucknow Zoo; Dr. Hemant Kumar (CF), Shri P.K. Rao, Director, Kanpur Zoo; Shri A.K. Jha, Director PNHZP, Darjeeling; Shri P.K. Mahanta, Director, Assam State Zoo; Shri A.K. Bhowmik, Director, Sepahijala Biological Park; Shri P. Raghuvir, Director, Nehru Zoological Park, Hyderabad; Ms. Vijukumari Amma, Director In-Charge, Thiruvananthapuram Zoo; Shri K.B. Markandiah, Director SCZG, Mysore; Dr. R.K.Jadhav, Director, Pune Zoo, Dr. Uttam Yadav, In-Charge Kamla Nehru Prani Sangrshalaya, Indore; Ms. Aakansha Chaudhary, Director, Jodhpur Zoo; Shri A.K.Gupta, Director Jaipur Zoo, Dr. R.K. Sahu, Superintendent, Kamla Nehru Zoological Garden, Ahmedabad; Shri V.J. Rana Director, Sakkarbaugh Zoo; Shri Vijulal F.R., Director, Pt. G.B. Pant High Altitude Zoo, Nainital; Shri Abhay Kumar, Director, Sanjay Gandhi Biological Park, Patna and Sri M. Tago, Director Banerghatta National Park.

We also express our sincere thanks to our colleagues in different zoos without whose help this project could have been never completed. We put on record our special thanks to each one of them: Drs. Sandip Rattan, Shimla; Nirmaljeet Singh, MCZP Chattbir; U.K. Shrivastava,V.O, Kanpur Zoo; Utkarsh Shukla, Deputy Director, Lucknow Zoo; Deepak Sharma, PNHZP, Darjeeling; Madan Shankar, Deputy Director, Gangtok Zoo; M.L. Smith, SVO, A.K. Gogoi, VS, Assam State Zoo; Sajal Das VAS, Sepahijala Biological Park; P.K. Roy, SVO, A.K. Samantray, SVO and A.K. Das, VO, Nandankanan Biological Park; Md. Haqim, Nehru Zoological Park, Hyderabad; Joe Jacob Sebastian, Thiruvananthapuram Zoo, Suresh Kumar, Assistant Director, S. Dhanalaxmi and Prayag, SCZG, Mysore; R.K. Jadhav and R.K. Nighot, Rajiv Gandhi Zoo and Wildlife Research Institute, Pune; Uttam Yadav, Indore Zoo; Atul Gupta,VO, Vanvihar National Park, S.K. Mittal, In-Charge, Gwalior Zoo; R.K.Sahu, Superintendant, N.K. Sabhdhariya, SVO and J.B. Kacha, VO, Kamla Nehru Zoological Garden, Ahmedabad; CM Bhuva, SVO and R.K. Kadiwar, Shakkarbaugh Zoo; Arvind Mathur, VO, Jaipur Zoo; S.S. Rathore, Jodhpur Zoo; Ajit Singh SVO, Sanjay Gandhi Biological Park, Patna; J. Panor, Biological Park, Itanagar; S.A. Tripathi, VO, Virmata Jijabai Bhosale Prani Udyan, Mumbai, L.K. Sanwal, Pt. G.B. Pant High Altitute Zoo, Nainital.

It is only human to forget the some of the Individuals/Institutions who made significant contribution to the successful accomplishment of the project and any such omission is unintentional. We express our sincere gratitude to one and all.

Asit Das

Asit Das

Preface

The primary goal of captive animal management has taken a paradigm shift during the last decade. Conservation breeding is the main focus of captive animal management in zoos across India. With the CZA initiatives, conservation breeding plan has been finalized. However, the contribution of nutrition cannot be ignored for successful conservation breeding, as in the past many ex-situ conservation measures have failed due to inadequate or improper feeding management. Improper feeding can cause severe health problems and adversely impact animal welfare. Improved nutrition is positively linked with immunity, disease prevention, growth, reproduction and longevity. Over 46 nutrients have been identified to be essential for vertebrates. The importance and interrelationships among health, reproduction and nutrition have been understood. However, only limited information is available on nutrition of zoo animals. Most of this information is from Western zoos which use commercially manufactured diets to feed their zoo animals. Such feeding practice may not be applicable for many different reasons like people's perception, deviation from normal feeding behaviour of animals, lack of behavioural stimulation and problems of dental health etc. Saying this, it is acknowledged that basic nutrient requirement data and principles of nutrition will remain the same and results obtained in those experiments will form the basic structure of feeding guidelines for captive animal in Indian zoos. In most of the Indian zoos, animals are fed empirically on the basis of experience of the Zoo Keepers. In most cases they have got excellent practical knowledge and the diets being fed are time tested. The diet of those zoos which successfully keep particular species over time is adopted by other zoos even if the diet in question is sub-optimal. Some zoo animals were able to survive on such sub-optimal diets for years and thus such diets are accepted. These issues were discussed in CZA meeting between the member secretary, CZA, Dr. D. Swarup and other Technical Committee Members and the importance of proper nutrition and feeding guidelines were realized. It was then decided that a project should be initiated to standardize animal diet in Indian zoos.

Initially a request was sent to NIN, Hyderabad, then to NIANP, Bangalore and finally to the IVRI, Izatnagar. Being premier Institute, IVRI is always concerned with the animal health and welfare of captive animals. Further, IVRI already had some experience on conducting nutritional experiments on captive wildlife. Prof. M.P. Yadav, the then Director of IVRI responded positively of CZA's request to pursue a project. Dr. Asit Das was specifically assigned the responsibility to pursue the project. Under the competent leadership of Dr. D. Swarup, a project proposal was submitted to CZA which was approved by the Technical Committee of CZA. Finally, a Memorandum of Understanding was signed between IVRI and CZA and the project was initiated.

Even though the importance of proper nutrition is recognized, number of studies conducted on zoo animals is rather scarce. It was decided that basic data regarding consumption and utilization of major nutrients would be generated for selected species of mammals, birds and reptiles. Further, nutritional status of the captive animals in Indian zoos would be ascertained on the basis of experimental results, review of literature and established nutrient requirements of the model animals. Considering the difficulties in classifying animals on the basis of feeding behaviour, we have described animals as per the order/family they belong to. For the easy understanding of the readers whose basic qualification is not Animal Nutrition, a chapter on "Principles of Zoo Nutrition" has been added. At the beginning, a brief description of the animal (size, lifespan, sexual maturity, gestation length etc.) is provided which is of elementary in nature, but could be handy. Then, we have described the feeding ecology, feeding habit in nature and the kind of food being offered in zoos. We have incorporated data pertaining to nutritional composition of different food items being fed to zoo animals. These data will not only serve as baseline data, but will also help in formulation of diet chart by the Zoo Authority themselves in future. Then, we have included the findings of experiments regarding food consumption, diet digestibility and utilization of major nutrients. These findings were compared with similar works done elsewhere in the particular species or other similar species. Based upon these, we have indicated any imbalance/inadequacy of a particular nutrient or a group of nutrients. Finally, corrective measures and guidelines were suggested.

During the present investigation, we had to conduct feeding trial on more than fifty different species; only little is known about their digestive physiology, nutrition and impact of nutrition on their health and reproductive performance. To conduct feeding trials on such animals is a challenging task, collection of urine (pre-requisite to ascertain nutrient balance) is impossible. Quantitative collection of faeces was also difficult in hoofed stock those were housed as flock. We used internal and external markers to determine intake and digestibility in those animals. The utility and limitations of these markers have been debated by nutritionists for a long time. However, in such circumstances we will probably continue to use these markers. Direct determination of nutrient requirement is a lengthy process and involves feeding of a particular nutrient in different concentrations. The animal performance is then assessed for treatment effect. The experimentally produced deficiency and toxicity are then studied to determine minimum and maximum nutrient requirement. Such kind of direct experiments are not possible in endangered species. Another point of concern is the number of replicates. Often zoos have only one, a pair or a few individuals of a species in their collection. We have tried to overcome these difficulties by repeated measurements of different parameters. In spite of the difficulties, we have come out with basic data on feed consumption, diet digestibility and utilization of major nutrients in selected species. Very little to nothing is known about the nutrition of these species. This book will provide baseline data for research and diet formulation. Nutritional adequacies were tested by rigorous animal experimentation and detailed laboratory analysis. Case specific ameliorative measures have been suggested. Finally, detailed suggestive guidelines for feeding have been provided for each of these species. We are confident that these guidelines will provide new impetus to feeding and nutrition of wild animals in Indian zoos. If followed properly, the suggested feeding guidelines would improve nutritional status, immunity and reproductive performance of the animals and above all the quality of life in captivity.

M. Saini

CHAPTER-1

Introduction

1. Introduction

India is a mega-biodiversity hotspot which is home to 80,000 known animal species. All of them occupy their unique ecological niche and contribute to maintain delicate balance in the ecosystem. Human population explosion and global climatic change have devastatingly deteriorated, fragmented and destroyed habitat of many of these species. Consequently, many a wildlife species is now endangered. Central Zoo Authority (CZA) and its affiliated zoos have always shown concern and contributed significantly towards conservation of these species. Researches conducted in zoos have provided vital impetus for conservation of endangered species. Zoos have always contributed to increase public awareness which is vital for conservation of a species. Recently, CZA is actively involved in conservation breeding of endangered species. It is obvious that proper management of animal is of paramount importance for success of conservation breeding programme.

Nutrition is a vital component of captive management of wild animals. In nature, animals are free to choose their food and nutritional wisdom of animals will drive them to eat those food items which are best suited for their normal physiological and behavioural development, growth, reproduction, immunity, and longevity. In zoos, however, animals are completely dependent on human to cater their nutritional needs. Feeding of zoo animal is a challenging task because the specific nutrient requirements of most of the wild animals are not known. So, more often than not their captive diet is formulated with those ingredients which they are known to consume in free range. However, this approach is not always correct because qualitative and quantitative information available on feeding ecology of an animal may not be sufficient to formulate a captive diet. Further, it is not always practically feasible to procure those ingredients which are being eaten by the animals in wild. The situation becomes even more complicated as the nutrient composition of food items available in the wild are completely different from those cultivated in farm. So, many nutritionists use information available on similar domestic animals to formulate diet for captive wild animals. Nutrient requirements are in fact very similar among different species of closely related family/sub-family. However, there are differences in digestive physiology, metabolic strategy and nutrient requirements even among closely related species. Thus, species specific information on nutrition and its possible impact on development, reproduction and health need to be studied.

Number of studies conducted on nutrition and feeding of wild animals is much lesser than that of domestic and laboratory animals. Even though scientifically challenging and professionally satisfying, there are some inherent difficulties in pursuing research on wild animal nutrition. Sample size is often limited, sample collection is tedious (many times impossible), and these animals can not be put under rigorous experimental regimes. Inspite of all these difficulties, research have been conducted to develop proper dietary guidelines for captive animals. Such efforts from the Nutritionists have contributed significantly towards improvement of captive animal management. One great example is eradication of metabolic bone diseases in captive felids, primates and birds. Due to efforts of many Scientists, it is now possible to improve the reproductive performance of captive animals by delicately balancing the diet. Recognizing these efforts, Species Survival Plan (SSP) of many endangered species now includes nutrition chapter or dietary guidelines. These handbooks provide valuable informations on digestive physiology, metabolic adaptation and nutrient requirements of the species. However, the kind of food ingredients used in most Western zoos are completely different than those fed in Indian zoos. Thus, it may be practically difficult to implement those guidelines in Indian zoos.

In India, most of the captive animals are fed empirically on the basis of food preferences of the free ranging animals, domestic animal data and experience of the keepers. These diets are time tested and many a times practical knowledge of the keepers are excellent and not many nutrition related problems have been reported. However, their knowledge and skills lack scientific validation. Saying so, it does not mean that nutrition related problems are not there in Indian zoos. In fact most of the cases of nutritional deficiency/ imbalances go un-noticed because marginal deficiency does not manifest in clinical symptoms. Impact of nutrition on normal development, reproduction and health is a long term process. Malnourished animals are immuno-compromised and are more susceptible to pathogens. When the animal suffers/ dies, it is attributed to the pathogen undermining the importance of nutrition. Similarly, poor reproductive performance of animals in many cases could be due to deficiency/ imbalance of one or more nutrients. Another practical difficulty in this empirical approach of feeding is large inter-zoo variation in feeding schedule of captive animals. Some variation due to geo-climatic location of the zoo and ingredients available at that location are normal. But these variations should not be too large to cause large variation in supply of nutrients. In view of the above facts, CZA felt the necessity of preparing a standard diet schedule. Such a diet schedule should provide all the nutrients in optimum quantity so as to improve general health, immunity, life span and chances of captive breeding. To develop such diet it would be necessary to generate basic data on nutrient composition of different feedstuff being fed to animals in zoos, actual consumption of food, digestive capacity and utilization of major nutrients by different species of captive animals. Deficiency/ imbalances of one or many nutrients have long been suspected.

1.1 Central Zoo Authority initiatives to formulate standard diets for zoo animals

Considering the above facts CZA decided to develop guidelines and protocol for standardization of the captive wild animal diets and to develop feeding regimen in order to enable the Indian zoos to adopt the same plan. The CZA awarded a project to IVRI in 2007 to standardize animal diets in Indian zoos. The project was mandated to provide information in form of a handbook dealing with the following aspects

1. Developing feeding regimen for selected species by carrying out literature and field survey, analyzing the existing feed resources, feeding habits and feed consumption
2. Collection of information with regard to nutrition, feeding ecology and diet to be provided while hand rearing of various species.
3. Identification of nutritional imbalances/ inadequacies in the existing feeding system of captive animals in Indian zoos

4. Collection of information with regard to nutrition, feeding ecology and diet to be provided to various species of animals in different geo-climatic zones of the country.
5. Development of feeding strategies and feeding regimen for representative species including informations on
   a) Feeding habits of animals and feed consumption by the animal
   b) Nutrient composition of feed and browse material offered at zoos
   c) Details on supplementation of deficient nutrients
   d) Standardization of diet and working out the feeding strategies of captive wild animals

Technical programme of the project completed by IVRI

As envisaged under MoU signed between CZA and IVRI, following technical activities were completed to achieve the objectives of the project

1. The team of IVRI Researchers visited different zoos representing 5 different regions in the country (Appendix1) and conducted feeding-cum- digestion trials on different species to ascertain feed consumption, diet digestibility, nutrient utilization, diet adequacy and nutritional imbalances. During the period, all foods were offered in measured amount. Feed refusals were collected in full to determine the actual feed consumption. In flock animals in which it was not possible to collect faeces in full, faecal output was measued by indirect method using standard digestibility markers. Representative samples of feed, refusals and faeces were collected and nutrient contents were analyzed using standard laboratory methods.
2. All the samples were analyzed for dry matter (DM), gross energy (GE), crude protein (CP), ether extract (EE), Ca, P, Fe, Cu and Zn content. Besides, samples of herbivores and omnivores were also analyzed for neutral detergent fibre (NDF) content.
3. Informations were gathered on
   a. Common and scientific name
   b. Normal body weight of adult males and females
   c. Age at maturity
   d. Longevity in the wild and in captivity
   e. Description of the gastrointestinal tract
   f. Digestive strategies (browser, grazer, carnivore etc.)
4. Further information on feeding habit, feeding ecology and feeding behaviour of the animal in free range was also gathered.
5. Information available in published literature on feeding and nutrition of captive wild animals were consulted to compare the findings of our experiments.

Information available in literature on hand-rearing of orphaned neonates was collected.

Analytical techniques

Samples of feed, orts and feces were dried in a hot-air oven (Yorko Hot Air Oven, Yorko Scientific Industries, 1325, Fasil Road, Delhi) at 100°C for 16 h to determine the DM content. At the end of trial, each individual's ort and faeces were pooled across the trial period. Sub-samples of feed, faeces and orts were dried in a hot-air oven at 50°C for 4 d, ground to pass through a 1-mm screen in a grinding mill (Retsch, Germany) and stored at room temperature in air-tight plastic containers (Tarsons Products, New Delhi) for later analysis. The milled samples of feed, orts and feces were analyzed for crude protein (CP) according to the method of AOAC (2005) and neutral detergent fibre (NDF) according to the method of Van Soest et al. (1991). Analysis of gross energy (GE) content of feed and faecal samples was done in a Ballistic Bomb Calorimeter (Model CBB 330, Gallenkemp, London, UK) using benzoic acid as standard.

Feed and faecal samples were also analyzed for Ca (Talapatra et al., 1940) and P (AOAC, 2005). Levels of copper (Cu), iron (Fe) and zinc (Zn) in feed and faecal samples were determined using atomic absorption spectrophotometry (Model No: AAS 4141, ECIL, Hyderabad, India) following wet digestion method.

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CHAPTER-2

Principles of Zoo Animal Nutrition

2. Principles of Zoo Animal Nutrition

The pioneer work of Sanyal (1892) forms the basis of feeding animals in Indian Zoos. In most of the zoos, animals are empirically fed on the basis of their natural food habit and from the experience of the Zoo Keeper. Such diets could be deficient in one or more nutrients. The problem becomes more complicated because many a times marginal deficiency of a nutrient is not clinically manifested. However, the long term effect of these deficiencies could have devastating effect on performance and health of the animals. To understand and tackle these situations, it is necessary to understand the basic principles of nutrition. The process of nutrition involves intake, absorption and assimilation of nutrients in the body to support vital functions. During the last century, a lot of advancement has been made in the field of nutrition. Nutritionists are now able to say the precise requirement of amino acids, trace elements, essential and non-essential fatty acids. Link of nutrition with many diseases have been well established. With dietary management it is now a days possible to reduce the risk of many fatal diseases. The field of wildlife nutrition, however, is still in infancy. Nevertheless, like other mammal, wild mammals also require 45-47 known nutrients and the basic principle of nutrition will be applicable to them as well.

Water

Water is the most important nutrient. For better performance, water must be made available to animals at all time. Animal meet their requirement either by drinking fresh water or through feed, fodder, grasses and tree leaves or partly from metabolic water. Oxidation of 100 g feed nutrients such as protein, carbohydrate and fat yields 42, 60 or 108 g of metabolic water, respectively. The drinking water must be free from any contamination. The moisture in food is important source of water for many animals. Free ranging kangaroo rats, ground squirrels, peccaries, antelope, wallabies, numerous carnivorous and insectivorous birds and mammals have been able to meet their water requirement from preformed and metabolic water (Robbins, 1992).

The body excretes water through urine, faeces, and milk, and by vapourization through lungs and skin. In species that drink water, it is usually 2-5 times of dry matter intake (Fowler, 1986). Water consumption in Indian rhinoceros is 3.5-5.2 l/kg DM (Clauss *et al*., 2005) and an elephant can drink up to 200 l of water daily (Holdo *et al*., 2002). Water requirement varies from animal species to species. Those species which have higher metabolic activity will consume more water. Owing to the intense metabolism and corresponding high rate of pulmocutaneous water loss, small passerines generally dehydrate during flight at air temperature above 7ºC. Water requirement of mammals are higher than birds because excretion of urea require more water than uric acid, consequently water requirement is higher in mammals.

Carbohydrates

Carbohydrates are composed of carbon, hydrogen and oxygen. Simple sugar, oligosaccharides, hemicellulose, cellulose, starch and non-starch polysaccharides are all included in the broad term carbohydrates. Most of the herbivores and omnivores derive majority of their energy from carbohydrates. However, carbohydrates may not be a dietary essential in many species, if supply of glucogenic precursor like propionate and glucogenic amino acids is ensured. Wild felids fulfill their glucose demand by converting gluconeogenic amino acid to glucose. Glucose is required in erythrocyte, medulla of kidney and central nervous system, although central nervous system can also use ketone bodies to some extent.

Dietary fibre is a common term which includes cellulose, hemicellulose, gum, pectin, enzyme resistant starch and lignin, whereas, the detergent method of analysis describes the structural carbohydrates. Neutral and acid detergent fibres (as estimated by the method of Van Soest *et al*., 1994) are important source of nutrients for herbivores. Even omnivorous species like man and pig can utilize sizeable amount of this fibre. By far, cellulose is the most abundant organic substance in the earth. NDF concentration of free ranging Gorilla diet was 46 % (Roger *et al*., 1990), for orangutan it was 56 % (Knott, 1999) and in lemur diet it was 40% (Dempsey *et al*., 2002).

Mammalian species including herbivores do not have any enzymes to degrade complex carbohydrates like cellulose and to extract energy from it. This handicap has, however, been overcome by developing highly specialized digestive system. They harbour an array of micro-organisms in their gut who have capability to degrade complex carbohydrates.

Microorganisms found in the hind gut ferment sugars, starches, cellulose, hemicellulose and pectin into volatile fatty acids (VFA), CO_2, CH_4 and H_2. These VFA's are readily absorbed in body and are major source of energy to herbivores. The short chain fatty acids (SCFA) contribute to the maintenance requirement and an Asiatic elephant can derive 100% of its maintenance energy from these SCFA (Jenson, 1986). VFA at the concentration of 120 mmol/l of faecal matter were reported in elephant (Jenson, 1986). The proportion of acetate : propionate : butyrate was about 70:15:15. Monkeys generally obtain 30% of their energy from VFA, in comparison to about 6-10% in human being (Schmidt *et al.*, 2005). The average pH of rumen liquor of Sika deer was 6.1 and total VFA content was 114.6 mmol/l (Li and Qin, 1991).

Protein

Protein and amino acids are indispensable to maintain life as they perform many biochemical function in the body and are vital structural and functional components of both soft and hard tissues of the animal body. 22 amino acids constitute the building blocks of proteins. Across the mammalian species ten amino acids are dietary essentials. These are arginine, valine, histidine, isoleucine, leucine, methionine, phenyl alanine, tyrosine and tryptophan. Among these essential amino acids, methionine may be partially replaced by cystine and phenylalanine by tyrosine. Domestic cat and other felids require free amino acids taurine in the diet (Howard *et al*., 1987). Much of a mammal's protein requirement is actually requirement for essential amino acids, although dietary proteins also supply other non-essential amino acids that are used as a source of organic nitrogen for synthesis of tissue proteins. S-containing amino acids are quite low in vegetable protein. This fact must be considered while formulating ration for wild herbivores.

Fat

Dietary fats are the major source of energy in strict carnivores. Fat also improves the palatability of the diet and increases the energy density of the diet, thus making it most suitable for those animals whose energy demand is very high. Animals do not require dietary fat *per se*. In most of the species linoleic acid is the essential fatty acid required to be provided through diet. However, domestic cat and other specialized carnivorous species require arachidonic acid as well.

Minerals

Macro and micro minerals perform many vital functions in the body. Minerals are involved in activation of several enzymes, physiological processes and maintain acid base balance of the body. Mineral status of animals can be judged from the mineral contents of soil and plants consumed by animals. When animals graze on grassland and vegetations deficient in minerals, they are prone to mineral deficiency.

Macro minerals are required in more quantity and their concentration is expressed as percentage of total diet dry matter. The major minerals are Ca, P, Mg, S, Na, K, and Cl. Micro minerals are required in lesser amount, and their concentration is expressed as mg/kg dry matter or ppm.

Calcium and Phosphorus

About 98% of the body's calcium (Ca) and 80% of the body's phosphorus (P) is stored in bone, teeth and skeleton. Ca and P are also essential for antler growth. Hardened deer antlers contain about 22 percent calcium and 11 per cent phosphorus. Ca is required for blood clotting, muscle contraction, transmission of nerve impulses, regulation of the heart beat, secretion of hormones, enzyme activation and stabilization.

Phosphorus is necessary to maintain osmotic and acid-base balance, cell growth and differentiation, cell-membrane fluidity and integrity. P plays vital roles in energy transfer and use, gluconeogenesis, fatty acid transport, amino acid and protein synthesis, and activity of the sodium-potassium pump. Clinical signs of deficiency include a decline in plasma inorganic P concentration and an increase in plasma alkaline phosphatase activity. Severe deficiency results in abnormalities of the bones and teeth, retarded growth, depressed appetite and pica.

Calcium absorption coefficient in captive Asiatic elephant averaged 60%, independent of concentration of Ca in diet (Meyer and Coenen, 2002). High urinary calcium concentration in captive elephants was reported by Ruedi (1995). Calcium absorption from the hay or pelleted diet was significantly lower than grasses in elephant.

The apparent absorption coefficient for phosphorus was between -129 and 29% in rhino and 10–30% in Asiatic elephant (Clauss *et al*., 2003). Endogenous phosphorus losses were 10 mg/ kg BW for rhino and 6.0 mg/ kg BW for Asiatic elephant.

As Ca and P are closely related and absorption is dependent on proper ratio of the two minerals, they are considered simultaneously when designing or evaluating a ration. Calcium requirement is dependent on the physiological state of the animal. For adult maintenance, Ca requirement is rather low. Calcium to phosphorus ratio of at least 1.5 to 1 is needed. For most of the species it will be desirable to have wider ratio of 2:1.

Leguminous green fodders are very good source of calcium. Green fodder and tree fodder are also very good source of Ca. Most of the herbivores in Indian zoos are fed green fodder which is a good source of Ca. So, deficiency of Ca is unlikely to occur in herbivores. In addition, herbivore diet is supplemented with cereal byproduct based concentrates which are very good source of P. So, in practical situation, Ca and P deficiency is not very common in captive wild herbivores. Grains and fruits are very poor source of Ca. Special care may be taken while formulating ration for granivorous birds and frugivorous animals. Grains and fruits are not only deficient in Ca, but the Ca:P ratio is also skewed. Boneless meat is a very poor source of Ca and Ca:P ratio is highly skewed at 1: 15-20. Thus, boneless meat must be supplemented with $CaCO_3$ @7-10 g/kg meat. Ca deficiency results from inadequate dietary intake, decreased intestinal absorption and excessive loss of Ca through faeces, urine and sweat. The deficiency sign include ricket in the young and osteomalacia in the adult animals. Other symptoms could be lameness, stiffness and enlarged joint. (Bland Sutton, 1988).

Magnesium

About 55% of the body magnesium is in skeleton and teeth. In the young, as much as 30% of its Mg store may be mobilized during a dietary deficiency, whereas, only 2% of stored Mg could be mobilized in the adult. Magnesium activates enzymes involved in muscular contraction, nerve conduction, transfer of methyl group, oxidative phosphorylation and synthesis of protein, fat, carbohydrate and nucleic acids. The requirement of Mg is 0.04 to 0.02% of the diet.

Sodium

This element is a major extra-cellular cation; about 35 to 40 per cent of body sodium is found in bone. About 25 to 35 per cent of that fraction is a labile sodium reserve. Sodium deficiency in un-supplemented animals is most likely to occur during lactation, rapid growth, or intense activity. Marine animals possess nasal glands that allow them to consume sea water and excrete excess sodium chloride externally. Sodium toxicity is uncommon unless fresh water is not available. Sodium requirement is 0.08 to 0.30 percent of diet of pinnepod.

Chlorine

About 85 per cent of body chlorine is located in extra-cellular fluid, and this accounts for about two thirds of its acidic milliequivalents. A simple dietary deficiency of chloride is rare. Chlorine toxicity has not been demonstrated; salt (sodium chloride) toxicity is a consequence of excessive sodium retention. Chloride requirement is about 0.10 to 0.30 per cent of the diet.

Potassium

This element is a major intracellular cation involved in maintaining acid base balance, osmotic pressure, and cell membrane potential. A primary dietary potassium deficiency is rare and usually is restricted to ruminants or equines fed high concentrate, low forage diet. Certain medical problem such as persistent vomiting or diarrhea, chronic renal disease may result in hypokalemia. Potassium toxicity is generally not caused by excessive dietary levels, but may occur as a consequence of renal failure, acute dehydration and adrenal insufficiency. Potassium requirement ranges from 0.2 to 0.8 per cent of the diet; equine animals require about 0.6 per cent and ruminants need 0.6 to 0.8 per cent.

Sulfur

Sulfur in tissues is found as methionine, cysteine, taurine, thiamine, biotin, glutathione, sulphate esters of various metabolites, and certain glycolipids. In amino acids it functions as a component of protein. Sulfur is important as structural component of connective tissue, in detoxification and maintenance of cell redox potential. Nitrogen and sulfur exist in fixed proportions in tissue protein. For ruminants, with relatively less pelage, nitrogen- sulfur ratios should be no greater than 12 to 15:1 and for animals with more pelage, it should be no greater than 10:1.

Iron

Hemoglobin contains 60 to 70 per cent of body iron; myoglobin contains 4%, ferritin and hemosidarin (storage form) contain 30%, and remainder is found in heme enzymes and transferrin. A primary dietary iron deficiency is not common in animals that consume solid food. However, prolonged exclusive consumption of iron deficient milk by quickly growing animals may result in hypochromic anemia. Acute iron toxicity may result from accidental over consumption of ionizable iron salt. Iron requirement is about 40 to 100 ppm in the diet.

Copper

Tissue distribution of copper varies greatly among species. Ruminants tend to have larger concentrations in the liver than non-ruminants. Plasma levels are commonly 0.3 to 2 ppm, and copper is associated with ceruloplasmin and albumin. Copper is involved in synthesis of connective tissue, melanin, and mobilization of iron stores. A primary dietary deficiency of copper is unlikely to occur in ruminants or non ruminants. Copper deficiency in ruminants is usually secondary to excess ingestion of molybdenum. Copper requirement of non ruminants is 5 to 10 ppm. Requirement of ruminants range from 1 to 10 ppm.

Iodine

The thyroid contains 70 to 80 % of total amount of iodine in the body. It is mainly involved in synthesis of thyroxin and triiodothyronine, the primary regulator of tissue metabolism. Iodine deficiency is associated with geographical region that are low in soil iodine. Marine products are particularly high in iodine content. Iodine requirements for growth ranges from 0.05 to 0.15 ppm in the diet and for reproduction about 0.2 to 1.0 ppm is needed.

Cobalt

The highest tissue concentration of cobalt is found in the liver and kidney. Levels in these organs are affected by cobalt intake, and they have been used in the diagnosis of cobalt deficiency. Cobalt deficiency is essentially a ruminant disease. Cobalt in excess has been associated with cardiomyopathy and pancreatic degeneration. Dietary requirement for ruminants is 0.1 ppm.

Zinc

This element is concentrated in several tissues such as retina and prostate, but it is widely distributed throughout the body. Zinc is associated with several enzymes and is involved in the synthesis of DNA and protein. Zinc deficiency has been described in nearly all domestic animals that have been restricted to unsupplemented vegetable diet. Zinc is relatively non-toxic, but excesses have induced copper deficiency in several species. Dietary requirement ranges from 40 to 80 ppm, and excessive intake of calcium tends to increase the requirement.

Manganese

The tissue rich in mitochondria have high concentrations of manganese, although the skeleton may be a major storage organ for this mineral. Manganese functions as a cofactor in a variety of enzyme system. Manganese deficiency has been most commonly described in birds. The requirement for this element is higher in birds than mammals. Manganese is not very toxic, but large excesses may depress growth and concentrations of hemoglobin. Dietary requirement for birds ranges from 30 to 50 ppm and for mammals it is 10 ppm.

Selenium

The element is found in all tissues, and concentrations are greater in kidney and liver than muscles. It is a component of glutathione peroxidase, an enzyme that detoxifies organic peroxides and hydrogen peroxides. If diet is un-supplemented with selenium and vitamin E, exudative diathesis are seen in birds. The requirement for selenium is inversely related to vitamin E concentrations in the diet, within certain limits. Requirement ranges from 0.05 to 0.3 ppm.

Vitamin A

Vitamin A is required for maintenance of integrity of epithelial cells, optimum growth, vision, and immunity. Most herbivores can convert β carotene to vitamin A. However, wild felids can not convert β carotene to vitamin A. So, it is necessary to provide preformed vitamin A in the feline diet. Requirement of Vitamin A ranges from 2000-10,000 IU/kg diet. Liver is the main storage organ. Marine fish oils are good source of vitamin A.

Vitamin D

Vitamin D is intimately related with Ca and P metabolism. Two forms of the vitamin i.e. ergocalciferol (D_2) and cholecalciferol (D_3) are found. Vitamin D_3 is a dietary essential for birds, reptiles, amphibians and fish. New world monkey can not convert vitamin D_2 to D_3.

Vitamin E

There are 8 known compounds which have vitamin E activity, among them α tocopherol is the most potent one. Vitamin E performs several vital functions including maintenance of membrane integrity, protection of unsaturated fatty acids from damage caused by free radicals, improvement of immunity and regulation of oxidation-reduction process.

Vitamin K

Vitamin K is required for synthesis of pro-thrombin, which plays crucial role in blood clotting. Cereal grains and oilcakes are poor sources of vitamin K. Animal products, green vegetable and fodders are all good source of vitamin K. In practical feeding situation, it’s deficiency is not very likely.

Thiamin

Thiamin is required for oxidative carboxylation of pyruvate. It is also necessary for maintaining integrity of cell membrane and nervous tissue, synthesis of acetyl choline and synthesis of nucleic acids. Cereal byproducts are excellent source of thiamin. This vitamin is thermo-labile. Some Bracken ferns and frozen fish contain thiaminase activity which destroys the vitamin. Caution might be taken while feeding piscivores. Canned frozen fish should be avoided.

Riboflavin

As a component of flavin adenine mono-nucleotide (FMN) and flavin adenine dinucleotide, riboflavin is involved in several metabolic processes which generate energy from the organic compounds. Green vegetables are good source of riboflavin. However, cereal grains are poor source. The diet of the granivorous birds must contain 2-4 mg/kg DM of riboflavin.

Pantothanic acid

Pantothanic acid is required for synthesis of steroid, heme and fatty acid. Cereal grains are poor source. Leafy vegetables are good source. Deficiency may occur in those animals whose diets contain high proportion of cereal grains.

Niacin

As nicotinamide adenine dinucleotide (NAD) it is required in oxidation-reduction reactions. Green fodders are good source. Both nicotinic acid and nicotinamide have equal vitamin potency.

Folacin

Folacin is the generic name of folic acid and related compound with similar biological activity. Folacin deficiency is unlikely because of its wide distribution, although the need for this compound may increase in the late stage of pregnancy. Requirement has been estimated to be 100 to 300 μg /kg diet.

Pyridoxine

This vitamin is present in 3 different forms i.e. pyridoxine, pyridoxal phosphate and pyridoxol. Out of these 3, pyridoxine phosphate is the most potent form. Most feedstuff contain good amount of this vitamin. Requirement may varies from 1-2 mg/kg DM.

Biotin

This enzyme is involved in regulation of the enzyme transketolase. Cereal grains are good source, but most of the biotin in cereals is bound to phytate. A positive correlation between biotin and wound healing has been established. Dietary requirement ranges from 100-300 μg/kg DM. Avidin present in egg white is an antagonist of biotin.

Cyanocobalamin

Synthesis of methionine, choline and folacin is dependent on cyanocobalmin. For absorption of this vitamin from the gut an intrinsic factor secreted by the gastric mucosa is required. Cobalt is an integral component of this vitamin. Microorganisms present in the gut can synthesize the vitamin. This vitamin is not found in food of plant origin. All animal products are good source of the vitamin. Requirements have been estimated to be 5 to 25 μg /kg diet.

Vitamin C

Amphibians, reptiles and birds synthesize vitamin C in kidney. Most mammals synthesize vitamin C in liver. Some Passeriformes (Bulbul, Asian pardise flycatcher, oriole, sun-bird and shrikes) are not capable of synthesizing this vitamin. Some others birds (sparrow myna, starling and Magpie robin) synthesize the vitamin in the liver, whereas, Indian house crow and common myna synthesize ascorbic acid in both liver and kidney. Most mammals synthesize ascorbic acid in liver, but a few including primates, bats, guinea pigs lack a synthetic ability. Ascorbic acid and L-dehydroascorbic acid are biologically active form of vitamin C. Deficiency signs include shortness of breath, pain in joints and muscles, gingivitis and petechial hemorrhages. Requirements are in the range of 50 to 100 mg/kg diet. Vitamin C is not as widespread as many of the other water soluble vitamins. The richest sources are green plants and fleshy fruits, such as citrus fruits, but is virtually absent in eggs, seeds, grains, most bacteria and protozoa. Animal tissues are in general poor source of the vitamin (Mc Dowell, 1989).

Comparative digestive system of wild animals

Pre-gastric fermenters are those animals who have specialized, compartmental fermentation chamber before the actual stomach. Among the pre-gastric fermenters, ruminants are the most specialized and efficient to extract energy from complex carbohydrates. Ruminant stomach is compartmentalized into rumen, reticulum, omasum and abomasum. Ruminants can be further divided into 3 categories depending upon their digestive system and feeding behaviour.

a. Concentrate feeder: Barking deer, mouse deer and giraffe are well known example of concentrate feeder. The relative size of the fore-stomach range form 8-10% of the body weight.

b. Bulk feeder: Bison, Gaur, wild buffalo and domestic cattle are well known example of bulk feeder. The relative size of the fore stomach in these species could be as high as 12-14% of the body weight.

c. Intermediate feeder: Nilgai, wilde beast and spotted deer are well known example. The relative size of the fore-stomach ranges form 10-12% of the body weight

It is to be noted that most of the species are neither exclusive grazer nor browser.

Post-gastric fermenters are those species in which fermentation takes place after the enzymatic digestion in actual stomach has already taken place. Relative capacity of large intestine is 11-12.5% in ruminant herbivores, 60-65% in non-ruminant herbivores, 35-38% in omnivores, and 14-16% in carnivores. Zebra, Wild ass, tapirs, rhinoceros, elephant, wild hare and pica have capacious, sacculated large intestine and compartmentalized caecum. We can call all these animals as caecal fermenters. In elephants, the large intestine has got sacculated caecum and colon. The sacculation is achieved by longitudinal band of muscles.Wild pigs have moderately large caecum, but a very large sacculated colon (colon fermenters).

Seasonality of diet composition

Natural diets of wild animals are greatly influenced by seasons. Hence, this fact must be considered while formulating diet for captive aniamls. Feed consumption in carnivores is influenced by ambient temperature and photoperiod regulates intake in temperate species of hoof stock. "Flushing" is often practiced in livestock to maximize economic returns. Animals are fed at a lower plane of nutrition before the commencement of breeding season. The plane of nutrition is increased immediately before breeding. Similarly, maintence ration is fed in poultry as compared to breeding ration while they are not laying, birds are shifted to breeding ration just immediately before breeding. Howver, such dietary managements are not freequently practiced in captive species. The natural diet of giant hornbill is greatly influenced by seasons.

Hence, season specific diets must be formulated for them for successful captive propagation. Proportions of animal prey in the diet vary according to location, season and physiological state (pre-breeding v.s breeding vs. raising chicks).Similarly, concentrations of proteins, sugars, and lipids in native fruits are also sensitive to seasonal changes (Dierenfeld *et al*. 1991). While formulating rations, seasonal changes in feeding behaviour and nutritional composition of feedstuff should be duly considered. Based on these observations, three season specific diets were proposed for captive feeding of large hornbills. The maintenance diet contained moderate levels of protein and fat. The levels of protein and fat were elevated during courtship and breeding periods. During nesting period, a diet containing higher protein and calcium would be fed to support chick growth and female molt (Dierenfeld *et al*. 1991).

In mule deer, pH and acetic acid levels were higher during the winter and early spring period than the summer. On the other hand, concentrations of butyric and higher (valeric + isovaleric) acid were more druing the summer as compared to winter season. During the autumn, pH, rumino-reticular dry matter, and concentration of acetic acid increased and that of butyric and higher acids decreased. Concentration of propionic acid remained similar throughout the year (Short *et al*., 1966). Voluntary food intake (VFI) was 59 and 89 g dry matter intake (DMI)/kg bodyweight $^{0.75}$ /per d during winter and summer, respectively. The apparent digestibility of gross energy (0.60) or fibre (0.41) and the total capacity (volume) of the rumen were unaffected by season or level of intake. It is apparent that there is a seasonal change in digestive physiology in deer. Total rumen pool size, rumen ammonia production and total VFA pool size increased during summer, which are all independent of the increase in VFI (Short *et al*., 1966).

Art of Feeding

Zoo animal diets are generally formulated on the basis of

1. The documented natural food habit of the animal, which often does not contain specific ingredient.
2. Records from other captive management facilities, which are often incomplete or developed by trial and error methods.
3. Domestic animal models

If appropriately selected, the model domestic animal can provide valuable information regarding the digestive physiology, nutrition and feeding behaviour of related wild species. Howver, differernces do exist even among the closely related species with regards to anatomy, physiology and requirements for nutrients.For example, both giraffe and cattle are ruminants, however, their nutritional profile may vary considerably as giraffe is a selective browser and cattle are bulk grazer. Availability of diet item similar to those consumed in free free range is another problem. Although diet items may have been identified, they may not be available or may not be cost effective. Giraffe mostly feed on Acacia buds and twigs, and have never been observed to feed on grasses in the wild (Pellow, 1984). Yet, in captivity they are usually fed alfalfa or other types of hay and concentrates because it is not easy to procure the feed items those they consume in their natural habitat.

Food, not only provides nutrients but also cater to the psychological needs of the animals and influences the social hierarchical behaviour to a great extent. In recent times, these needs are understood and emphasized while developing management plans for captive animals. Food enrichment would meet some of the psychological needs of the captive animal and could be achieved by modifying or adding ingredients to a captive diet in a manner that will stimulate behaviours resembling those of healthy wild animals. Wild animals spend considerable amount of their time in finding and processing food (Brigham, 1997; Poole, 1997). This aspect needs to be taken into consideration while making a diet schedule. Semi-solid food materials like jam, jelly, groundnut paste, butter and yoghurt can be smeared on feeding devices instead of offering them as a scoop or cube. Basic idea is to encourage the animal to lick them naturally. Another aspect is to keep the animal occupied to get rid off the boredom imposed by captivity. Many such innovative ideas can be applied to accomplish the target of behavioural encrichment.

Food enrichment of ungulates can be even more challenging. As captive animals are fed by human they have to spend considerably less time in acquisition of food. As a result, they are deprived of the activities which are normal to a species. Consequently, animals develop stereotypic behaviour and such animals may not breed successfully. A common stereotypic behavior of giraffe is repetitive licking of non-food substances. Attempts made to curb this behaviour with chemical sprays have not been sucessful, due to giraffes apparent motivation to use it’s tongue in foraging behaviour.

The more solitary species such as large felids can be fed individually, which helps to monitor intake and avoid aggression. However, when feeding large social group of animals, such as chimpanzees or other primates individual intake often depend on its hierarchy in the group. The aim of the manger is to ensure that the most subordinate individuals in the group receives adequate amount of feed. Howevr, in such circumstances, there is a potential threat that the dominant individuals of the group are overfed. Hence, feeding stations should be evenly spread over the enclosures or food should be scattered around.Besides, taste, texture, odour, colour, size and shape should be given due importance because these factors can be more compelling than the actual nutrient content of the diet.

Mammals can be broadly classified into 3 groups according to their food habit i.e. herbivores, omnivores and carnivores. However, there is very thin lining between the species as far as their feeding habit is concerned. Some Artiodactylids may be omnivorous, whereas, some carnivores may be actually omnivorous. Even some strict herbivores may occasionally indulge in some food of animal origin.

General guidelines for feeding herbivores with special reference to cervids

Cervids are herbivores, feeding on grasses, twigs, leaves, barks and young shoots of trees and other plants. In captivity, deer will usually browse in the existing grasses, branches and twigs in large deer park. However, the existing vegetation will soon be destroyed unless supplemental browse and grain are provided (Fowler**,** 1986).

Small herbivores like musk deer are either concentrate feeder or mixed feeder which are adapted to digest readily fermentable, high energy feed which is needed to meet their relatively high energy requirements. Larger cervids which are often bulk and roughage feeders have more complex stomach to facilitate retention of feed for fermentation (Hofmann, 1973). Most cervids are either concentrate feeder (Moose, Rein deer, Muntjac) or mixed feeders (Wapiti, red deer, Caribou, fallow deer, Chinese water deer). Fallow deer is considered as intermediate between mixed feeder and grass eaters (Hofmann, 1989).

Deer exhibited longer nocturnal grazing activity (Piasentier *et al.,* 2007). Peak feeding activity is in the early dawn and late dusky periods of the day in winter and summer months. During rainy season also feeding is mostly in the cool hours of the day.

Foraging is the most dominant activity of free ranging ungulates. Wild ungulates typically devote 40-60% of each day in finding and consuming feed (Hanley, 1982). Foraging requires 0.32 kcal of energy/kg body weight/hour (Wickstorm *et al.,* 1984). It is lesser than domestic ruminants (Graham, 1964; Holmes *et al.,* 1978) because biting rate in cervids is lesser than domestic ruminants (Holmes *et al.,* 1978). The proportion of each day committed to grazing increases when forage availability declines and competition with cattle increases for grazing (Kie *et al.,* 1991).

Deer are seasonal animals with feed intake that varies with day length, reaching lowest in winter, feed intake rises rapidly in spring (Casey, 2002). Diet shifts occur in elk during winter which might be an adaptive mechanism to match browse digestibility, lower metabolic rate and digestive turnover time (Brown and Doucet, 1991). During summer, deer selected higher amount of shrubs. Shrubs and forbs have lower levels of fiber and higher level of energy as compared to grasses (Ramirez *et al.,* 1996).

Elk feed mainly warm season grasses, forbs and cold season graminoids in summer, winter and spring, respectively. They seldom browse throughout the year except during severe winter. Similarly, white tailed deer diet was composed of 94.2% browse species, 5.2% forbs, and 0.6% grasses (Ramirez *et al.,* 1996).

Chital feed mainly on short, tender grasses, herbs, shrubs and fallen leaves. A chital may stand on their hind legs to pluck the leaves and fruits from height of upto 6 feet from the ground. Most preferred grasses are *Commelina, Desmodium, Pseudoarthria, Solamem* and *Mimosa* (Arora, 2001). Deer diet consists of high proportion of grasses in spring and low proportion of grasses in winter and fall.

Intake and digestibility of nutrients

In captivity dry matter intake (DMI) of elk was reported to be 2.6-3.3% of live weight (Robbins *et al.*, 1981), whereas digestible DMI of a roe deer for maintenance was 34.5g/kgBW $^{0.75}$ when fed high quality grass and alfalfa (Hungerford, 1952; Robbins *et al.,* 1981). Similarly, CP, DCP and DE intake for Roe deer were 7.89g, 4.1g/kg $BW^{0.75}$ and 144kcal/$kgBW^{0.75}$; respectively for maintenance (Papageorgiou *et al.*, 1981). Protein intake per unit weight gain is higher in deer than that of sheep, which is due to higher body protein content in deer (Robbins, 1974).

Grass, browse consumption rate and mean bite size varies with different species of cervids (Wickstrom *et al.,* 1984). Increased feed intake per kg $BW^{0.75}$ was observed in fawns during growth like other ruminants (Holter *et al.,* 1977). Mean daily *ad libitum* intakes of hinds increased between 150 and 220 days of pregnancy. Variation in nutrition during the last trimester of pregnancy may influence fetal development (Casey, 2002). Supplementation of *Leucaena leucocephala* at 30 % level along with grasses in captive red deer increased the total dry matter intake by 30% and ME by 37%.

Tannin reduces the palatability of forages which leads to decreased forage intake (Leslie and Starkey, 1987). On the other hand, feeding low quality hay caused acute digestive impaction and ulceration. Further, feeding only low quality hay may limit intake to such an extent that maintenance requirements of cervids are not fulfilled (Short *et al.,* 1974). But feeding high energy concentrate to deer adapted to natural forages caused ruminal acidosis and death (Woolfe, 1977).

Holter *et al.* (1977) found that overall digestibility of deer feeds declined in mid summer due to increase in feed intake. Digestibility coefficient of CP and GE were 51.6% and 55.4%, respectively for roe deer in captivity (Papageorgiou *et al.*, 1981). Digestibility of DM, CP in spotted deer fed sorghum fodder were 78% and 79%, respectively (Arora, 2001).

Estimated true protein digestibility was found to be 77.5 and 92.3% during antler growth and winter, respectively (Asleson *et al.,* 1996).True nitrogen digestibility was 98.7%, 84.4, 95.7 and 96% for elk, white tailed deer (Robbins *et al.,* 1974; Holter *et al.,* 1977) and red deer (calculated by Robbins,1973), respectively.

General considerations

1. The basic diet of most ungulates and other herbivores should contain roughage and concentrate. The mash should be formulated to complement roughage. Free water should be provided at all times.
2. Roughage quality should be carefully evaluated.
3. Concentrates must be formulated by an Animal Nutritionist familiar with the peculiarities of the species. The amount of concentrate should be restricted so as to supply not more than 1/3 of dietary energy.
4. Special attention should be paid to level of protein, fibre, vitamin E, calcium, phosphorus, copper and selenium, since the target level and actual content in the feed may vary.
5. Deficiencies should not be addressed by top dressed supplementation, as they can rarely be delivered with any accuracy.
6. When top feed/ browse are used as behavioral stimulation care must be taken to limit amount and type in view of the potential for toxicity.
7. Some herbivores such as colobine monkey and red panda require specialized diet.

General guidelines for feeding of omnivores with special reference to non-human primates

Omnivorous species of primates and other mammals select food item from a broad array of plant and animal food in the wild. Howver, it may not be possible to provide such variety in captivity due to many reasons. Nevertheless, a reasonable diet schedule is possible to develop which will ensure the supply of all nutrients in requisite amount and would also provide behavioural stimulation to the species. Further, the composition of produces available in the market are widely different from fruits and vegetations available in the nature. Thus, it is difficult to replicate the natural diet. A more practical approach is to provide a diet that will provide all the nutrients in requisite amount, and will also provide sufficient amount of fibre to ensure for normal digestive function and reasonable amount of variety to provide behavioral stimulation.

Digestive adaptation

GI tract of primates is neither simple like terrestrial carnivores nor complex like highly compartmentalized herbivore stomach. Primate Stomach is simple. Their small intestine has moderate length. Colon and caecum are sacculated and moderately developed, which are fermentation chamber. Colobids are highly folivorous, having compartmentalized stomach.

Metabolic adaptation

Since they eat wide array of diet they are able to handle wide array of substrate formed in the metabolism. They are having sucrase because they are eating more fruits (which are rich in sucrose).

Primates have limited ability to conserve nitrogen.One of the striking aspect is their inability to synthesis vitamin C due to absence of gulonolactone oxidase. Deficiency occurs due to short supply of juicy (citrus) fruits during off season, and the loss of vitamin during storage and processing.The only primates those are able to synthesize vitamin C are belonging to the family lorisidae.

New world primates can not utilise vitamin D_2 as effectively as vitamin D_3. In these species, deficiency occurs due to indoor captivity without sunlight.The infants who solely fed on milk are more susceptible.

Nutrient requirements

Protein

Protein requirement as % of ME will decrease as the age advances in most of the primates. NRC recommends 12.5 and 10% CP, during pregnancy and lactation, respectively (NRC, 2003)

Minerals and vitamins

Some primates appear to be susceptible to iron-storage disease, particularly in the absence of iron-binding polyphenols. When large quantities of fruits are offered, and consumption of foliages are limited the chances of occurrence increase. It is therefore desirable to limit dietary iron concentrations to near or slightly below the recommended value.

Niacin in corn, grain sorghum, wheat, and barley is poorly available, unless they have undergone fermentation.

Most primates require vitamin C in their diet, deficiency leads to scurvy.

Some practical considerations

1. Produce should not constitute more than 30% of diet DM, because more produce will cause nutrient dilution in the diet. Cultivated fruits are having less protein (2-6%), Ca (0.03-0.3) and fiber. On the contrary, such feed contain more water, sugar and other soluble carbohydrates, which lead to excessive fermentation. So while offering cultivated fruits and vegetables to the highly folivorous foregut fementers like colobid monkeys, precaution should be taken to avoid a sudden increase in fermentation activity induced by a sudden increase in sugar concentration in the foregut
2. Some of the zoos feed insect as treat to their primates. The commonly used insects are crickets and mealworm larvae. While offering insect it is to be remembered that insects are good source of protein, fat, but poor source of

calcium. While offering insects to the non–insectivorous primates, there is no essentiality to provide Ca supplementation, but in case of insectivorous primates Ca supplementation may be done by dusting of $CaCO_3$ on crickets. Other method of Ca supplementation is to feed Ca to crickets at least 48h before feeding. Thereby, Ca will accumulate in the GI tract of the crickets and while feeding on crickets, primates will get their Ca.

3. Other treats commonly fed to primates are seeds and nuts, which are highly palatable because they are rich in fat. High consumption of these nuts and seeds lead to inadequate intake of lysine, Ca, P, Na, Mn, Zn and vitamins.

Some of the nutritional problems commonly observed in primates include Acacia fibre induced impaction in common langurs (NRC 2003), bloat in langurs and bonnet macaque, diarrhea caused by increased fat in the diet, obesity and Simian bone diseases. (Sutton, 2002).

General guidelines for feeding of carnivores with special reference to tiger

Tiger can prey on a number of species including, wild pig, all different species of deer, gaur and many other species. In its natural habitat, a tiger will consume about 70 chital, 111 hog deer or 18 sambar in a year. Tigers are intermittent feeder i.e. they can consume a very big prey (size of a buffalo) over a few meals and then they may not eat at all for days together. Schaller (1977) suggested that on an average, a tiger will consume 5.4 to 6.8 kg of meat per day. Sunquist (1981) suggested 5-6 kg for a tigress and 6-7 kg for a tiger per day. A tiger will consume all but the horns, hooves and gastro-intestinal tract content of the prey. Even though they are nocturnal and mostly take rest during the hot part of the day, they can eventually hunt during the day as well.

Digestive and metabolic adaptation

1. Digestive tract of tiger is very simple and the strategy adopted is to retain the food for a very short period of time in the GIT.
2. Absence or limited activity of enzyme glukokinase.
3. Higher excretion of nitrogen irrespective of dietary nitrogen.
4. Inability to convert β carotene to vitamin A.
5. Arachidonic acid is a dietary essential.
6. Taurine is a dietary essential.

Nutritional problems

Vitamin A deficiency and toxicity

Ca deficiency and metabolic bone disease

Hind quarter paralysis probably due to micronutrient imbalance/ deficiency

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CHAPTER-3

Species-wise Detailed Project Report on Feeding Behaviour, Feeding Practices, Nutrient Composition, Diet Supplementation and Nutritional Adequacy

3.1 Spotted Deer

Order	:	Artiodactyla
Family	:	Cervidae
Genus	:	*Axis*
Species	:	*A. axis*
Common name	:	Cheetal

Spotted deer (*Axis axis*) is the most common deer species of wooded forests, in India, Sri Lanka, Nepal, and Bangladesh (Prater 1971; Schaller 1967). They have still not faced too much threat and are far away from the risk of extinction. They are included under least concerned category in Red List of Threatened Species (IUCN Red Data Book, 2009) and protected under Schedule III of Indian Wildlife Protection Act (WPA, 1972). However, they are being hunted at a rapid pace and are even losing their habitat to humans, who are using it for agricultural and residential purposes. If this continues unabated, there is a possibility that the population of Indian spotted deer may become threatened in the future.

Its coat is reddish fawn in colour, marked with white spots, and it's under parts are white. Its antlers, which it sheds annually, are usually three-pronged and curve in a lyre shape and may extend to 75 cm. A well-built stag stands 90 cm at the shoulder and weighs about 85 kg while hinds are shorter as well as lighter (Prater, 1971). They are prolific breeders and breeding can occur throughout the year. For this reason, males do not have their antler cycles in synchrony with breeding cycle and there are some fertile females at all times of the year. Males sporting hard antlers are dominant over those in velvet or those without antlers, irrespective of their size and other factors. Sexual maturity is attained at 12-14 months of age. Gestation length is 210-225 days after which a single fawn is born (Prater, 1971). Life span is 8-14 years (Nowak, 2002).

Spotted deer are known to feed on more than 160 species of plants (Schaller 1967). They are primarily grazers (Mishra, 1982) and graze forms the bulk of their feed (Schaller, 1967). Their grazing behaviour is also influenced by season and food availability. At Sariska National Park, spotted deer is a grazer as long as green grasses are available (monsoon and post-monsoon seasons), but switches over to fallen leaves, flowers and fruits in winter (Sankar 1994). In a day, peak feeding times are observed during dawn and dusk. They usually have two major resting periods, before dawn and mid-day. Chital usually drink water once a day, and more frequently in summer.

Feeding in Captivity

However, only limited information regarding the nutrition of this species in captivity is available, which mostly pertains to nutritive value of some cultivated pasture (Arora, 2001). In most of the captive facilities, the animals are fed either empirically from the experience of the zoo keepers or nutrient requirement is calculated on the basis of requirements of goat. Consequently, there is large variation in feeding schedule of spotted deer in different zoos across India. They are fed on different type of green fodders and tree leaves (Table 1).

Dry matter intake (DMI) in spotted deer fed sorghum based diet was 50±1.2 g/kg $BW^{0.75}$ (Sahoo *et al.*, 2010). Forage only diets are characterized by low intake. When diet containing oat, berseem and concentrate was fed DMI increased to 71±5 g/kg $BW^{0.75}$. Combination of leguminous and cereal fodder was better source of roughages for spotted deer in comparison to either of the forages fed alone (Das *et al.* 2010). On an average, DMI ranged from 2.28-2.41% of BW in spotted deer fed mixed rations comprising of oat, berseem, and concentrates (Suresh, 2008). Irrespective of the diet, digestibility of DM in spotted deer was higher than other cervids and antelopes (Arora, 2001). Garg *et al.* (2002) observed DM digestibility of 78.5 and 75.5% in spotted deer fed on green sorghum and maize fodder. Sahoo *et al.* (2010) reported that DM digestibility in spotted deer fed sorghum based diet was 72±0.7%.

Table 1: Diet Chart of spotted deer in different Indian zoos

Sr. No.	Name of the zoo	Concentrate	Quantity	Produces	Quantity	Roughage	Quantity
1	Sepahijala Biological Park	Compound ration	0.5-1 kg			Green grasses	3-5 kg
2	Lucknow Zoo	Soaked gram Wheat bran	300 g 500 g			Fodder	5 kg
3	Jaipur Zoo	Cattle mash	500 g	Carrot Cucumber	500 g 500 g	Green fodder	5 kg
4	MCZP, Chhatbir	Black gram (soaked) Jaggery	250 g 100g			Green fodder	15 kg
5	VJB Udyan, Mumbai	Soaked gram Wheat grain Commercial cattle mash	500g 500 g 250 g	Carrots	250 g	Lucerne Hay	1 kg 1 kg
6	Alipore Zoo	Soaked gram Wheat bran Groundnut cake Crushed barley Crushed oat	100 g 500 g 40 g 100 g 50 g	Chopped Vegetable Banana	100 g 2-4 pcs	Paddy straw Tree fodder	150 g 2 kg
7	Ranchi Zoo	Commercial cattle mash Mahua cake Salt	500 g 100 g 100 g			Fodder	10 kg
8	SV Zooological Park, Tirupati	Commercial cattle mash	500 g			Lucerne Hay Green grass	1 kg *ad lib* *ad lib*
9	Pune Zoo	Cowpea Wheat grain Gram Salt Mineral mix	20 g 115 g 20 g 20 g 20 g	Spinach Beet Carrot Onion	100gm 400gm 150gm 30 g	Lucerne grass Hay	2.7 kg 200 gm

10	Nagpur Zoo	Cattle mash	500 g	Green grass	*ad lib*	Berseem	5 kg
11	NZP, Hyderabad	Cattle feed	500 g	Green grass	*ad lib*	Lucerne Hay	1 kg ad lib
12	Tiruvanantpurum Zoo	Cattle feed Bengal gram Green gram	1 kg 70 g 70 g	Tree fodder Cotton seed	4 kg 70 g	Star Grass Cultivated fodder	1 kg 500 g
13	Manglore zoo	Horse gram Wheat bran	250 g 300 g	Mixed vegetables Salt	200 g 20 g	Local tree leaves	3 kg
14	Assam State Zoo	Whole gram Peanut Soya flakes Broken rice Molasses	100 g 50 g 150 g 50 g 20 g	Carrot Banana Pea green	100 g 4-5pcs 200 g	Local tree leaves Common salt	10 kg 20 g
15	Nandankanan Biological Park	Deer mash	1 kg			Common grass Succulent fodder	2 kg 1 kg
16	National Zoological Park, Delhi	Commercial cattle mash	750 g			Green fodder	2 kg
17	Kanpur Zoo	Commercial cattle mash	750 g			Green fodder	5 kg
18	SCZG, Mysore	Groundnut cake Horse gram Wheat bran	150 g 300 g 450 g			Green fodder Grass hay Lucerne	2 kg 125 g 250 g

Materials and Methods

An experiment was undertaken at IVRI to assess the feed consumption and nutrient utilization of captive spotted deer (*Axis axis)* fed diet containing different levels of CP. Fifteen spotted deer (66.93 ± 2.73 kg) were randomly distributed into 3 equal groups. All the animals were fed wheat bran as a concentrate source. The CP content of the diet was varied through different levels of berseem. The CP content was 9, 13 and 17 % in groups I, II and III, respectively After a preliminary feeding of 30 days, a digestion trial of 5 day collection period was conducted to estimate intake and digestibility of nutrients along with faecal pellet characteristics.

Another experiment was conducted to determine the optimum levels of concentrates in the diet of captive spotted deer. Twelve (9 male, 3 female) adult (3-4 years of age, 64-76 kg BW) spotted deer were distributed into 3 groups of 4 each (1 female in each group). All the animals were fed a basal diet of berseem and oat in 50:50. Plane of energy nutrition was elevated by supplementation of 500 g and 1 kg of balanced concentrate mixture in groups II and III, respectively. Animals in Group I received no supplementary concentrate. A digestibility trial of 5 days collection period was conducted on days 55-59 of the trial period.

Results and Interpretations

Feed consumption, nutrient utilization and faecal pellet characteristics of spotted deer fed different levels of crude protein (CP)

Intake and digestibility of nutrients

Data pertaining to feed consumption, nutrient intake, and digestibility are presented in Table 2. Over all, dry matter intake was lower in high protein fed groups. There was small but significant ($P<0.05$) increase in digestibility of dry matter when CP content was increased to 13%, beyond which there was no further improvement. The ability of spotted deer to digest neutral detergent fibre (NDF) was inversely correlated ($P<0.01$, $R^2 = 0.69$, Fig 1) to the acid detergent lignin (ADL) content of diets. Data pertaining to CP intake and utilization are presented in Table 3. Apparent digestible N was linearly related to N content of the diet ($P<0.01$, $R^2 = 0.98$, Fig 2). Metabolic faecal nitrogen (MFN) calculated as the intercept of digestible N (Y) was 180 mg/kg $W^{0.75}$. However, MFN was also estimated as the fraction of faecal N which was soluble in neutral detergent soluble (NDS) and was assumed to be endogenous in origin. MFN thus estimated, was 3.06, 3.68 and 3.15 g N/kg DM in the 3 respective groups. Enogenous urinary nitrogen (EUN) loss was comparable among all the groups as it is a function of body weight and body weight was similar in all the 3 groups. Based upon the endogenous losses, the minimum N requirement was calculated, to be 477 mg/kg $BW^{0.75}$.

Table 2: Mean (±S.E.) feed consumption, nutrient intake and digestibility of nutrients in spotted deer fed diets containing different roughage sources

Parameter	**CP % in diet**		
	9 (I)	13 (II)	17 (III)
DM intake (%BW)	2.36± 0.14	2.21 ± 0.08	2.18± 0.08
Digestibility of nutrients (%)			
Dry matter*	65.70 ± 1.48^a	71.49 ± 1.96^b	69.12± 2.43^b
Nitrogen*	68.002 ± 1.74^a	75.628 ± 1.13^a	75.69 ± 2.13^b
Ether extract	74.54 ± 1.20	74.22 ± 2.87	79.40 ± 1.54
ADF	63.08 ± 1.47	64.36 ± 2.45	60.56 ± 1.09
Hemicellulose*	57.82 ± 0.72^a	63.23 ± 2.15^b	61.52 ± 3.37^a
Cellulose*	63.33 ± 1.95^a	67.97 ± 2.56^b	64.11 ± 2.24^a
Nutrient content of the diet			
CP (%)	9	13	17
Ca (%)	1.16	1.64	2.17
P (%)	0.44	0.45	0.45
Fe (ppm)	231	188	174
Cu (ppm)	9.8	12.2	15
Zn (ppm)	29.5	36	43

Means in the same row with different letters are significantly different (*$P < 0.05$ and ** $P < 0.01$). S.E.M, standard error of the mean; DM, dry matter; NDF, neutral detergent fibre; ADF, acid detergent fibre

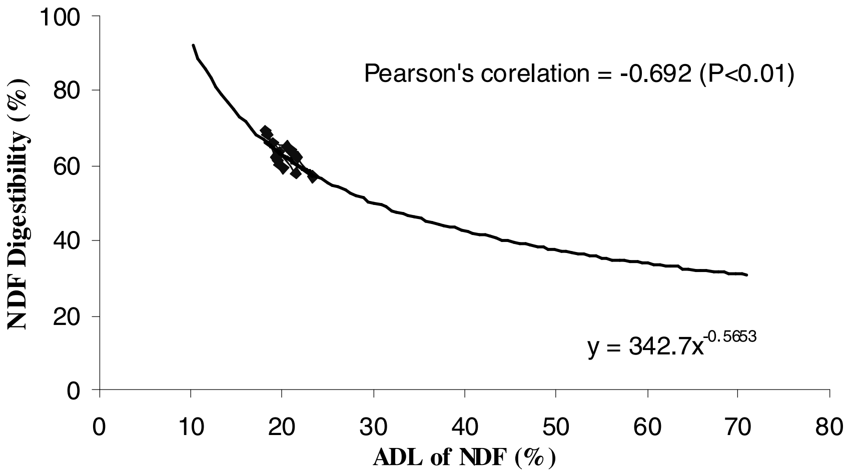

Fig 1: NDF digestibility of diets consumed by captive spotted deer (*Axis axis*) as a function of ADL content of the NDF of these diets

Intake and utilization of CP

Table 3: Nitrogen utilization in spotted deer fed diets containing different protein levels

Parameter	CP % in diet		
	9 (I)	13 (II)	17 (III)
Nitrogen intake**	23.54 ± 2.14[a]	30.17 ± 2.82[b]	38.65 ± 6.61[c]
MFN (g)	4.78 ± 0.09	4.542 ± 0.10	4.654 ± 0.22
EUN (g)	3.12 ± 0.24	3.256 ± 0.19	3.264 ± 0.20

*, **Means in the same row with different letters are significantly different (*P < 0.05 and ** P < 0.01).

It was concluded that maximum utilization of nutrients could be achieved when spotted deer are fed diet containing 13% CP. All the diets were adequate in Ca, P, Fe and Cu. The low protein diet which contained no leguminous fodder was not able to meet the requirement of zinc. Increasing the protein content to 13% through supplementation of berseem increased the intake and supply of zinc.

Effect of feeding different levels of concentrates on feed consumption and nutrient utilization in spotted deer

Total dry matter (DM) and organic matter (OM) intake was higher in concentrate supplemented groups. Digestibility of fibre was significantly (P<0.05) higher in group II in comparison to other two groups. Supplementation of forage only diet with 500 g of air-dried concentrate mixture improved intake and digestibility of nutrients with improvement in liver and kidney function, without change in body mass.

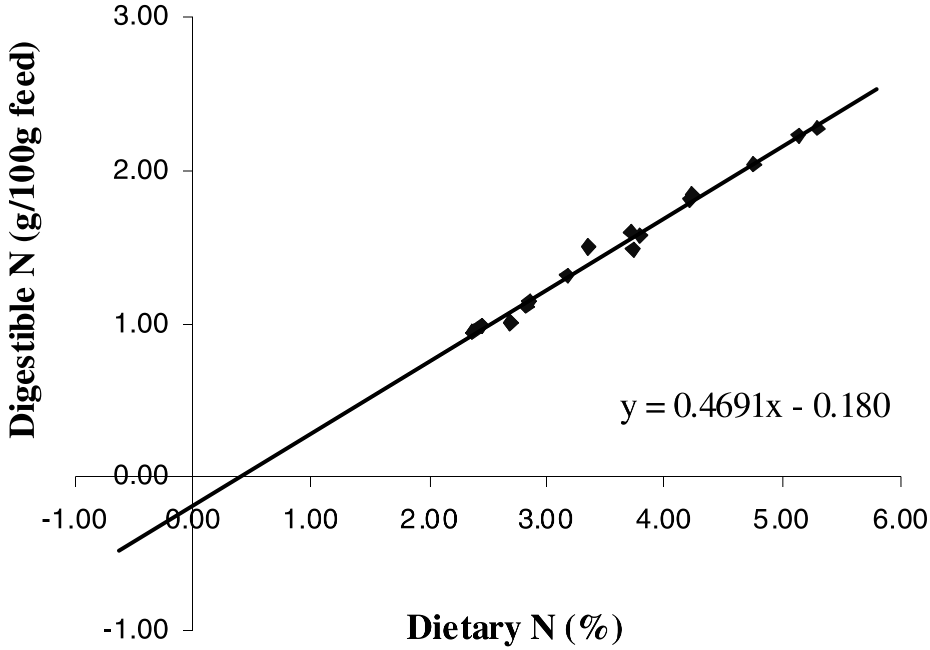

Fig 2: Apparent digestible N of captive spotted deer (*Axis axis*) as a function of dietary N.

Suggested guidelines for feeding

1. Basal diet of spotted deer should be comprised of good quality green fodder. Best combination would be a leguminous fodder and a cereal fodder fed in equal proportion.
2. Six kg of good quality green fodder (~25% DM) would be adequate for an adult spotted deer weighing 70 kg. It would be preferable if a combination of leguminous and cereal fodder in equal proportion on dry matter basis is used. Amount of concentrate should be restricted to 500 g/ animal /day. In no case concentrate (for detail see Appendix III) should constitute more than 30% of the total diet on dry matter basis.
3. Concentrate mixture should be supplemented with a balanced mineral mixture @2% (for detail please see Appendix VI).
4. Fruits and vegetables are not recommended.
5. To avoid overfeeding/underfeeding concentrate feed should be offered in different feeding stations inside the enclosure.

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3.2 Swamp Deer

Order	: Artiodactyla
Family	: Cervidae
Genus	: *Cervus*
Species	: *C. duvaucelc*
Common Name	: Barasingha

Swamp deer is endemic to Dudhwa National Park in Uttar Pradesh, Kanha National Park in Madhya Pradesh and a few other protected places in India and Nepal. The species is protected under Schedule I of Wildlife Protection Act, 1972. IUCN Red Data Book lists the species as vulnerable. An adult could measure 180 cm in length and 119-135 cm in height. A stag may weigh up to 170-180 kg; hind could weigh 130-145 kg (Kotwal, 1987). The coat colour is brownish. The males are darker than females. The under coat is whitish. The antler is characterized by 10-14 tines. One full grown antler could grow upto 1 meter. A record antler was 41 inches long (Schaller, 1967). Mating season longs from September to April and fawning take place after a gestation period of 240-250 days. Usually a single fawn is born (Schaller, 1967). In captivity, lifespan could be upto 23 years (Nowak, 2002).

Barashingha is primarily a grazer. Schaller (1967) reported that the most preferred vegetations were *Saccharum* sp, *Imperata cylindrica*, *Narenga poryphyrocoma*, *Phragmites karka*, *Oryza rufipogan*, *Hygrooryza* sp and *Hydrila* sp. They are diurnal by nature, most of the feeding takes place during early morning and late evening. Swamp deer diet consisted of 75% grasses and 12% woody plants (Wegge and Shrestha, 2006).

Feeding in Captivity

Feeding schedule of swamp deer in some of the Indian Zoos

Lucknow Zoo				
	Wheat Bran 1 kg	Soaked gram 500 g		Green fodder 5 kg
Alipore Zoological Garden, Kolkata				
	Wheat Bran 500 g	Crushed barley 125 g	Soaked gram 200 g	Ground nut cake 250 g
	Oil cake 150 g	Crushed oat 50 g	Carrot/red potato 500g	Leaves Salt L.S. L.S.
National Zoological Park, New Delhi				
	Mash 2 kg	Jowar kutti 4 kg	Soaked gram 500 g	Tree fodder 500 g
Nandankanan Biological Park, Bhubaneswar				
	Common grass 15 kg	Deer mash 1.5 kg	Paragrass 3 kg	

Materials and Methods

During the present investigation, we conducted feeding trials on 4 Swamp deer each in Nehru Zoological Park, Hyderabad and Lucknow Zoo. During the experimentation in Hyderabad, swamp deer were fed a diet comprising of 1.5 kg of compounded concentrate mixture, 1 kg of Lucerne, 1.5 kg of vegetable mixture, 1.5 kg of Ficus leaves and 5 kg of paragrass. Animals in Lucknow zoo were a fed a diet comprising of 1 kg wheat bran, 500 g of soaked gram and 5 kg of Jowar fodder. During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods.

Table 1: Chemical composition of some of the commonly fed feed ingredients to swamp deer in different Indian Zoos

Feed		Nutrient composition (%DM)						
	DM%	CP%	GE (kcal/kgDM)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Cattle feed	89.47	18.23	4430	0.74	0.94	55	9	52
Wheat bran	90.11	13.25	4080	0.58	0.85	40	11	43
Soaked gram	52.11	27.45	4370	0.42	0.29	65	14	68
Barley	91.43	11.23	4000	0.12	0.58	50	7	40
Oat	92.35	12.05	4150	0.09	0.64	58	8	38
Jowar fodder	27.48	8.21	3750	0.59	0.14	180	8	16
Ficus fodder	29.38	11.03	3680	1.18	0.17	230	6	18
Paragrass	18.43	7.74	3720	0.98	0.16	170	5	22
Lucerne	22.05	20.21	3680	1.48	0.29	175	9	38
Carrot	8.25	5.23	3900	0.43	0.17	150	5	14
Sweet potato	37.39	5.56	4020	0.24	0.45	62	14	39
Banana	28.33	4.12	4120	0.09	0.34	29	4	9
Cabbage	11.45	21.22	3850	0.78	0.29	71	10	42

DM, dry matter; CP, crude protein; GE, groses energy

Results and Interpretations

Nutrient composition of feeds and fodder is presented in Table 1. Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2.

The work conducted on swamp deer nutrition is limited. Earlier work conducted at this institute Indicated that dry matter digestibility was lowest in swamp deer in comparison to spotted and hog deer (Garg *et al.* 2002). Comparison with our own data (Das *et al.* 2010) would indicate that dry matter digestibility was only marginally higher in spotted deer. Dry matter consumption expressed as proportion of body weight was, however, much lower in swamp deer in comparison to spotted deer. Comparative evaluation of the two diets indicates that food consumption was higher in Hyderabad zoo simply because different various ingredients were offered to the deer. Dry matter consumption of swamp deer was satisfactory in both the zoos when compared with other cervids of similar body weight (Robbins, 1993).

Table 2: Feed consumption, diet digestibility, and nutritional adequacy of swamp deer diet in captivity

Parameter	Lucknow	Hyderabad
Feed consumption (g/d)		
Cattle mash	0	1356
Wheat bran	901	0
Soaked gram	261	0
Paragrass	0	622±62.5
Jowar fodder	1209±61.7	0
Ficus leaves	0	367±42.6
Lucerne	0	220
Vegetable mixture	0	307±18.9
Dry matter intake (g/d)	2371±55.7	2872±142.5
Dry matter digestibility (%)	65.7±0.45	65.3±0.33
ME intake(kcal/kg $BW^{0.75}$)	137.6±3.14	173.8±2.43
Nutrient content (%)		
CP (%)	12.6±0.12	15.1±0.50
Ca (%)	0.57±0.001	0.86±0.017
P (%)	0.43±0.008	0.56±0.018
Zn (ppm)	32.00±0.41	41.9±1.18
Fe (ppm)	1151±1.75	112.5±6.2
Cu (ppm)	9.94±1.84	7.84±0.09

ME, Metabolizable energy ; CP crude protein

Nutrient requirements of swamp deer are not known. So to test the diet adequacy, we compared the findings of the present experiments with the NRC requirements for cervids (2007). According to that, a white tailed deer hind of 140 kg would require 5.0 M Kcal of energy daily. From the perusals of the data, it seems that the diet of Lucknow Zoo diet was adequate to meet this requirement. The Lucknow Zoo diet was almost restricted feeding where 5 kg of fodder was offered along with concentrates. It would be desirable to increase the amount of green fodder. It would be further possible to cut down the amount of concentrates in the diet. As a thumb rule, no more than 25-30% of the dietary energy should come from concentrates. In Hyderabad, however, the energy supply was in excess of requirement. Even though chances of obesity in deer are much less than that observed in larger herbivores, the amount of cereals and produces may be restricted. In fact, produces are not required if green fodders are available.

Both the diets were adequate in protein content. NRC (2007) recommends 10% CP for pre-breeding, breeding, and gestating cervids. The Nehru Zoological Park diet provided 15% CP which was higher than the recommended. We suggest that amount of concentrates may be restricted. Both the diets supplied adequate amount of Ca, P, Fe, and Cu. However, diet of Lucknow Zoo was deficient in Zinc. We suggest that a suitable trace element mixture may be added to the diet of Lucknow Zoo.

Suggested Guidelines for feeding

1. A balanced concentrate mixture (see Appendix III) supplemented with 2% of mineral mixture (see Appendix VI) should be fed in restricted amount (not more than 30% of the total diet dry matter). The amount of concentrates should be 1000 and 1250 g for an animal weighing 150 and 180 kg, respectively. Sub-adult animal weighing ~100kg would require only 750 g of concentrates to fulfill requirement
2. Good quality green fodder could be offered 20% in excess of actual consumption. As a thumb rule, 10 and 12 kg of green fodder (having 25% DM content) would be sufficient for an animal weighing 150 and 180 kg, respectively.
3. Swamp deer are grazer; hence there is no need to add any leguminous fodder in their diet.
4. Fruits and vegetables are also not required.
5. Body condition and body weight may be regularly monitored; diet may be modified/ changed accordingly.

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3.3 Hog Deer

Order	:	Artiodoctyla
Family	:	Cervidae
Genus	:	*Hyelaphus*
Species	:	*H. porcinus*
Common name	:	Padha

Hog deer is a small species of deer found in grasslands of northern India. Unlike other species of deer they do not leap over the obstacles, rather they duck under it. This peculiar hog like behavior earned the name of the species. The coat colour of the species is dark brown which is paler underneath. A male may stand 70 cm and weigh 50 kg, females is much shorter at 60 cm and may weigh upto 30 kg (Prater, 1980). They have pre-orbital and pedal glands. Males bear antlers, which usually contain 3 brow-tines with solid main beam. The brow tine forms an acute angle with the main beam, which is specific to the species. Unlike barking deer, hog deer form large social group. Hog Deer reaches sexual maturity at 8 -12 months of age. Mating May takes place during any month of the year. Gestation period lasts for 240 days (Acharjyo, 1988). Females give birth to one and very rarely 2 fawns. Life span in free range varies from 12-15 years (Mayze and Mayo, 1990). In captivity they may live upto 20 years (Michelin, 2008)

Hog deer use grasslands almost exclusively and prefer grasslands to forests. They were found to be active during 41% of the day and 26-29% of the night. Grasses, ferns, flowers of *Bombax ceiba*, and fruits of *Trewia nodiflora* were important food items. *Sacchrum* sp., *Imperata cylindrica,* and *Cynodon dactylon* comprised 70% of the grass species available as food and cover (Dhungel and O' Gara, 1991). Average dry matter intake was 2.25% of the body weight and dry matter digestibility was 76.5% (Arora, 2001).

Feeding in Captivity

Feeding schedule of hog deer in different Indian Zoo

Nehru Zoological Park, Hyderabad				
	Cattle feed 500 g	Lucerne 1 kg	Green grass *ad lib*	
Zoological Garden, Alipore				
Wheat bran 500 g	Crushed barley 100 g	Crushed oat 50 g	Soaked gram 200 g	Salt Lump sum
Groundnut oil cake 40 g	Chopped vegetables/leaves Lump sum	Paddy straw 100 g	Carrot and red potato 250 g	
Thiruvananthapuram Zoo, Kerala				
Local grass 1 kg	Fodder 3.50 kg	Cattle feed 1 kg	Bengal gram 60 g	
Green gram 60 g	Cotton seed 60 g	Mineral mixture 20 g		

Nandankanan Biological Park, Bhubaneswar

Wheat bran	Soaked gram	Common gram
250 g	250 g	1 kg

Lucknow Zoological Garden

Wheat bran	Soaked gram	Green fodder
250 g	250 g	1 kg

MC Zoological Park, Chattbir

Black gram	Green fodder
250 g	*ad lib* (not less than 15kg)

Materials and Methods

During the present investigation, we conducted feeding trials on 4 hog deer in Lucknow zoo. All the animals were fed their normal zoo diet which comprised of 250 g wheat bran, 200 g soaked gram and 2 kg of jowar fodder. During the period of trial, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretations

Nutrient composition of feeds and fodder is presented in Table 1. Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2.

Table 1: Chemical composition of hog deer diet on DM basis

Feed	Nutrient composition (on DM basis)							
	DM (%)	CP(%)	GE(kcal /kg DM)	Ca (%)	P(%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Wheat bran	91.94	14.14	3890	0.21	0.78	40	42	11
Cattle feed	92.05	18.29	4050	0.46	098	70	65	13
Soaked gram	50.85	24.08	4140	0.42	0.37	60	75	14
Jowar fodder	26.14	8.91	3770	0.48	0.18	260	17	8

DM, dry matter; CP, crude protein; GE, gross energy

Dry matter intake (as % of body weight) was higher in hog deer in comparison to spotted deer. Dry matter intake in the present experiment was higher than that earlier observed by Arora (2001). Digestibility of DM was, however, marginally lower in the present experiment in comparison to that observed earlier (Arora, 2001). The diet supplied 13.77% of CP which was higher than the recommended value of 11% for cervids (NRC, 2007). The diet was also adequate in Ca and P to meet the requirement of breeding cervids. In most of the zoos green fodders are the main component of the diet. Green fodder is rich source of Ca. These fodder based diets are usually supplemented with cereals or their by products, which are good source of P.

Table 2: Feed consumption and nutrient supply in hog deer

Feed consumption (g/day)	
Wheat bran	230
Soaked gram	127
Jowar	309±67.9
Dry matter intake (%BW)	2.69±0.06
Estimated ME intake (kcal/kgBW$^{0.75}$)	140.0±4.06
Dry matter digestibility (%)	68.05±0.33
Nutrient Supply	
Crude protein (%)	13.47±0.39
Ca (%)	0.39 ±0.008
P (%)	0.38±0.01
Fe (ppm)	169.5±7.29
Cu (ppm)	9.76±0.14
Zn (ppm)	31.36±1.16

In practical feeding situation, deficiency of Ca and P is unlikely. As green fodders contain a lot of iron, its deficiency is also unlikely, however, iron content of the diet was much below than the 500 ppm, which is the maximum tolerable limit. Similarly, copper was also adequate. NRC (2007) recommends 33 ppm of Zinc in the diet. The evaluated diet contained 31.4 ppm of zinc. As the requirement of zinc is yet to be established, marginal deficiency may not warrant any immediate measure. However, a suitable mineral supplement may be used in the case of eventual deterioration of the body conditions, coat texture and hoof health.

Suggested guidelines for feeding

1. Diet comprising of 280 g of balanced concentrates (see Appendix III) and 3.75 kg of green fodder (25% DM) should meet the nutrient requirements of an adult weighing ~40 kg.
2. Many zoos feed green fodder *ad lib*. Restricting the amount of concentrates and fodder would not only be economical, but will also reduce the refusals.

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3.4 Brow-Antlered Deer

Order	:	Artiodactyla
Family	:	Cervidae
Genus	:	*Cervus*
Species	:	*C. eldii*
Common name	:	Sangai, Manipur deer

Sangai deer is an endemic species found in Keibul Lamjao National Park in Manipur. According to the census conducted in 2003, there are 180 animals in the park (Singsit, 2003). The species is protected under Schedule I of Wildlife Protection Act, 1972. IUCN Red Data Book lists the species as endangered. Sangai is a moderate sized deer. A fully grown male may weigh upto 95-110 kg and could be 115-125 cm high at shoulder. The female is moderately smaller and lighter than the male. Sangai has characteristic antlers which are 100-110 cm long (Hussain *et al*., 1990). The antler of one side is not symmetric to other. The brow tine is very long. The two tines are positioned at right angle to each other. The forward protruding beam appears to come out of the eye brow, hence the name "brow antlered deer". Females attain sexual maturity at 2-3 years of age, whereas, males attain it at 3-4 years of age (Acharjyo, 1988). Gestation length is 220 to 240 days with calving between September and end of December (Acharjyo, 1988). Usually a single fawn is born. Life span varies from 15-18 years (Hussain *et al*., 2004).

In Keibul Lamjao National park, Sangai hop on and off from one "phundi" to another and relish on luxuriant growth of reeds and grasses. Tombi Singh (1991) has reported that they consume shoots, leaves, and flowers of 34 different species. Some of the important species consumed by Sangai included *Zizania Latifolia, Saccharum munjal, S. Bengalensis*, *Eriathus prosperous* and *E. revmanae*. Sangai prefer to graze during the cooler part of the day (4-30 to 8 a.m. and 3.00 to 6.00 p.m.). During the hotter parts of the day, they usually rest in tall grass and reeds.

Feeding in Captivity

According to inventory Report of CZA (2008-09), there were 183 Sangai deer in different zoos of India. Arora (2001) compiled the diet schedule of the species in different zoos. The Arignar Anna Zoological Park, MC Zoological Park Chattibir, Manipur Zoo, Shakkarbaugh Zoo, Kanpur Zoo, National Zoological Park, Delhi, Sanjay Gandhi Biological Park, Patna and SCZG, Mysore are successfully breeding the species. The nutrient requirement of the species is not known. However, the species is closely related to Pere David deer (*Cervus elaphurus*). Hence, nutrient supply of the species would be expected to be similar to Pere Davids deer. Among The Indian species, it resembles swamp deer in size and appearance.

Table 1: Feeding schedules of Sangai deer practiced in Indian zoos

Nandankanan Biological Park, Bhubaneswar				
Common grass		Deer mash	Para grass	
15 kg		1 kg	3 kg	
Zoological Garden, Alipore				
Wheat bran	Crushed barley	Crushed oat	Soaked gram	
0.75 kg	0.200 kg	0.050 kg	0.200 kg	
Carrot & red potato	Ground nut oilcake	Chopped vegetables	Paddy straw	
0.300 kg	0.050 kg	*Ad lib*	0.100 kg	
Nehru Zoological Park, Hyderabad				
Cattle feed	Lucerne	Hay	Green grass	
1 kg	2 kg	*ad Lib*	*ad Lib*	
Assam Sate Zoo cum Botanical Garden, Guwahati				
Carrot	Banana	Black salt	Molasses	
100 g	3 numbers	20 g	20 g	
Common salt	Gram whole	Wheat bran	Green gram	Soybean flakes
5 g	200 g	300 g	100 g	150 g
Broken rice	Green pea	Amla	Lessara	Local tree leaves
50 g	200 g	50 g	200 g	10 kg
National Zoological Park, New Delhi				
Mash		Kutti	Tree fodder	
1 kg		4 kg	0.5 kg	
Sanjay Gandhi Biological Park, Patna				
Deer mash		Bengal gram	Green fodder	
600 g		600 g	2 kg	
Kanpur Zoo, Kanpur				
Concentrates		Green fodder	Gur (Jaggery)	
1.0-1.5 kg		15-20 kg	100 g (during winter)	

Materials and Methods

During the present investigation, we collected feed and fodder samples from Kanpur zoo. The animals were fed their normal zoo diets comprising of 1.5 kg of concentrate mixture and 15 kg of green fodder. These samples were analyzed for nutrient content using standard laboratory methods. We also measured feed consumption by giving measured amount feeds and measuring the refusals. We also analyzed external and internal markers for indirect determination of feed consumption and diet digestibility. The results are presented in Table 2 and Table 3.

Results and Interpretations

From the perusal of the data, it seems that the diet of Kanpur zoo provided adequate amount of crude protein, Ca, P, Fe, Cu and Zn to meet maintenance requirement (Lintzenich and Ward, 1997). It is further evident that feed consumption as proportion of body weight was similar to other species of cervids (Das *et al.*, 2010). It is also observed that refusals were quite higher when 10-15 kg of green fodder was offered. Nutritional requirements could be fulfilled with 0.5-0.75 kg of concentrates and 7-9 kg of green fodder. These animals are always fed in group.

The upper range of the diet is indicated for lactation and pregnancy, whereas, lower range of the food may be safely fed to those animals kept at maintenance

Table 2: Chemical composition of feeds and fodders fed to Sangai deer in Kanpur and Patna Zoo

		Nutrient Composition (%DM)						
Feed ingredient	**DM (%)**	**GE(kcal /kg DM)**	**CP (%)**	**Ca (%)**	**P (%)**	**Fe (ppm)**	**Cu (ppm)**	**Zn (ppm)**
Deer mash (Patna)	90.45	4250	23.45	0.76	0.81	65	12	68
Concentrates (Kanpur)	91.24	4210	20.19	0.84	0.85	63	12	65
Jowar (Patna)	20.15	3670	9.74	0.44	0.16	240	9	17
Jowar (Kanpur)	20.92	3650	9.85	0.38	0.14	270	9	16

DM, dry matter; GE, gross energy; CP, crude protein

Table 3: Feed consumption and nutrient supply in captive Sangai deer

Feed consumption on dry matter basis (g/day)	
Concentrates	1026
Jowar fodder	975±40.9
Dry matter intake (g/d)	2002±149.9
Nutrient content of diet (%DM)	
CP (%)	15.11±0.18
Ca (%)	0.61±0.009
P (%)	0.50±0.01
Fe(ppm)	164.6±3.72
Cu(ppm)	10.5±0.003
Zn (ppm)	41.0±0.88

Suggested guidelines for feeding

1. The proportion of concentrates in the diet should be restricted to 25-30% on DM basis. In no case, it should exceed 30% of total diet on DM basis. Concentrates may be used as a vehicle for supplementation of minerals and other micronutrients.
2. Considering the average flock body weight of 100 kg, average daily dry matter consumption would be 2 kg. If 75% of it's to be provided through roughages, DM from roughages should be at least 1.5 kg. Considering the moisture content of green fodder (75-80%), deer should consume 6-7.5 kg of grasses. If we further allow, 20% refusal, than the amount of fodder to be fed would be 7.5-9 kg/animal/day. So feeding of 7-9 kg of green fodder with as low as 500 g of concentrates would ensure adequate nutrition for a sangai deer wieghing ~ 100kg of body weight.
3. The concentrate mixture (see Appendix III) should be supplemented with 2 % of balanced mineral mixture (see Appendix VI).

4. Some zoos feed fruits and vegetables. This is not necessary. Rather it may reduce nutrient density. If at all the practice is to be continued for behavioral enrichment, the produces should not contribute more than 2% of diet on dry matter basis.
5. Food should be provided in many different feeding stations so as to avoid overfeeding by dominant and underfeeding by the subordinate animals.

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3.5 Barking Deer

Order	:	Artiodactyla
Family	:	Cervidae
Genus	:	*Muntiacus*
Species	:	M. muntjac
Coomon name	:	Kakkar (Hindi)

Barking deer is a small species of deer distributed in forests of the most of the oriental region of the world (Prater, 1980). It is well established at various kinds of habitats. The Indian Muntjac is the mammal with lowest chromosome number. The male has 7 diploid, whereas, the female has only 6 chromosomes. Reeves' Muntjac has got 46 diploid chromosomes. Such dramatic chromosome variation and emergence of several new species has made the genus important for evolutionary studies (Wurstor and Bencrische, 1970).

Barking deer is red in colour. The tail is short. Large pre-orbital gland is present in both the sexes. A male may weigh 22 kg, whereas female is little lighter at 20 kg (Barette, 1987). Males have short antlers which can re-grow. Males have well developed upper canine which are used as weapon during territorial fight (Chapman, 1997). A female can breed at an early age of 10 months (Chapman, 1993). They are not seasonal breeder. Mating and fawning takes place round the year. Gestation length is around 6 months (Acharjyo, 1988), after which a single fawn (rarely twins) is born. The female comes on to oestrus almost immediately after parturition. Males are also capable of breeding at all time of the year. It is unique among the deer species that other deer generally breed only when they have hard antlers; however, barking deer can mate even while on velvet (Chapman, 1997). Average life span is about 10 years (Acharjyo, 1988)

Muntiacus are found in most of the forests where they can conceal themselves from predators. Because of their smaller size, Muntiacus require large quantity of food materials in proportion to their body size (Dinerstein, 1987). To allow this, they have to depend on highly digestible feed ingredient which is rich in calorie and protein, but low in fibre content.

Feeding in Captivity

Barking deer are classified as concentrate selector. They relish young shoots, flowers, buds, and immature grass blades. Feeding usually occurs during early morning and late evening. They prefer small growing twigs and fallen leaves of S*horea robusta*, *Adina cardifolia*, the flowers and fruits of *Bahunia purpurea*, dry fallen leaves of *Bischofa javonica*, leaves and stem of S*chlecera lrijnga* and fruits, flowers and tender leaves of C*aria arborea* (Majupuria, 1990). Daily feed consumption may go upto 1.1 kg of DM equivalent to 4687 kcal of gross energy.

Feeding schedule of barking deer in different Indian zoos

Gandhi Zoological Park, Gwalior

Concentrates	Green fodder		Mixed vegetables	Common salt
830 g	2.5 kg		2.5 kg	60 g

Bhagwan Birsa Biological Park, Ranchi

Bird mash	Spinach	Green fodder/Tree leaves	Common salt	Mahua
500 g	500 g	2 kg	10 g	50 g

Zoological Garden, Alipore

Wheat bran	Gram	Crushed barley	Crushed oat	Common salt
300 g	200 g	100 g	100 g	20 g
Red potato	Carrot	Leaves/vegetable		
125 g	125 g	Lump sum		

Biological Park, Itanagar

Concentrates	Sweet potato	Banana	Soaked gram	Rock salt
500 g200 g	4 nos	200 g	20 g	

Green fodder *ad lib.*

Himalayan Nature Park | **Sepahijal Biological Park, Tripura**

Mash	Green fodder		Compounded ration	Green fodder
0.5 kg	3 kg		0.5 kg	5 kg

Nandankanan zoological Park, Bhubaneswar | **Zoological Garden, Lucknow**

Deer mash	Bengal gram	Wheat bran	Soaked gram	Green fodder
750 g	1 kg	250 g	250 g	1 kg

National Zoological Park, Delhi

Concentrates	Soaked gram		Kutti	Tree fodder
500 g	250 g		1 kg	500 g

Materials and Methods

During the present investigation, we conducted feeding trials on barking deer in Himalayan Nature Park, Kufri (n=6), Nehru Zoological Park, Hyderabad (n=3) and Lucknow zoo (n=3). In Himalayan Nature Park, Kufri, the animals were fed a diet containing 500 g of concentrates and 3 kg of oak leaves. In Hyderabad, a diet containing soaked gram, carrot, banana, sweet potato and Lucerne was fed. In Lucknow zoo, the diet comprised of wheat bran, soaked gram and jowar fodder. During the trial period, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods. Nutrient composition of feeds and fodder is presented in Table 1.

Results and Interpretation

Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2. Barking deer is a concentrate selector. It requires more energy per unit body size as compared to other ruminants. As gut capacity can not cope up with high energy and protein requirement, they selectively feed on ingredients rich in nutrients. For this reason, it is a challenge to feed these animals in captivity.

Table 1: Nutrient composition of some common feeds and fodder fed to barking deer in Indian zoos

	On DM basis							
	DM (%)	CP (%)	GE (kcal /kg DM)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Banana	28.45	4.89	4100	0.06	0.11	85	12	32
Sweet potato	27.11	5.11	3850	0.28	0.46	31.6	11	14
Soaked gram	52.11	25.11	4100	0.41	0.39	40.0	12	65
Carrot	8.27	8.45	3600	0.31	0.29	80.0	9	35
Wheat bran	93.85	13.87	4050	0.24	0.75	55.0	9	53
Compounded feed	90.11	19.25	4050	0.78	0.95	75.0	12	70
Jowar	28.78	9.14	3720	0.48	0.17	195.0	11	22
Lucerne	30.15	24.78	3740	0.91	0.28	225.0	12	32
Oak leaves	23.45	9.85	3680	0.95	0.21	215.0	10	22

DM, dry matter; GE, gross energy; CP, crude protein

Table 2: Feed consumption and nutrient supply in barking deer fed different rations

Parameter	Name of the zoo		
	Kufri	Hyderabad	Lucknow
Feed consumption on dry matter basis (g/day)			
Soaked gram	-	415±42.6	234
Wheat bran		-	129
Concentrate mixture	424±10.9	-	-
Banana	-	82.7±6.2	-
Carrot	-	70.1±2.91	-
Sweet potato	-	240±40.1	-
Lucerne	-	119±21.3	-
Jowar fodder	-	-	259±8.1
Oak leaves	431±28.8	-	-
Total	855±39.7	901±41.1	622±8.1
Dry matter intake (% BW)	4.28±0.14	4.15±0.21	3.11±0.04
Dry matter digestibility (%)	67.29±0.67	65.02±0.48	66.69±0.71
ME intake (kcal/kg $BW^{0.75}$)	206.0±6.63	239.6±2.12	153.0±4.23
Nutrient supply			
CP%	14.53±0.18	18.52±1.50	14.55±0.08
Ca%	0.87±0.003	0.41±0.003	0.37±0.0001
P (ppm)	0.58±0.015	0.37±0.009	0.42±0.003
Fe (ppm)	145.4±2.76	69.0±1.04	112.3±1.07
Cu (ppm)	10.98±0.06	11.90±0.36	10.18±0.03
Zn (ppm)	46.04±1.03	43.85±3.86	43.26±0.28

ME, metabolizable energy

The perusals of the data obtained during the present investigation indicate that their feed consumption in proportion to body size is higher than other species of deer (Arora, 2001). However, they can utilize the nutrients quite as efficiently as other species of Indian deer. The diet of barking deer at Himalayan Nature Park, Kufri, and Lucknow Zoo was marginally deficient in protein as compared to 16-20% recommended for concentrate selector. However, considering the general health, management record and breeding history of the species at these facilities, protein deficiency is unlikely. Further NRC (2007) has recommended much lower level of protein for other species of cervids. All the diets supplied adequate amount of Ca, P, Fe, Cu, and Zn to fulfill their requirements. Energy supply in Nehru Zoological Park, Hyderabad was higher than other zoos. Hence, the feeding of produces may be reassessed. A blue duiker (~4 kg) can maintain its body mass with 145 kcal/ME/kg $BW^{0.75}$. The barking deer which is much larger than duikers can maintain their body mass with ME supply of 153 kcal/kg $^{0.75}$ as evident from the body condition score observed in this study.

Suggested Guidelines for feeding

1. The natural fruits, buds, and flowers contain higher fibre than produces used in zoos. The practice of feeding produces to barking deer may be stopped.
2. The daily ration may be divided into 3-4 smaller meals.
3. A balanced concentrate mixture (see Appendix III) should be fed @ 250g/d/animal.
4. Depending upon the moisture content, green fodder should be fed @ 2-3 kg/animal/day.
5. In nature, barking deer are solitary animals. Feed should be offered at many different places to avoid fighting when they are fed in a group.

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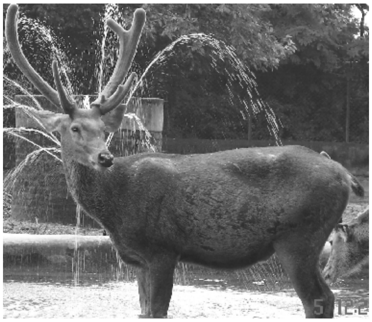
3.6 Sambar

Order	:	Artiodactyla
Family	:	Cervidae
Genus	:	Cervus
Species	:	*C. unicolor*



Sambar is one of the largest species of deer found in India. The average height could be 102-160 cm. An adult stag on an average weighs 220-330 kg. Hinds are lighter at 135-225 kg (Schaller, 1967). Their body coat is yellowish brown or dark grey in colour. Their antlers could grow up to 1m. Antlers shed during summer, velvet appear during monsoon and during rest of the time they are in hard antlers (Acharjyo, 2004). Most of the rutting activities take place during October-December. Gestation length is 8 months, after which usually one or (rarely) 2 fawns are delivered. The age at puberty is around 18 months. In captivity, lifespan is 15-18 years (Acharjyo, 2004). In free range, they will seldom survive more than 12 years. Samber can survive on wide variety of habitat ranging from desert to ever green forest. Sambars are generalist feeder (Arora, 2001). They can either graze or browse. Their natural diet consists of wide variety of grasses, forbs, fruits, aquatic plants and algae (Schaller, 1967). Their food preference is reported to be influenced by the season. During monsoon when the grasses are abundant and nutritious, they prefer grazing to browsing. In winter season, they, however, prefer browsing to grazing (Richardson, 1972).

Feeding in Captivity

Feeding schedule of sambar deer in different Indian Zoos

Zoological Garden, Lucknow

Green fodder	Wheat bran	Soaked gram
2.5 kg	1 kg	500 g

M.C. Zoological Park, Chhatbir

Green fodder	Black gram	Gur
5 kg	500 g	200 g

Jaipur Zoo, Rajasthan

Green fodder	Cattle feed	Seasonal vegetables
6 kg	1 kg	500 g

Nandankanan Bioological Park

Green fodder	Deer mash
Adult 15 kg	Adult 2.5 kg
Sub-adult10 kg	Sub-adult 1.75 kg

Biological Park, Itanagar

Concentrates	Banana	Bengal gram	Sweet potato	Rock salt
2 kg	6 nos	300 g	300 g	20 g

Thiruvananthapuram Zoo, Kerala

Common grass	Green fodder	Cattle feed	Bengal gram	Green gram	Cotton seed	Mineral mixture
1.5 kg	7 kg	1.5 kg	80 g	80 g	80 g	25 g

Dr. Shivaram Karanth Pillikula Biological Park					**Gandhi Zoological Park**			
Wheat bran	Horse gram	Mixed vegetables	Green leaves	Common salt	Deer mash	Green fodder	Green vegetable	Rock salt
500 g	300 g	200 g	4 kg	30 g	1.3 kg	14 kg	5 kg	500 g

Nehru Zoological Park, Hyderabad			
Cattle feed	Lucerne	Hay	Green grass
1 kg	3 kg	*ad lib*	*ad lib*

Assam State Zoological Park, Guwahati						
Carrot 100g	Banana 2 nos	Bengal gram 200 g	Black salt 20 g	Molasses 10 g	Soybean flakes 150 g	Wheat bran 300 g
Broken rice	Tree leaves	Common salt	Green pea	Amla		Garlic
75 g	20 kg	5 g	200 g	50 g		100 g

Materials and Methods

During the present investigation, we conducted feeding trials on 3 Sambar deer in Lucknow zoo. During the trial period, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Table 1: Nutritional composition of feeds and fodder fed to Sambar in Lucknow Zoo

	on DM basis							
Feed stuff	**DM %**	**CP (%)**	**GE**	**Ca (%)**	**P (%)**	**Fe (ppm)**	**Zn (ppm)**	**Cu (ppm)**
Jowar fodder	26.8	9.11	3750	0.64	0.24	285	19	9
Wheat bran	92.5	14.25	3940	0.24	0.98	40	45	11
Soaked gram	52.9	23.48	4140	0.46	0.34	48	84	14

DM, dry matter, GE, gross energy, kcal/kg DM: CP, crude protein

Table 2: Feed consumption, diet digestibility and nutritional adequacy of Sambar diet

DMI (kg/d)	2997.4±139.1
Dry matter digestibility (%)	70.13±0.14
ME intake (kcal/kg $BW^{0.75}$/d)	138±5.38
Nutrient content of the diet	
CP (%)	14.44±0.23
Ca (%)	0.49±0.01
P (%)	0.49±0.01
Fe (ppm)	170±5.1
Zn (ppm)	37.90±0.84
Cu (ppm)	10.44±0.05

DMI, dry matter intake; ME, metabolizable energy; CP, crude protein

Results and Interpretations

Data pertaining to nutrient composition of feeds and fodder is presented in Table 1 and those related to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2.

Average ME consumption was 138 kcal/kg $BW^{0.75}$ which was very similar to the recommendation of NRC (2007) for red deer and elk. This diet was able to supply 14.44% of dietary CP which was higher than the value of 10% recommended for breeding red deer (NRC, 2007). However, the values were very similar to those recommended for medium size intermediate grazer. The diet supplied adequate amount of Ca, P, Cu, and Zn to fulfill the respective requirement (Lintzenich and Ward, 1997). However, it is desirable and economical to reduce the amount of concentrates in the diet. This can be achieved by increasing the amount of green fodder in the diet. If a Sambar is consuming 3 kg of dry matter as observed during the present investigation, at least 2 kg of it should be provided through roughages. If the moisture content of fodder varies from 20-25%, 8-10 kg fodder will be required. If we allow 20% refusals, this would translate into 10-12.5 kg of green fodder. This is based on an average weight of 150 kg. In a herd, body weight among the animals varies considerably. Hence, regular monitoring of body condition and approximation/ actual weighing of animal is necessary. The amount of feed then may be adjusted accordingly. In any case, proportion of concentrate should not exceed 30% of the total dry matter.

Suggested guidelines for feeding

1. The amount of concentrates should not be more than 30% of the diet on dry matter basis.
2. Good quality green fodder should be fed @ 11 kg/animal/day.
3. If available, tree fodder should be included in the diet @ 2 kg/animal/day. If tree fodder is included in the diet, then 9 kg of good quality green fodder (25% DM) would be sufficient for a sambar weighing 150 kg.
4. The concentrates (see Appendix III) should be supplemented with a mineral mixture (see Appendix VI) @ 2% of concentrate on DM basis.
5. Feeding of fruits and vegetables are discouraged.

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3.7 Mouse Deer

Order	:	Artiodactyla
Family	:	Traguilidae
Genus	:	*Moschiola*
Species	:	*M. indica*
Common name	:	Indian chevrotain

Indian Mouse deer is a very timid nocturnal animal. It is one of the most primitive ruminant species. The species was developed during Miocene (50 million years ago); when it was widespread, but have changed little since then (Dubost, 2001). The species has 4 chambered fore-stomach, but the third chamber is poorly developed. Like other ruminants, mouse deer lacks upper incisors and has similar dentition formula as other deer. The mouse deer is the smallest ungulate to be found in Indian forests. An adult could grow up to 33 cm in height, 51 cm in length and may weigh up to 2.5 kg (Raman, 2004). The coat colour is brown, speckled with white markings. The body is sturdy, legs are thin and legs have 4 toes. Neither male nor female has any horn or antler. Upper canine is longer in male than in female. They do not have facial scent glands. They are solitary in nature and only interact with other during mating (Nowak, 1995). Mouse deer is commonly found in tropical deciduous, moist evergreen and semi-evergreen forests of peninsular India. They are distributed in Eastern Ghat upto Orissa, Western Ghats and Forest of Central India (Duckworth *et al*., 2008). Weaning takes place at three months of age. They reach sexual maturity at between five and ten months. Gestation length is about 5 months (MacDonald and Norris, 2001).

Krishnan (1972) reported that the Indian chevrotain relished the fruits of species such as *Terminalia bellerica*, *Gmelina arborea*, and *Garuga pinnata.* As a small-bodied ruminant, the chevrotain may be expected to have higher energy requirements per unit body mass, which may be met by the selection of an easily digestible fruit-based diet that allows rapid fermentation and swift gut passage. Mouse deer have been reported to feed on shoots, young leaves and fruits of several plants. It has not been recorded to feed on plants from the Graminae family. The preferred feed item of lesser mouse deer has been reported to be Kong Kong (*Ipomoea aquatica*), long bean (*Vigna sinensis*), French bean (*Phaseolur vulgaris*), and carrots as roughage and commercial rabbit pellet as concentrates (Abdullah *et al.*, 2001). Total dry matter intake was 45 and 36 g/kg $BW^{0.75}$ for male and female, respectively and dry matter digestibility was 72%. Nolan *et al*. (1995) have reported that groundnut leaves could be a good fodder source for mouse deer. They can maintain body mass when they are fed with DE intake of 150kcal/kg $BW^{0.75}$.

Feeding in Captivity

Feeding schedule of captive mouse deer in some Indian zoos

Sri Chamarajendra Zoological Garden, Mysore

Green grasss	GN Cake	Hay	Horse gram	Lucerne	Wheat bran	Banana
1.5 kg	100 g	150 g	200 g	100 g	500 g	100 g

Dr. Shivaram Karanth Pilikula Bilogical Park, Mangalore

Green leaves	Wheat bran	Horse gram	Mixed vegetable	Rice
100 g	50 g	50 g	100 g	50 g

Nehru Zoological Park, Hyderabad

Sweet potato	Potato	Gram	Brinjal	Lucerne	Cabbage	Green grass
100 g	100 g	50 g	2 nos	100 g	100 g	*ad lib*

Materials and Methods

We conducted digestion trial on 10 mouse deer in Nehru Zoological Park, Hyderabad. They were kept in 2 different enclosures. During the trial period, measured amount of food was offered and all the refusals and faeces were also collected for consecutive 5 days. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Nutrient composition of feeds and fodder is presented in Table 1. Data pertaining to feed consumption, diet digestibility, and nutritional adequacies are presented in Table 2.

Table 1: Chemical composition of commonly fed feedstuff of mouse deer

Food stuff	DM (%)	On dry matter basis						
		CP (%)	GE*	Ca (%)	P (%)	Cu ppm	Zn ppm	Fe ppm
Mixed grass	23.45	9.12	3680	0.38	0.17	7	17	220
Groundnut cake	90.45	40.45	4810	0.51	0.28	11.0	52	42
Horse gram	91.25	26.45	4150	0.38	0.49	12.0	48	38
Wheat bran	87.45	14.11	3990	0.34	0.78	9.8	40	51
Soaked gram	49.23	26..25	4340	0.44	0.52	11.2	52	42
Banana	28.11	5.14	5100	0.05	0.11	8.1	12	10
Lucerne	23.45	21.45	3780	0.98	0.24	8.8	21	195
Cabbage	11.23	23.82	3840	0.52	0.26	12.1	25	79
Potato	26.85	6.45	4010	0.06	0.21	11.0	18	70
Sweet potato	28.43	5.73	4170	0.16	0.16	12.0	22	72
Jack fruit shoot	29.45	17.85	3845	0.48	0.22	8.1	14	150
Apple	15.25	5.68	3815	0.06	0.12	8	22	62
Carrot	8.14	4.89	3440	0.08	0.14	9	18	72
Peepal leaves	25.43	11.15	3680	1.14	0.22	11	19	270
Cucumber	6.61	5.88	-	-	0.14	13	22	85

DM, dry matter; GE, gross energy kcal/kg dry matter; CP, crude protein

From the perusals of the data, it is evident that the dry matter intake in the present experiment was much higher than the earlier reported value (Abdullah *et al*., 2001). Such higher value could be due to the fact that in the present experiment, proportion of produces was much higher. It is desirable to reduce the amount of tubers and produces from the diet. The diets supplied adequate amount of CP, Ca, P, and Cu to fulfill the requirement recommended for concentrate selector (Lintzenich and Ward, 1997). However, both the diets were deficient in Zinc. Thus, a suitable supplement is sought.

Table 2: Feed consumption and nutrient supply in mouse deer

Parameter	Group 1	Group 2
Feed Consumption (g/d)		
Banana	34.8	29.1
Potato	16.5	10.3
Apple	17.2	14.6
Carrot	4.8	3.9
Sweet potato	15.4	11.4
Cucumber	1.4	-
Soaked gram	51.3	39.5
Lucerne	13.2	20.2
Peepal	2.0	4.7
Total	**156.6**	**133.5**
Dry matter digestibility (%)	81.6	77.9
Crude protein (%)	16.42	16.28
Ca (%)	0.37	0.48
P (%)	0.28	0.30
Cu (ppm)	10.11	12.32
Zn (ppm)	29.03	29.3

Suggested guidelines for feeding

1. Suggested diet:
   Tubers- 80 g
   Hard fruits- 100 g
   Soaked pulse- 80 g
   Carrots/ beans/ cabbage-100 g
   Lucerne/*Ipoema aquatica*/ groundnut leaves- *ad lib*
2. The ration should be divided onto 2-3 equal meals.
3. Fruits and vegetables may be cut into 2-3 cm cubes.
4. At least 500 ml of drinking water may be provided, Water consumption in mouse due is about 280 ml/day.

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3.8 Blackbuck

Order	:	Artiodactyla
Family	:	Bovidae
Genus	:	*Antilope*
Species	:	*A. cervicapra*
Common name	:	Indian blackbuck

The blackbuck (*Antelope cervicapra Linnaeus*) is an endangered species of antelope, included and protected under Schedule I of the Indian Wildlife Protection Act (WPA, 1972) and regarded as near threatened species by IUCN Red Data Book (2011). They are mainly found in open plains of India and parts of Pakistan and Nepal. They can run very fast and outrun most of the predators over long distance. They are distributed in various types of habitats ranging from semi arid grassland, scrub to open forest; however, their most preferred habitat is open grassland (Schaller, 1967). Adult males weigh 34 to 45 kg and are of striking black (or dark brown) in colour with white ring around belly and eyes, whereas, adult females weigh 31 to 39 kg and are light-brown coloured (Ranjitsinh, 1989). Unlike females, males bear distinctive long and diverging ringed horns with 1 to 4 spiral turns (Schaller, 1967). Gestation length is 5 months. Females are receptive 2 weeks after parturition and average fecundity is 1 or 1.5 per year (Schaller, 1967). Even though they can breed round the year, 2 main rutting seasons take place during March-April and August-October (Ranjitsinh, 1989).Their maximum life span recorded is 16 years with an average of 12 years (Hoffman, 2004).

Blackbucks are primarily grazers (Jhala, 1997), but do occasionally browse (Goyal *et al.*, 1988). Grass is the preferred forage and they selectively prefer shorter grass to taller grass. Blackbucks prefer open grass lands and wasteland and avoid thick covers (Ranjitsinh, 1989). The areas they inhabit are characterized by low to highly variable rainfall with marked seasonal variability. Although blackbucks feed mostly on grasses, browse (such as seed pods of species like *Prosopis sp*. and *Acacia* sp.) can form a significant portion of their diet (Goyal *et al.*, 1988; Ranjitsinh, 1989; Jhala, 1997). Blackbucks have also been reported to raid crops (Jhala, 1993).

Feeding in Captivity

Recently, considerable attention has been paid on captive management of antelopes. However, in most of the Indian zoos, they are fed empirically based on the experience of the zoo keepers. As a result, there is large variation in feeding schedules practiced in different zoos (Table 1)

Table 1: Diet chart of spotted deer in different Indian zoos

Name of the zoo	Ingredients	Qty	Ingredients	Qty.	Ingredients	Qty.
Lucknow Zoo	Wheat bran	250 g	Soaked gram	250 g	Green grasses	1 kg
Ranchi Zoo	Wheat bran Groundnut cake	150 g 150 g	Crushed oat Mung bean	150 g 150 g	Crushed maize Fodder	150 g 5 kg
Jaipur Zoo	Commercial cattle mash	500 g	Cucumber	500 g	Green fodder	5kg
MCZP, Chhatbir	Black gram soaked	250 g			Green fodder	*Ad lib.*
Tirupati Zoo	Cattle feed	250 g	Lucerne	1 kg	Tree leaves Green fodder	2 kg *ad lib.*
Nandankanan Biological Park	Deer mash	750 g	Fodder	1 kg	Common grass	1 kg
NZP, New Delhi	Deer mash	500 g	Jowar kutti	2 kg	Tree fodder	500 g

Qty, quantity

However, only limited information regarding the nutrition of this species in captivity is available, which mostly pertains to nutritive value of some cultivated fodder (Arora, 2001). Pathak *et al.* (1992) reported that DMI in blackbucks fed berseem was higher than those fed oat as sole fodder. Das *et al.* (2012) reported that within the range of 6.5-14% of CP, dry matter consumption was not influenced by CP content of the diet. Total DMI ranged from 58.7 to 60.1 g/kg $BW^{0.75}$. In another study, blackbucks were fed diet containing varying amounts of concentrates. DMI intake ranged from 2.29 to 2.39% and was not influenced by level of concentrates (Das *et al.*, 2013). Dry matter digestibility ranged from 65 to 75%. It was (Pathak *et al.*, 1992: Arora, 2001) reported that total DMI ranged from 2.2 to 3.5% of BW in blackbucks fed different type of forages. Supplementation of small amount of concentrates could increase the digestibility of dry matter (Das *et al*., 2013). In another study, it was observed that increasing CP content from 6.5 to 10.5 resulted in increased organic matter digestibility. Increasing the CP content to 14%, however, did not result in any further improvement in organic matter digestibility. Based upon the intake, digestion, and estimation of endogenous losses it was established that the minimum CP requirement for maintenance of blackbucks was 10.5% (Das *et al.* 2012). It was further established that a diet of oat fodder supplemented with 150 g of concentrates was able to supply adequate amount of energy to maintain body mass (Das *et al.*, 2013).

Materials and Methods

Two feeding trials were conducted. First trial (75 days duration) was conducted to know the optimum level of crude protein (CP) in the diet of *Antelope cervicapra* at which the feed consumption and nutrient utilization was maximum. Fifteen (12 male and 3 female) blackbucks (BW 25-34 kg) were distributed into 3 groups of 5 each (4 male, 1 female) in an experiment of 75-days duration. All the animals were offered 200 g of concentrates and fresh maize fodder *ad lib*. The concentrate mixture of Groups I, II and III contained 8.95, 22.77 and 36.83% CP, respectively. Overall, CP content of the diets were 6.5, 10.5 and 13.0% in groups I, II, and III, respectively. A digestion trial consisting of 5 day collection period was conducted. The animals were weighed before and after the trial period. Brief results of the experiment are presented in Table 2.

Another feeding trial was conducted to know the optimum level of energy density in the diet of *Antelope cervicapra* at which the feed consumption and nutrient utilization was maximum. Fifteen (12 male, 3 female) blackbucks (24 to 34 kg BW) were distributed into 3 groups of 5 each (4 male, 1 female). Fresh oat (*Avena sativa*) and berseem (*Trifolium alexandrinum*) fodder was offered *ad lib* to all the animals. The fodders were neither chopped nor made into a blend, but were offered separately. In addition, animals in group II and III received concentrate mixture in a proportion so as to make the TDN content of the diet to 60, 65 and 70% in groups I, II and III, respectively

Results and Interpretation

Feed consumption, nutrient utilization, serum metabolite profile and faecal pellet characteristics of blackbuck fed different levels of protein

Brief results of the experiment are presented in Table 2.

Table 2: Feed consumption, nutrient intake and digestibility in blackbuck fed diet varying in CP content

Parameter	**Treatments**		
	I (6% CP)	II (10% CP)	III (13% CP)
Dry matter intake (%BW)	2.53±0.14	2.60±0.04	2.51±0.08
OM intake (g/kg kg $BW^{0.75}$)	53.3±1.48	54.2±1.32	51.8±1.54
CP intake **(g/kg kg $BW^{0.75}$)	4.1±0.04^{a}	6.3b±0.06	7.4±0.02^{c}
NDF intake (g/kg $kgW^{0.75}$)	23.4±0.54	23.8±0.47	23.5±0.39
Dry matter digestibility (%)*	64.8±1.14^{a}	68.1±2.13^{b}	67.9±1.78^{c}
Gross energy digestibility (%)*	67.0±0.96^{a}	71.9±0.74^{ab}	74.3±1.28^{b}
Nutrient content (on dry matter basis)			
Ca (%)	0.45	0.55	0.59
P (%)	0.35	0.34	0.33
Fe (ppm)	227	233	234
Cu (ppm)	9.0	8.24	9.1
Zn (ppm)	23.85	24.76	28.2

^{a,b,c} values bearing different superscription in a row differ significantly (* P<0.05 and ** P<0.01); OM, organic matter; CP, crude protein; NDF, neutral detergent fibre

Intake and digestibility of CP increased (P<0.01) with increased level of CP in the diet, consumption of other nutrients were not significantly different among the groups. However, digestibility of dry matter (DM), organic matter (OM), neutral detergent fibre (NDF) and DE increased (P<0.05) only up to 10.5% level of CP beyond which there was no further improvement.

Faecal N content increased linearly (P<0.01) with increased level of CP in the diet. Other faecal morphometry parameters and chemical attributes were not significantly different among the groups (Table 3). It was concluded that a diet containing 10% CP was optimum for maximizing nutrient utilization without any adverse effect on voluntary feed consumption and nutrient utilization of blackbucks. The SUN concentration could be effectively used as an indicator of dietary CP in wild.

Table 3: Faecal pellet characteristics in blackbuck fed diet varying in CP content

Parameter	**Treatments**			**SEM**
	I (6% CP)	II (10% CP)	III (13% CP)	
Length (mm)	8.0	8.0	8.2	0.22
Diameter (mm)	5.8	5.6	6.4	0.29
Fresh wt (mg)	478.0	476.4	477.0	6.41
Dry wt (mg)	201.2	193.6	193.0	9.68
Chemical composition of faeces (% DM basis)				
OM	85.18		89.72	1.72
CP**	5.84^{a}	9.64^{b}	11.07^{c}	0.27
NDF	41.09	41.69	47.08	2.84
ADF	23.96	24.20	27.59	1.94

^{a,b,c} values bearing different superscription in a row differ significantly (* P<0.05 and ** P<0.01)

Effect of Feeding Different Levels of Energy on Nutrient Utilization in Captive black buck

As the energy density of the diet increased, consumption of fodder decreased (P<0.01). Overall dry matter intake was not significantly different among the groups. There was a significant increase (P<0.01) in consumption of ether extract and decrease (P<0.01) in consumption of NDF, ADF, hemicellulose and cellulose with increased level of energy in the diet. Digestibility of DM OM and EE increased (P<0.01) with increased level of energy in the diet.

Table 4: Faecal pellet characteristics of blackbucks fed roughage based diet supplemented with graded level of energy

Morphometry Parameter	Dietary treatments			SEM
	Group I	Group II	Group III	
Length (mm)*	11.04^{a}	9.88^{ab}	9.10^{b}	0.14
Diameter (mm)	6.04	5.50	5.82	0.09
Length/ width*	1.83^{a}	1.81^{a}	1.57^{b}	0.06
No. of pellets/defecation	70.80	70.80	68.20	0.30
Fresh pellet weight (mg)**	475.40^{a}	442.00^{a}	390.00^{b}	0.87
Dry pellet weight (mg)**	213.00^{a}	195.00^{b}	171.00^{b}	0.69

^{a,b,c} values bearing different superscription in a row differ significantly (* P<0.05 and ** P<0.01)

Table 5: Chemical composition of faeces voided by blackbucks fed roughage based diet supplemented with graded level of energy

Parameter	Dietary treatments			SEM
	Group I	Group II	Group III	
Dry matter	44.92	44.55	43.89	0.64
Organic matter*	84.83[a]	83.09[ab]	82.79[b]	0.16
Ether extract*	2.82[a]	2.80[a]	3.29[b]	0.08
Crude protein**	9.08[a]	10.63[b]	13.15[c]	0.18
NDF**	58.95[a]	60.38[a]	66.30[b]	0.28
ADF**	35.64[a]	38.54[b]	40.99[b]	0.22
Hemicellulose**	23.31[ab]	21.84[a]	25.10[b]	0.28
Cellulose**	20.95[a]	22.09[ab]	23.23[b]	0.16

[a,b,c] values bearing different superscription in a row differ significantly (* $P<0.05$ and ** $P<0.01$)

Digestibility of NDF, hemicellulose and cellulose was not affected by increasing TDN content upto 65%, however, digestibility of these nutrients decreased ($P<0.01$) when TDN content of the diet was 70%. Digestibility of ADF decreased ($P< 0.01$) even at 65% level of TDN. Number of pellets per defecation was not altered by level of concentrates in the diet. However, fresh weight and dry weight of faecal pellets were reduced ($P<0.01$) in the animals in group II having 65% TDN (Table 4). As the level of energy increased in the diet, the length of faecal pellet decreased ($P<0.05$) without any change in diameter

Dry matter content of faecal matter did not vary between treatment groups. Faecal concentration of CP increased with increasing energy level in the diet (Table 5). When EE, NDF, ADF, and cellulose were evaluated, it was found that faecal concentrations in group III were significantly higher than group 1, with variable relationships in group II

Salient findings

Supplementation of concentrates at the rate of 0.5% of body weight was adequate to supply all the nutrients in adequate amount to fulfill the requirements of breeding blackbucks. Faecal pellet count and number of defecation per day was fairly constant over the experimental groups, hence, the present data will be useful for population count of blackbucks in free range. However, faecal concentration of various metabolites showed variable response as an indicator of nutritional status of blackbuck and might be used with caution.

Suggested guidelines for feeding

1. Blackbucks are primarily grazers. Their basal diet should be comprised mainly of grasses.
2. About 2.5-3.0 kg of good quality green fodder should be fed.
3. The amount of concentrates (see Appendix III for detailed composition) should be restricted to 30% of total diet on dry matter basis. Concentrates should be used as a vehicle for supplying micronutrients. A balanced

concentrate @ 250 g/animal/ day would be adequate if good quality green fodder is fed as mentioned above.

4. Concentrate mixture may be supplemented with a balanced mineral mixture @2% (see Appendix VI).
5. Body condition of the animals should be monitored regularly, diet may be changed accordingly. Any change in diet schedule should be done in gradual manner.

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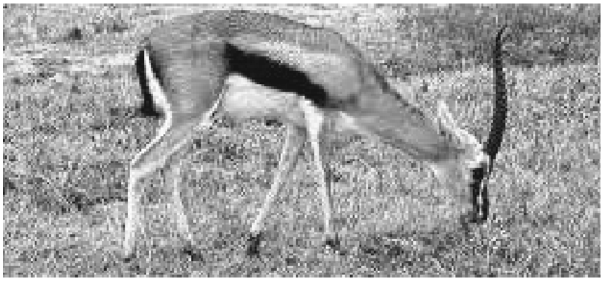
3.9 Chinkara

Order	: Artiodactyla
Family	: Bovidae
Genus	: *Gazella*
Specics	: *Gazella bennettii*
Common name	: Chinkara



The chinkara is presently distributed in the plains and low hills of western and central India. Chinkara is tawny or sandy is colour. There is a distinctive white streak on both side of the face. Both male and female bear horns. A mature male may weigh up to 23 kg, whereas, female may weigh up to 18 kg (Grooves, 1985). Chinkara can mate throughout the year (Prater, 1971). Gestation period lasts for 5-6 months. Females give birth to one or two young ones. There are two birth peaks- the major one in April and the minor one in autumn. Life span is about 12-15 years (Pai, 2009).

Chinkara prefers grasslands, desert areas, woodlands and shrub lands. Chinkara is a browser. It selectively consumes leaves, soft stems, flowers, barks and stems. They are reported to prefer browses like *Zizhypus Mauritania* and *Acacia tortolis*. They also prefer pods of *Prosopis cineraria* (Dookia, 2002). Most of the natural diets of chinkara contain 7-12% crude protein (Goyal *et al.*, 1988). Perusals of data show that food consumption in chinkara is comparatively higher than blackbuck (Das *et al*., 2012). They can also utilize fiber quite as efficiently as other ruminants (Das *et al.*, 2010).

Feeding in Captivity

Diet schedule of Chinkara in different Indian zoos

Nehru Zoological park, Hyderabad / SV Zoological Park, Tirupati				**Gandhi Prani Udyan, Gwalior**		
Cattle feed	Lucerne	Peepal leaves	Green grass	Compounded feed	Produces	Green fodder
250 g	1 kg	2 kg	*ad lib*	800 g	2.85 kg	3.58 kg
Lucknow Zoo				**National Zoological Park, Delhi**		
Wheat bran	Soaked gram	Green fodder	Mash	Tree fodder	Soaked gram	
250 g	250 g	1 kg	500 g	1 kg	200 g	
MC Zoological Park, Chattbir				**Jaipur Zoo**		
Black gram	Jaggery	Green fodder	Lucerne	Compounded feed		Carrot
250 g	100 g	*ad lib*	4 kg	500 g		500 g

Materials and Methods

During the present investigation, we conducted feeding trials in Gwalior (n=9), MCZP, Chattbir (n=3), Jaipur (n=2) and Jodhpur zoo (n=3). During the trial periods, each animal in MCZP was fed 250 g of black gram and 2 kg of Jowar fodder. In

Gwalior, each animal were fed 500 g of concentrates, 2 kg of green fodder and 2.5 kg of bottle gourd. In Jaipur, they were fed 200 g of gram husk, 300 g cattle feed and 2 kg of Lucerne fodder. In Jodhpur, 250 g of concentrates, 2.5 kg of Lucerne and 2 kg of vegetables were fed to the Chinkaras. During the trial periods, measured amount of food was offered and all the refusals and faeces were also collected for consecutive 5 days. For determination of intake and digestibility in animals housed in group, both external and internal marker was used. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Nutrient composition of feeds and fodder is presented in Table 1. Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2.

Table 1: Chemical composition of some commonly fed feeds and fodders to Chinkara

Feed stuff	Nutrient composition on dry matter basis							
	DM (%)	CP (%)	GE*	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Gram husk	91.22	13.43	4010	0.32	0.52	40	13	4
Cattle feed	90.45	18.82	4240	0.75	0.68	88	65	14
Lucerne	22.84	20.15	3850	1.32	0.17	211	18	7
Cucumber	7.48	11.22	3570	0.58	0.23	70	32	11
Bottle gaurd	8.14	13.22	3370	0.65	0.37	110	39	12
Black gram	90.45	27.45	4140	0.31	0.62	70	68	14
Jowar fodder	24.82	9.45	3780	0.88	0.22	225	14	8

DM, dry matter; CP, crude protein; GE, gross energy kcal/kg DM

Table 2: Feed consumption, diet digestibility and nutrient supply to captive Chinkaras in some of the Indian zoos

	Chattbir	Jaipur	Gwalior	Jodhpur
DMI (g/d)	747±20.1	808±75.3	753±73.6	686±29.9
MEI	159±2.86	185±071	147±17.6	155.3±2.45
	Nutrient density of the diet			
CP (% DM)	15.5±0.23	18.37±0.16	17.87±0.19	19.25±0.03
Ca (% DM)	0.72±0.006	0.93±0.005	1.11±0.049	1.02±0.01
P (% DM)	0.34±0.006	0.42±0.005	0.34±0.038	0.45±0.01
Fe (ppm)	180.46±1.64	134.1±0.65	137.7±4.02	170.35±2.59
Cu (ppm)	9.73±0.07	8.52±0.049	11.37±0.23	9.72±0.14
Zn (ppm)	29.52±0.57	31.50±0.93	32.1±2.49	31.52±0.74

DMI, dry matter intake; MEI, metabolizable energy intake kcal/kg $BW^{0.75}$

Evaluation of the four zoo diets shows that all of them provided adequate amount of crude protein to fulfill their requirement (Lintzenich and Ward, 1997). Among the zoos, Chattbir diet provided least amount of protein. However, this is adequate as per our estimates of endogenous losses (Das *et al*., 2012). This is further supported by the fact that MCZP has got a successful breeding record. In nature, Chinkara diet contains only 7-12% crude protein. Energy requirement of Gazelles is not known; we compared the findings with that recommended by NRC (2007) for breeding goats. In this regard, all the diets supplied excess energy than required. It seemed smart in our eyes to feed produces like bottle gourd and cucumber in a sense that they supply a lot of water. Chinkara prefer to fulfill their water requirement through feed and may not like drinking. They do not like eating a lot of dry feeds. In fact in Gwalior Zoo, they did not consume even 50% of the concentrates offered to them. Irrespective of the amount offered, actual consumption of concentrate was around 250 g in all 3 Zoos. In Jaipur, the concentrate consumption was slightly higher, as gram husk was also offered to them. From the present evaluation it seems unnecessary to feed more than 250 g of concentrates. Adequate nutrition could be provided with as little as 150 g of concentrates. All the 4 diets provided adequate amount of minerals. However, Zinc was marginal in all the diets. So, the animals should be monitored for Zinc deficiency symptoms. This become even more important as zinc plays important role in reproduction and immunity.

Suggested Guidelines for feeding

1. Feeding of 200 g of concentrates (See Appendix III for detailed composition) and 2-2.5 kg of green fodder (20-25% DM) is suggested.
2. Concentrates should be used as a mean of supplementing minerals and vitamin, not as a source of energy. In no case proportion of concentrates should exceed 30% of the total diet on dry matter basis.
3. Include high moisture feeds during summer.
4. If deficiency symptoms of trace elements (especially Zinc e.g., poor coat, hair fall, parakeratosis etc.) are observed, a trace mineral mixture (see Appendix VII for composition) may be supplemented.

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3.10 Four-horned Antelope

Order	:	Artiodactyla
Family	:	Bovidae
Genus	:	Tetraceros
Species	:	*T. quadricornis*
Common name	:	Chowshingha

Four-horned antelope is the smallest antelope of India. An adult could be 55 to 64 cm tall and may weigh 17-22 kg. Generally, they have a slender body with thin legs and short tail. The most distinctive feature of the species is presence of two pairs of horns, usually one pair between the ears and another pair further forward. Their horns are distinctive of having no rings. Only males bear horns, but not all males bear horns. There is dark black band on the anterior side of each leg (Sharma and Rehmani, 2004). The mating season is May-July. Gestation length is 8 months, after which one (sometimes 2) kid is born. Sexual maturity is attained at 2 years of age (Leslie and Sharma, 2004. Life span is about 10 years (Hoffman, 2004).

They are inhabitant of dry deciduous forest (Prater, 1980, Karanth and Sunquist, 1992) and prefer forested areas to open grassland. They are endemically distributed from Gangetic plains of Uttar Pradesh in the north to Tamil Nadu in the south and from Orissa in the east to Gujarat in the west. The four horned antelope is protected by listing it in Schedule-I of the Wildlife Protection Act of India, 1972. The four-horned antelope is considered vulnerable by IUCN. Four horned antelopes are smaller in size; hence they are believed to be concentrate feeder (Karanth and Sunquist, 1992). Berwick (1974) conducted a series of experiments through which it was proven that four horned antelopes prefer shrubs to grasses. Some important food species were *Bahunia racemosa*, *Terminalia cranulata*, *Lamnea corromandelica*, *Embellica officinalis*, *Acacia leucocepholea*, *Diospiros* spp., *Zizyiphus* spp., *Soymida* spp. and *Bombax ceibao* flowers.

As four-horned antelopes are smaller in size, it would be predicted that they pass digesta quickly and could not utilize fiber as efficiently as the larger ruminants (Dement and Van Soest, 1985). Hence, they would require a diet containing higher energy concentration and they have to derive substantial amount of energy from sources other than microbial fermentation of fibre (Nowak, 1991). However, studies with smaller antelopes like Dik-Dik (5 kg BW) have established that smaller antelopes could utilize dietary fibre quite as efficiently as largeer antelopes and other ruminants (Conklin-Brittain and Dierrenfeld, 1996). Considering this, it has been included as a general diet feeder (Rehmani, 2001).

Feeding in Captivity

Feeding schedule of Four-horned antelope in some Indian zoos

Nehru Zoological Park, Hyderabad

Cattle feed	Lucerne	Peepal	Napier grass
250 g	1.0 kg	2 kg	*ad lib*

National Zoological Park, Delhi

Mash	Jowar kutti	Soaked gram	Tree fodder
500 g	2 kg	250 g	20 kg

Rajiv Gandhi Wildlife Institute and Zoo, Pune

Maize	Soaked gram	Mot bean	Onion	Carrot	Spinach
65 g	35 g	65 g	65 g	2.5 kg	250 g

MC Zoological Park, Chattbir, Punjab

Black gram	Gur/fodder
250g	100g /*ad lib*

Materials and Methods

We conducted feeding trial on 4 animals in MCZP, Chattbir and 3 animals in National Zoological Park, New Delhi. During the trial periods, animals in MCZP were fed 250 g of black gram and 2 kg of Jowar fodder. In Delhi zoo, the animals were fed 500 g of concentrates, 1 kg of jowar kutti and 1 kg of Gular leaves. During the trial period, measured amount of food was offered and all the refusals and faeces were also collected for consecutive 5 days. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Nutrient composition of feeds and fodder is presented in Table 1. Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2.

From the perusal of the data, it is evident that four horned antelope can consume more food dry matter in comparison to spotted deer and blackbuck (Das *et al*., 2010, 2012). Both the diet supplied excess amount of energy than recommended by NRC (2007) and Nutrition Advisory Group (Lintzenich and Ward, 1997).

All the diets were adequate in Ca. The MCZP diet was marginally deficient in P. Both the diets were excess in protein, which may cause problem to liver and kidney. This could be easily overcome by reducing the amount of concentrate mixture in the diet.

Table 1: Chemical composition of commonly fed feedstuff of four-horned antelope

Feed stuff	Nutrient content on dry matter (DM) basis				
	DM (%)	CP (%)	GE(kcal/) kg/DM	Ca (%)	P (%)
Maize grain	90.42	8.45	4000	0.05	0.28
Soaked gram	51.42	23.12	3950	0.29	0.52
Motbean	92.42	29.97	3890	0.34	0.39
Black gram	90.45	24.45	3940	0.32	0.41
Compounded concentrates	91.22	18.48	4040	0.45	0.68
Jowar fodder	24.82	09.45	3780	0.88	0.22
Hybrid Napier	31.85	07.87	3650	0.75	0.18
Lucerne	28.75	19.49	3780	1.58	0.19
Onion	12.45	16.48	4050	0.48	0.24
Carrot	09.27	6.45	3920	0.58	0.28
Spinach	07.45	19.48	3750	0.98	0.27
Peepal leaves	28.75	12.43	3760	1.14	0.24
Gular leaves	22.14	11.75	3790	1.27	0.19

DM, dry matter; CP, crude protein; GE, gross energy kcal/kg DM

Table 2: Feed consumption and nutrient supply in four-horned antelope

Parameter	Delhi Zoo	Chattbir Zoo
Dry matter intake (g/day)	614±8.5	701±40.5
Digestibility of nutrients (%)		
Dry matter	62.4±1.51	63.9±0.86
Gross energy	65.1±1.90	66.3±1.19
MEI (kcal/kg BW $^{0.75}$)	173.4±8.42	147.3±6.2
Nutrient content (%)		
CP % in diet	14.5±0.05	18.8±0.31
Ca % in diet	0.75±0.008	0.66±0.004
P % in diet	0.44±0.003	0.28±0.001

MEI, metabolizable energy intake

Suggested guidelines for feeding

1. A typical diet should comprise of 200 g connctrates (see Appendix III for detailed composition) and 2-2.5 kg green fodder (having 20-25% DM).
2. Wherever possible, the diet should be divided into several meals instead of one singular meal.
3. Use of produces should be restricted or even stopped.

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3.11 Gaur

Order	:	Artiodactyla
Family	:	Bovidae
Genus	:	*Bos*
Species	:	*B. gaurus*
Common name	:	Indian bison

Gaur is the largest of Bovids found in India. They can survive on different type of habitat ranging from dry deciduous, moist deciduous and tropical evergreen forests. IUCN red list of threatened species categorize the species as vulnerable. Wildlife Protection Act of India (WPA, 1972) protects the species under Schedule I. An adult male is 1.1-1.9 m tall at shoulder and female is 20 cm shorter. Body weight of male Indian gaur ranges from 600-1000 kg with an occasional bull weighing upto 1500 kg. Males are 25% bigger and heavier than females (Nowak, 1999). Male gaurs are deep brown or black in colour. Female and calves are much lighter in appearance. The lower parts of the legs are white. Both sexes have horn, which are curved forward. A typical gaur horn may grow 32.80 cm. The tail is shorter in comparison to cattle, reaching only upto the hock (Nowak, 1999). Sexual maturity is attained at an age of 2-3 years. Gestation length is 275 days. They are not seasonal breeder, but most of the breeding take place during December to June. Life span of wild Gaur is about 30 years (Srivastav and Nigam, 2010).

Wild Gaurs can both browse and graze. They prefer more nutritious portion of the plant i.e. young shoots, buds, leaves, flowers and fruits (Shukla and Khare, 1998). Their food preference is influenced by season. During monsoon, they graze on young grasses and leguminous herbs and during winter, bark of teak could provide substantial amount of their diet. Most of the foraging activity occurs during early morning and late evening (Gad and Shyama, 2009).

Feeding in Captivity

Feeding schedule of Gaur in Mysore zoo

	Shri Chamrajendra Zoological Garden, Mysore			
	Adult male	**Sub-adult male**	**Adult female**	**Sub-adult female**
Green grass	15 kg	9 kg	11 kg	8 kg
Groundnut cake	500 g	250 g	400 g	250 g
Horse gram	1 kg	500 g	1 kg	500 g
Lucerne	1.25 kg	500 g	1.5 kg	500 g
Wheat bran	3.0 kg	2.0 kg	2.0 kg	2.0 kg
Common salt	20 g	10 g	20 g	10 g
Hay	5 kg	2 kg	4 kg	3 kg

National Zoological Park, Delhi

Mash	7 kg	Jowar Kutti	10 kg	Tree fodder	3kg

Materials and Methods

We conducted 3 intake trials on 37 gaurs kept in SCZG, Mysore. They were housed in 2 separate enclosures (19+17 animals). All the animals were fed their normal diet as already mentioned in the diet chart of SCZG, Mysore. As it was not possible to isolate any animal from the group, we measured all the food offered, refusal and faeces in a particular enclosure. These procedures were repeated 3 times and the group mean are presented in the Table 2. For determination of intake and digestibility in animals housed in group, both external and internal marker was used. Samples of feed, faeces and refusals were subjected to nutrient analysis.

Results and Interpretation

Data pertaining to nutrient composition of feed and fodders fed to gaur is presented in Table 1.Data pertaining to feed consumption and nutrient supply are presented in Table 2.

Table 1: Chemical composition of feeds and fodder fed to Gaur

		Nutrient concentration (on DM basis)						
Feed	DM%	GE(kcal kgDM)	CP(%)	Ca (%)	P (%)	Fe ppm	Cu ppm	Zn ppm
GNC	90.45	4250	41.89	0.43	0.31	80	14	72
Horse gram	88.95	3910	27.45	0.48	0.33	70	12	68
Wheat bran	86.73	3790	14.15	0.39	0.85	85	10	61
Napier grass	28.15	3700	7.84	0.60	0.21	180	8	22
Lucerne	38.45	3680	19.84	1.09	0.34	180	9	31
Paddy straw	86.54	3790	3.91	0.37	0.10	90	6	14
Cattle mash	91.15	4240	18.45	0.58	0.48	110	11	40
Ficus leaves	30.87	3740	11.05	0.98	0.31	220	12	23

GNC, groundnut cake; DM, dry matter; GE, gross energy (kcal/kg DM); CP, crude protein

Table 2: feed consumption and nutrient supply in Gaur diet

Feed consumption (g/d)	7073±497
Nutrient supply	
CP (%)	11.44±0.47
Ca (%)	0.53±0.02
P (%)	0.33±0.02
Zn (ppm)	33.32±1.34
Cu (ppm)	8.40±0.30

There is no data pertaining to nutrient requirement of wild gaur. To test the diet adequacy, we compared the findings with the recommendation of Lintzenich and Ward (1997) for large sized intermediate browser. The diet of Mysore zoo provided CP adequate to meet the requirement. Diet was also adequate in Ca, P, Cu and Zinc concentration. The tested diet contained about 31% of concentrates on dry matter basis, which is also quite satisfactory. Hence, diet of captive gaur in Mysore zoo was found to be adequate.

Suggested guidelines for feeding

1. For an adult weighing 800 kg, a diet containing 500 g groundnut cake, 3 kg of wheat bran, 1kg of horse gram or any other pulses, 15 kg of green fodder, 2 kg of leguminous fodder and 50 g of common salt would be adequate.
2. The body condition score should be regularly monitored and amount of feeds to be provided may be decided accordingly.
3. Trace element mixture (see Appendix VII for composition) may be added to the concentrates for better performance.
4. We do not encourage use of any produce in wild gaur diet. Wild animals do consume fruits, but those are much more fibrous than cultivated one. As such all requirement could be fulfilled without any inclusion of produce.

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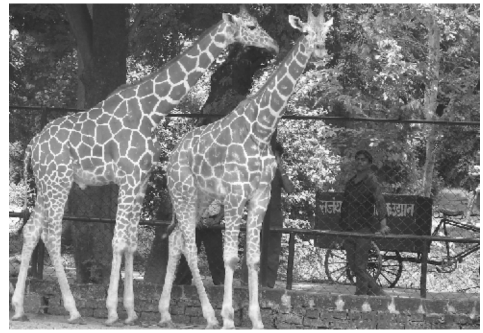
3.12 Giraffe

Order	:	Artiodactyla
Family	:	Giraffidae
Genus	:	Giraff
Species	:	*G. Camelopordalsis*
Common name	:	Giraffe



Giraffe is the tallest of terrestrial mammals, approximately, 14-18 ft tall. An adult male may weigh up to 1200 kg, whereas, females are lighter at 830 kg. Male giraffes are on an average 5.3 m tall and a very big bull may weigh upto 1930 kg (Nowak, 1999). Female giraffes are shorter and weigh less (minimum 550 kg) (Nowak, 1999). Gestation length is 400-460 days, after which a single calf is generally born. Females attain sexual maturity at an age of 4 years, whereas, males attain maturity at 4-5 years of age. However, they will not get a chance to mate till they are fully grown at 7 years of age (Estes, 1992). A giraffe can survive upto 25 years in wild (Pellow, 2001).

Giraffes are even toed ruminant ungulates. Other most closely related species is Okapi. It generally inhabits savannah, grasslands, or open woodland of Africa. Most preferred vegetation is Acacia plant. Giraffe is a highly specialized concentrate selector, they have larger parotid glands than grazer (Nowak, 1999). The relative size of parotid gland is 0.36, 0.28 and 0.18% in concentrate selector, intermediate feeder and grazer, respectively (Hoffman, 1989). More saliva will aid in passing the soluble carbohydrates through ventricular groove escaping microbial fermentation in the rumen. This will also help in buffering against tannins. The rumen papillae are also larger in giraffe than grazers (Hoffman and Metern, 1988).

As per the CZA inventory report (2008-09), there are 25 giraffe distributed into 8 different zoos of India. Giraffe selectively eat on buds and twigs as their tall body structure, hairs, prehensile lips, narrow muzzle and long tongue aid them in stripping off twigs. Their natural diet contains more than 20% digestible protein (Pellew, 1984). The same author reported that daily dry matter intake is 1.6 and 2.1% of body weight in male and female, respectively. The most important nutritional problems encountered in captive giraffe are par acute mortality, chronic wasting disease, urolithiasis, pancreatic disorders, dental problem and laminitis (Ball, 2005). Mean serum Ca and P concentrations in giraffe were reported to be 8±0.8 mg/dl and 10.5±2.9 mg/dl. Thus, captive giraffe had an inverse serum Ca: P ratio of 0.53: 1 (Schelgel *et al.*, 2004). These imbalances could be one of the causative factors of uroliths.

Feeding in Captivity

Feeding schedule of Giraffe in different Indian Zoos

National Zoological Park, New Delhi

Green fodder	Tree fodder	Soaked gram	Banana	Gur	Carrot/Cucumber
5 kg	25 kg	1.5 kg	12 piece	1 kg	1kg
Common salt	Wheat bran	Oat grain	Crushed barley	Potato	Orange
50 g	3 kg	5 kg	1.5 kg	2.5 kg	1 kg
Crushed maize	Onion	French beans	Apple	Tomato	Oil cakes
1 kg	2.5 kg	3 kg	1.5 kg	250 g	0.5 kg

Thiruvananthapuram Zoo, Kerala

Fodder	Bengal gram	Cattle feed	Green grass	Green gram	Cotton seed	Oats
30 Kg	800 g	4 kg	15 kg	800 g	800 g	1 Kg

Zoological Garden, Lucknow

Sweet lime	Banana	Apple	Carrot	Guava	Onion
1 kg	6 kg	1.25 kg	1.50 kg	500 g	250 g
Sweet potato	Beans	Crushed lentil	Crushed maize	Oats	Barley
500 g	1.25 kg	250 g.	1 kg	1 kg	1 kg
Mustard oil cake	Ground nut cake	Wheat bran	Gram	Black salt	Salt
200 g	250 g	3 kg	1.25 kg	25 g	25 g
Jaggery	Green leaves				
300 g	20 kg				

Zoological Garden, Alipore

Wheat bran	Crushed gram	Crushed barley	Carrot/red Potato	Crushed oat	Crushed maize
4 kg	1 kg	500 g	450 g	300 g	2.4 kg
Onion	Beans	Banana	Apple	Orange	Boiled lentil
200 g	700g	3 kg	3 kg	4 Nos	200 g
GNC	Mustard oil cake	Jaggery	Black salt	Green leaves	
250 g	100 g	50 g	10 g	*Ad lib*	

Assam State Zoo, Guwahati

Carrot	Grapes	Apple	Banana	Lime	Black Salt	
1 kg	500 g	2 kg	20 nos	2 kg	20 g	
Common Salt	Crushed Gram	Crushed Maize	Pomegranate	Lassara	Orange	Chiko
40 g	3 kg	2 kg	2 kg	1kg	10 nos	50 g

Shri Chamarajendra Zoological Garden, Mysore

Onion	Bengal gram	Lucerne	Oats	Wheat bran	Salt
1 kg	750 g	3 kg	1.75 kg	3.25 kg	25 g
Carrot	Cabbage	Horse gram	Cut branches	Apple	Jaggery
1 kg	750g	1.5 kg	48 kg	250 g	50 g
Mosambi	Banana	Sweet potato		Groundnut cake	
200 g	2 kg	250 g		100 g	

The AZA nutrition advisory group (Lintzenich and Ward, 1997) recommended 30-40% concentrates and 60-70% hay in diets for giraffe and okapi. Since, hays are not used in Indian Zoos they can be easily replaced by equal proportion of good quality green fodder. Kanselaar *et al*., (1999) reported that okapi diet of 8 European zoos comprised of 42% alfalfa hay, 42% energy and protein concentrates (mostly grains) and 10% sugar rich fruits and vegetables. Schmidt and Barbiers (2005) reported that zoos generally feed 50-75% of the diet as concentrates. Their recommendation included decreasing starch and sugar, protein and P content, and increasing fibre content.

Suggested guidelines for feeding

Based upon the review, we suggest following diet for an average sized (800 kg BW) adult giraffe.

Wheat bran, 3.5 kg; Bengal gram, 0.75 kg; horse gram or any other pulse, 1.5 kg; crushed maize, 0.5 kg; cut branches (assuming that only 1/3 is leaves, barks and buds, rest is inedible lignified materials), 45 kg; leguminous fodder, 15 kg; banana, 2 kg; apple, 200 g; sweet lime, 200 g; carrot, 2 kg; onion, 1 kg; cabbage, 1 kg; sweet potato, 250 g; jaggery, 50 g and common salt, 50 g.

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3.13 Wild Pig

Order	:	Artiodactyla
Family	:	Suidae
Genus	:	Sus
Species	:	*Sus scrofa*
Common name	:	Wild boar

Wild pigs are non-ruminant ungulates native to Eurasia. The sub-species found in Indian subcontinent is S*. scrofa cristatus*. A wild pig has distinct sparse coat and black bristle around the nape and neck. A full grown male may weigh upto 230 kg (Chauhan, 2004). The lower tusk in male could be as big as 32 cm. The average weight of wild pig is 50-90 kg (Chauhan and Rajpurohit, 1996). Wild pigs are very prolific breeders. They can have 3 litters each year with up to 14 piglets each time. After 3 months, the babies are weaned (can find their own food), but may still stay with the mother. At 1 year old, they are full-grown and have black fur. Gestation length is 115 days. Life span is about 15-20 years (Hoffman, 2004). The wild pig is one of the most widely distributed terrestrial mammals. They are found in all parts of the country except arid region of Gujarat, Rajasthan and cold deserts of the Himalayas (Chauhan, 2004). Wild pigs are omnivorous animals. They feed on roots, tubers, fruits and carion. Analysis of stomach content and faecal samples revealed that vegetable matter, fruits, seeds, roots and tubers constituted more than 90% of their natural diet (Spitz, 1986). They may also predate larger vertebrates such as fawn and goats (Hoogerwarf, 1970). They also raid crops and do a lot of damage to the crops (Ahmed, 1991). Feedings is generally a social activity and everyone join together. Pigs are non-ruminant. Microbial ferementation of fibrous materials take place in the hind gut. The volatile fatty acids produced in hind gut fermentation may meet 25-30% of maintenance requirement of a wild pig. A wild pig can be fed upto 5 kg of green succulent forages (10-15% DM).

Feeding in captivity

Diet schedule practiced in some of the Indian zoos

National Zoological Park, Delhi

Mash	Green vegetables	Rice	Mung	Bajra
1000 g	1000 g	200 g	100 g	100 g
Gur	Haldi	Common salt		Mustard oil
100 g	10 g	10 g		50 g

Hyderabad/Tirupati

Cattle feed	Potato/ sweet Potato	Lucerne	Green gram
500 g	500 g	1 kg	1 kg

Nandankanan Zoological Park

Black gram	Milk	Rice	Banana	Pumpkin	Sweet potato
100 g	100 g	1000 g	500 g	500 g	250 g

Kanpur zoo		Jaipur zoo		
Soaked gram	Fruits/Veg	Gram	Green fodder	Fruits
1.5 - 2.0 kg	1-2 kg	1 kg	6 kg	0.5 kg

MCZP, Chattbir

Mash	Amla	Gur	Potato	Cabbage
1.0 kg	100g	100g	100 g	2.0 kg

Materials and Methods

In this species we did not conduct any feeding trial. However samples of feeds fed to the wild pig in NZP, Delhi; MCZP, Chattbir; Nandankanan Biological Park, Bhubaneswar and Nehru Zoological Park, Hyderabad were collected. Observations were also made on the refusal pattern of feed item in those zoos. Samples of feed and refusals were analyzed using standard laboratory methods. Based upon the observations on refusal pattern and the chemical composition of feedstuff we estimated the dietary adequacies of the wild pig ration fed in different zoos.

Results and Interpretation

The results are listed in Tables 1 and 2.

Table 1: Nutritional composition of feed and fodders fed to wild pigs in different zoos

		Nutrient concentration (on DM basis)						
Feed	DM (%)	ME(kcal/ kgDM	Crude Protein (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Mash	91.64	3560	16.86	0.58	0.78	58.0	59.6	10.1
Blackgram	91.2	3352	25.71	0.33	0.46	59.1	54.6	12.1
Bajra	92.04	3685	11.42	0.09	0.49	54.3	-	-
Lucerne	25.88	2635	18.63	1.44	0.27	267.2	40.2	12.1
Napiergrass	21.52	2337	8.44	0.80	0.24	355.8	29.4	8.9
Potato	27.63	3959	6.02	0.26	0.38	126.8	34.6	11.7
Cabbage	25.88	2339	25.37	0.31	0.44	311.9	27.6	9.7
Milk	13.4	6000	23.1	0.92	0.38	-	-	-
Rice	92.5	4020	9.44	0.04	0.54	41.0	31.2	8.2
Banana	25.38	4010	4.53	0.13	0.22	22.7	23.8	4.3
Pumpkin	12.75	2451	6.64	0.23	0.22	135.3	43.1	9.6
Sweet potato	27.6	3956	6.01	0.45	0.18	128	34.5	12.2

DM, dry matter; ME, metabolizable energy

Table 2: Nutrient supply in wild pig rations in different zoos

Parameter	Name of the zoo				
	Nandankanan	NZP	NZG	MCZP	NRC+
ME content (Kcal/kg DM)*	3475	3315	3257	3557	3210
Crude protein (%)	11.15	16.30	13.81	18.7	12.0
Ca (%)	0.33	0.60	0.54	0.70	0.60
P (%)	0.43	0.56	0.46	0.63	0.50
Fe (ppm)	91.0	75.2	155	100.5	80
Zn (ppm)	42.6	49.3	48.2	43.9	50
Cu (ppm)	8.2	8.8	10.2	9.2	6

ME, metabolizable energy; NZP, National Zoological Park; NZG, Nehru Zoological Park Hyderbad; MCZP, Chattbir. * calculated. + Recommended nutrient content as per National Research Council (1998)

There is only limited information available in the literature regarding nutrition of wild pigs. We used the nutrient requirements for swine recommended by NRC (1988) to test the adequacies of the diet schedule practiced in different zoos. From the perusals of data, it is evident that all the diets supplied energy in excess of that recommended by NRC. We feel that the diet schedule practiced at Hyderabad and Tirupati Zoo was closest to the requirements. Diets practiced in other zoos supplied energy in excess of requirement which may lead to the obesity and other related problems. The diet of Nandankanan Zoo was marginally deficient in protein content. All the other diets supplied protein in excess of requirement. The diet of Nandankanan Zoo was also deficient in Ca, P, and Zn. All the diets were able to supply adequate amount of Cu to meet its requirement. The diet of Delhi Zoo was marginally deficient in Fe content, all other diets supplied adequate amount of iron to meet its requirement.

Suggested guidelines for feeding

1. Wild pigs are hindgut fermenter; structural carbohydrates are fermented in the hindgut of pig which produces volatile fatty acids. These volatile fatty acids can meet 25-30% of maintenance energy requirement of pig. Hence, wild pig diet should contain at least 25% of dry matter from green fodder/ leafy vegetables. These herbaceous materials are also good source of Ca and Fe.
2. How much to feed?

   On dry matter basis, a wild pig will consume 42 g of DM/ kg BW $^{0.75}$. As regular weighing is a problem in most of the Indian zoos average body weight was assumed as 50 kg for female and 90 kg for male. It is assumed that an adult pig of 100 kg will consume 1400 g of DM to fulfill its maintenance requirement, when the neutral detergent fibre (NDF) content of the diet is less than 55%.

A typical diet schedule for a wild boar of 100 kg would be

Mash (maize 57%, wheat bran 18%, SBM 16%, and min. mixture 2%) : 1000 g

Green fodder (Jowar/Napier) : 1250 g

Tubers (Potato/ sweet potato) : 500 g

Vegetables (Cabbage, beans, mixed) : 500 g

The nutrient supply of the suggested diet will be as follows:

DMI	ME (kcal/kg DM)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
1400g	3249	13.1	0.6	0.6	116.8	50.3	8.6

Similarly, for a 50 kg female wild pig the diet schedule suggested will be

Mash	600 g
Green fodder	700 g
Tubers	300 g
Vegetable	250 g

This diet will supply nutrient as follows

DMI	ME (kcal/kg DM)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
820 g	3250	13.7	0.57	0.57	123	53	9

DMI, dry matter intake; ME, metabolizable energy; CP, crude protein; ppm, parts per million

3. Pigs prefer coarsely ground material. The mash must not be too fine. There is no need of soaking or cooking the ingredients.
4. Pigs are very highly susceptible to gossypol poisoning Hence, cotton seed meal should never be used in the pig mash.
5. Wild pig should be provided with 2.5 kg of water per kg of dry matter intake. During summer the requirement of water may increase upto 4.5 kg/ kg dry feed intake
6. Milk is deficient in iron and copper. A dose of copper and iron (Impheron) may be given to the piglets on fourth and fourteenth day of life.

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3.14 Zebra

Order	:	Perissodactyla
Family	:	Equidae
Genus	:	*Equus*
Species	:	*E. zebra*

Zebras are well known for their distinctive black and white stripes. There are 3 species of Zebras i.e. plains, mountain and Grevy's Zebra. They inhabit in savannah, grassland and woodland of Africa. Common plains zebra is 217-246 cm long, 110-145 cm tall at shoulder and may weigh upto 175-385 kg. Females are slightly shorter and less heavier than males (African Wildlife Foundation, 2008). A mare is able to deliver the first foal at the age of 3. Males are not able to breed until they are 5-6 years of age. Weaning takes place when the foal is 1 year of age. The foal is brown in colour at birth, not black and white striped. In wild they live upto 20 years, but in captivity they may live upto 40 years (Nowak, 1991). Zebras are hindgut fermenters like horses and wild ass. Their most preferred food items are grasses. However, they may occasionally browse on trees and shrubs.

Abaturov (1996) reported that zebra prefer mature grasses over young shoots. The digestibility of dry matter varied from 40-45% and CP content of the diet was lower than 5%. Grobler *et al*. (1983) reported that cape mountain zebra are more selective and consumed only 7 out of 17 available plants in the study area. In most of the western zoos, zebras are fed with 2-3 kg of horse food and equal amount of coarse quality hay. Nutrition Advisory Group recommends (Lintzenich and Ward, 1997) that the diet should not contain more that 40% concentrates. It would be ideal if the concentrates are restricted to 25% of the total diet on dry matter basis

Feeding schedule of zebra in selected Indian zoos

Zoological Garden, Alipore

Wheat bran	Crushed maize	Crushed gram	Crushed barley	Carrot
2.25 kg	0.90 kg	0.90 kg	0.70 kg	1 kg
Salt		Green leaves		Green grass
50 g		5 kg		2 kg

Zoological Garden, Lucknow

Wheat bran	Oat	Jaggery	Black salt	Green grass
1.25 kg	1.25 kg	0.30 kg	20 g	10 kg

Nehru Zoological Park, Hyderabad

Cattle feed	Lucerne	Hay	Grasses
2 kg	3 kg	*ad lib*	*ad lib*

Sri Chamarajendra Zoological Garden, Mysore

Hay	Lucerne	Paddy straw	Crushed oat		Common salt
3 kg	1.5 kg	0.5 kg	0.5 kg		10 g
Green grass	Cabbage	Carrot	Horse gram	Bengal gram	Wheat bran
3 kg	1 kg	1 kg	1.5 kg	0.25 kg	2.00 kg

Sanjay Gandhi Biological Park, Patna

Deer mash	Bengal gram	Wheat	Bhusa	Sudan grass
2.5 kg	750 g	1 kg	10 kg	10 kg

Feeding in Captivity

Obesity is one of the major nutritional problems in captive zebras. The occurrence of obesity could be greatly reduced by feeding restricted amount of both concentrates and roughages. Excessive feeding of concentrates may cause colic and laminitis. As a thumb rule, they should not be fed more than 3 kg of concentrates. Sand colic is also common in captive zebras. We have analysed one caprolith from Sanjay Gandhi Biological Park.

Suggested guidelines for feeding

1. Feed concentrates @ 0.5-1.0% BW.
2. Coarse quality roughages may also be fed @ 1.5-2.0% of BW
3. Use of fruits and vegetables as zebra feed should be reassessed.
4. Protein requirement of zebra is rather low. Use of leguminous fodder may be stopped.
5. Browses are not the natural component of zebra's diet. Further, browses are difficult to procure. Hence, their use in zebra feeding should be relooked.
6. The diets should be supplemented with trace element mixture. Recommendation of Nutrition Advisory group indicate that requirement of Zn and Cu is higher than the actual concentration in most of the feed ingredients.

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3.15 Indian Wild Ass

Order	: Perissodactyla
Family	: Equidae
Genus	: *Equus*
Species	: *E. hemionus*
Common name	: Khur

Wild Ass is found only in Wild Ass Sanctuary in the little Rann of Kutch and surrounding landscape in Gujarat (Shah, 2004). The colour of the coat of Indian wild ass is sandy to reddish grey or fawn in colour. The belly is white and the white patch extends upto the flank. There is little dimorphism in this species. The female may stand upto 117 cm and weigh about 200 kg; adult male could be heavier at 240 kg. Indian wild ass (khur) is a seasonal breeder. Most of the mating and foaling takes place during monsoon. A female is sexually mature at 2 year 10 months; while male matures at 3 years of age. Average gestation length is 370 days (Malhotra, 1989).

Wild ass is primarily grazer. They feed on grasses, fruits and leaves, pods of Prosopis and saline vegetation. Animals graze mostly during dawn, dusk and at night (Shah 1993). In free range, equids and bovids of similar size would share similar resources. However, ruminant digestive system is much more efficient than the hindgut fermentation system of the equids. Nevertheless, equids compensate this difficulty by increasing forage consumption. They can survive on coarse forages (Duncan *et al.* 1990). Wild asses are grazers preferring grasses to browses. But they can also consume trees and bushes when the grasses are not available.

Feeding in Captivity

Diet schedule of Wild Ass in selected zoos in India

Sakkarbaugh Zoo, Junagarh

Soaked gram	Green fodder
1 kg	15 kg

Nehru Zoological Park, Hyderabad

Cattle feed	Lucerne	Hay	Kadvi
1 kg	2 kg	5 kg	5 kg

Nutritional problems in captive wild ass

Excessive concentrate feeding may lead to obesity. If excess of non-structural carbohydrate is fed to wild ass, they may not digest them all. The undigested carbohydrates then enter caecum. There is a sudden inflow of carbohydrates into caecum. This results into drop in pH due to proliferation of lactic acid bacteria. Consequently, fibrolytic bacterial population gets decreased. The harmful bacteria then produce endo- and exo-toxins, which enters into circulation. Due to increased permeability of intestinal mucosa caused by acidity, this endotoxemia reduces the circulation in peripheral organs, particularly in feet resulting in laminitis. Excessive feeding may also cause gastric ulcer and hyper lipidemia. In general, wild ass would be less susceptible to colic than horses.

Materials and Methods

We conducted digestion trial on 12 wild asses in Shakkarbaugh zoo, Junagarh. All the animals were fed their normal zoo diet as mentioned in the diet chart above. Four of them were housed individually. Therefore, feed consumption and faeces voided were measured directly to estimate the intake and digestibility. The 8 other animals were fed in a group. In them, the feed consumption and diet digestibility was measured indirectly using external and internal markers. During the trial period, measured amount of food was offered and all the refusals and faeces were also collected for consecutive 5 days. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Nutrient composition of feeds and fodder is presented in Table 1. Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2.

Table 1: Chemical composition of feeds and fodder fed to Wild Ass

Feed stuff		on DM basis						
	DM (%)	CP (%)	GE (kcal/kgDM)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Lucerne	24.81	21.56	3805	1.62	0.33	230	48	12
Soaked gram	55.18	23.87	4050	0.44	0.39	50	68	11
Mixed grass	23.72	8.15	3920	0.37	0.17	170	17	8

DM, dry matter : CP, cryde protein; GE, gross energy

Table 2: Feed consumption, diet digestibility, and nutritional adequacy of the diet

Feed consumption (g/day)	
Lucerne	565± 29
Gram	552±24
Grass	2925± 123
Total dry matter intake (g/d)	4042±92.2
Dry matter digestibility (%)	51.2±1.44
DE intake (kcal/kg $BW^{0.75}$)	155.4±1.74
Nutrient supply of the diet	
CP (%)	12.16±1.02
Ca %)	0.57±0.06
P (%)	0.23±0.01
Cu (ppm)	9.03±0.25
Zn (ppm)	28.87±2.30

DM, dry matter : CP, cryde protein; DE, diagestible energy

The diet of Sakkarbaugh Zoo provided adequate amount of DE. The NRC (1989) recommends 145 kcal DE/kg $BW^{0.75}$ for maintenance of ponies. The diet of Shakkarbaugh zoo supplied only marginally higher amount of digestible energy that that recommended by NRC (1989) for ponies. The above diet supplied more than adequate amount of crude protein. NRC (1989) recommends 8% CP for maintenance and 14% CP for growth. Further, equines have got tolerance of excessive protein. Moderate increase in CP content may not cause any adverse effect. The diet was also adequate in Ca and P content. NRC (1989) recommends 0.21-0.62% Ca and 0.15-30% of P for equid ration. Ratio of Ca: P is very important in case of equids. In the present observation it was 2.48:1. Ratio less than 1:1 may be detrimental to wild ass (when P intake is more than Ca intake). In such cases skeletal malformation may occur. On the other hand, Ca: P ratio as wide as 6: 1 is tolerated without any adverse effect. If the data are compared with NRC (1989) requirement of 50 ppm of Zinc and 10 ppm of Cu the above diet was deficient in both these elements. However, not all the research on hindgut fermenters does agree with higher requirement of zinc. As a safe guard, the diet may be supplemented with a suitable trace element mixture.

Suggested guidelines for feeding

1. The diet schedule practiced at Shakkarbaugh zoo seems adequate to supply requisite nutrients. A diet containing one kg of soaked Bengal gram, 2.5 kg of lucerne and 15 kg of green fodder (25% DM) would be adequate for an adult wild ass.
2. Suitable trace element mixture may be added in order to safeguard the marginal Cu and Zn deficiency
3. The diet should contain adequate fibre. Feeding of very low fiber diet may gives rise to problem of hair licking and formation of caprolith. Such kind of problem may not occur if the suggested feeding regime is followed
4. Feeding of very coarse, tough forage materials such as kadvi, straw etc. may be avoided to reduce the chance of impaction.
5. The grains should not be fed at a time; the entire amount may be divided into 3 equal meals.
6. Wild ass should be fed on proper manger. Do not feed on sandy ground. This may cause colic. Do not feed above shoulder level.

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3.16 Great Indian Rhinoceros

Order	:	Perissodactyla
Family	:	Rhinocerotidae
Genus	:	Rhinoceros
Species	:	*R. unicornis*
Common name	:	Greater one-horned rhinoceros, Indian rhinoceros

The Indian rhinoceros (*Rhinoceros unicornis*) is now found almost exclusively in Nepal and North-Eastern India. Two-thirds of the world's Great one-horned rhinoceroses are now confined to the tall grassland and forest of Kaziranga National Park in Assam (Sharma *et al*., 2009). The Indian rhinoceros has thick, silver-brown skin which creates huge folds all over its body. Its upper legs and shoulders are covered in wart-like bumps, and it has very little body hair. Fully grown males are larger than females, weighing from 2200-3000 kg. Male Indian rhinoceros stands 1.75-2.0 m tall. A female Indian rhinoceros may weigh about 1600 kg (MacDonald, 2001). Breeding takes place throughout the year. In wild, male and female attains sexual maturity at an age of 9 and 5 years, respectively. Period of gestation is about 16 months (Dimerstein, 2003). Life span in captivity is 47 years, whereas, in the wild it is about 30-35 years (Srivastav and Nigam, 2010).

It has simple stomach with cornified area. Small intestine is short. Caecum is huge and saccular; and colon is capacious having large loops. The rhinoceros is classed under mega-herbivore (Owen-Smith, 1988). Digestive system of rhinoceros resembles that of horse. Main energy source for rhinoceros is the microbial fermentation of plant fibres in the hindgut. Proportion and concentration of volatile fatty acids (VFA) in hindgut of rhinoceros are similar to those of horses. Mammalian enzymes are unable to digest the complex carbohydrates. Intestinal system of herbivores contains a characteristic consortium of bacteria, ciliated protozoa, anaerobic fungi and bacteriophages (Dehority and Odenyo, 2003). For the digestion of structural carbohydrates, they have to depend on the symbiotic bacteria and protozoa present in the hindgut. In rhinoceros, the caecum and the colon are the main site of fermentation. Microorganisms found in the hindgut ferment sugar, starches, cellulose, hemicelluloses and pectin into VFAs, CO_2, CH_4, and H_2. These VFAs are readily absorbed in body and are major source of energy to rhinoceros. Net VFA in rhinoceros was such that peak VFA concentration was in the caecum. Further, it was studied that net VFA flux was comparatively higher in rhinoceros than elephants. Acetate was the primary acid present in the volatile fraction. Concentration of acetate could reach as high as 75 mM/l of caecal content (Jensen, 1966). Faecal VFA concentration was similar in rhinoceros and horse. In both the species concentration and type of VFA was greatly influenced by the type of diet (Zeyner *et al.*, 1992). Concentrate supplementation of roughage based diet increased the content of total VFA and propionate in Indian rhinoceros (Clauss, 2005c).

Mean ingesta retention time (MRT) of the Indian rhinoceros were the longest among the simple stomached ungulates. General pattern found by Foose (1982) indicate that larger animals have larger gut capacity and thus longer retention time. Illius and Gordon (1992) derived allometric equations for the estimation of MRT from body mass. According to them, mean retention time for hindgut fermenters could be calculated as MRT (h) = 9.4 body mass $^{0.255}$.

In free range, the Indian rhinoceros is mainly grazer but could also browses. The rhinos prefer cool climate and swampy habitat. Occasionally they feed on aquatic vegetation. Mary *et al.* (1998) found that rhino grazed/ browsed on 47 species of plants. Rhinoceroses were found to graze on species of grasses like *Sacchrum* spp., *Cyanodon dactylon* (L) Pers., *Arundo donex*(L)., *Polytoca digitata*, *Hygroryza aristata, Vetiveria zizanioides,Imperata cylindrical,Themeda spp., Chryosopogon aciculatus, Setaria pellidefusca, Paspalidum flavidum*., sedges like *Cyperus* spp as well as herbs, shrubs and saplings of species like *Polygomum plebelium, Aageratum conyzoides, Erigeron spp., Solanum spp.,* and *Trewia nudiflora*. They also prefer aquatic plants like *Hydrilla verticillata, Vallisneria spiralis* and *Potemogeton* spp. The main item in the diet of the Indian rhinoceros, however, was *Saccharum spontaneum*. Natural diet of rhinoceros contained high crude fibre and low crude protein.

Feeding in Captivity

Dry matter intake of an Indian rhinoceros could range from 11.5-19.3 kg/day (Clauss, 2005a). In another study, Steuer *et al.* (2010) found that, for White rhinoceros, dry matter intake ranged from 56 to 90 g/kg $BW^{0.75}$/day. As the mean retention time (MRT) is higher in comparison to other hindgut fermenter mega-herbivores, rhinoceros achieve much higher digestibility co-efficient in comparison to elephant (Jensen, 1966). Organic matter digestibility could be as high as 52% (Foose, 1982), whereas, it seldom exceed 40% in elephants (Clauss, 2003). Improvement in digestibility was observed when roughage based diets were supplemented with concentrates (Clauss, 2005c). Supplementary food may be useful to balance minerals, vitamins and protein requirement. Dierenfeld (1999) recommended that the portion of concentrates should not exceed one-third of the overall calorific value. It has also been observed that it is possible to deliver sufficient amounts of energy and protein while providing much less amount of concentrates. In most of the Indian zoos, however, the animals are fed much higher amount of concentrates and produces.

Nutritional disorders

In captivity, many of the rhinoceros could be overfed considering the amount of mash, fruits and vegetables they are fed. Obesity in captive rhinos may result in foot lesions, and leiomyomas (benign uterus tumors). Benign uterus tumors (leiomyomas) occur frequently in both Indian rhinoceroses and elephants (Ruedi, 1995). Such tumors may reduce fertility as they could be mechanical obstacles to natural insemination. Investigation into the etiopathology of leiomyoma in rhinoceroses suggests that there is a correlation between the occurrence of leiomyomas and obesity. Although not fatal, chronic foot lesions have long been a veterinary problem in captive Indian rhinoceroses. Deficiency of Zn and biotin had been associated with these problems. Biotin is proposed to act as a prosthetic group in activation of keratin synthesis. Zinc is associated with immune system of body, thus, prevents further infection in cracked hoof. It also acts as co-factor of many enzymes. Obesity associated with excessive concentrate feeding exacerbates this problem (Clauss *et al.,* 2005b).

Diet schedule of Indian rhinoceros in different zoos

Thiruvananthapuram Zoo

Cattle feed	Poultry feed	Rice	Banana	Sugarcane	Local grass	Bengal gram
4 kg	3 kg	1 kg	2 kg	5 kg	15 kg	0.6 kg
Green gram		Fodder				
0.6 kg		30 kg				

Sepahijal Biological Park, Tripura

Banana	Mung bean	Bengal gram	Wheat bran	Green vegetables	Green gram	Common salt
20 nos	1 kg	2 kg	5 kg	10 kg	150 kg	100 g

Nandankanan Biological Park, Bhubaneswar

Black gram	Bengal gram	Pumpkin	Mineral mixture	Wheat bran	Common salt	Green grass	Para grass	Carrot (Oct-Mar)
1 kg	1 kg	0.5 kg	100 g	2.5 kg	100 g	30 kg	50 kg	1 kg

Zoological Garden, Lucknow

Wheat bran	Rice	Jaggery	Banana	Rock salt	Green fodder
1 kg	1 kg	1 kg	3 kg	25 g	40 kg

M.C. Zoological Park, Chhatbir

Mung bean	Black gram	Wheat bran	Seasonal fruit	Jaggery	Salt	Green fodder
1 kg	1 kg	3 kg	200 g	1kg/week	50 g	200 kg

Bhagwan Birsa Biological Park, Ranchi

Bengal Gram	Urad	Banana	Green fodder	Kutti
3 kg	2 kg	70 nos	100 g	10 kg

Assam State Zoological Garden, Guwahati

Green gram	Black salt	Dal grass	Molasses	Common salt	Bengal gram	Wheat bran	Broken rice	Soybean flakes
200 g	50 g	100kg	150 g	40 g	1 kg	1 kg	200 g	200 g
		Aonla	Lassara	Carrot	Banana			
		1 kg	1 kg	1 kg	8 nos			

Zoological Garden, Alipore

Wheat bran	Crushed oats	Crushed barley	Bengal gram	Sweet potato	Molasses	Pulses	Grass	Sugarcane top
6 kg	500 g	500 g	1.25kg	1.2kg	500 g	500 g	60 kg	15 kg

Sanjay Gandhi Biological Park, Patna

Deer mash	Bengal gram	Wheat	Wheat flour	Linseed cake	Wheat straw	Sudan/ berseem	Sugar cane	(Nov-Feb)
	5 kg	0.55 kg	0.45 kg	0.36 kg	0.18 kg	7.3 kg	45 kg	14 kg

Materials and Methods

An experiment was conducted to test the adequacies of diets fed to rhinos in Indian zoos. Feeding trials were conducted on 3 rhinoceros each in Kanpur and Guwahati zoo and on 9 rhinoceros kept in Patna zoo. The animals were fed on their normal zoo diets for more than 1 year. A digestion trial of 5 days collection period was conducted in each location. In Kanpur (A) zoo only banana was used as produce. In Guwahati (B) zoo produces comprised of banana, carrots, cabbage and peas, Patna zoo (C) did not feed any produces to their rhinos. Roughage components were a mixture of Dal grass and doob grass in Zoo B, and sorghum fodder in zoo A and C. In addition, wheat straw was also fed to the rhinos in Zoo C. Overall, proportion of concentrates in the 3 diets were 8, 13 and 33% respectively. All the animals were fed individually. During the trial period measured amount of food was offered and all the refusals and faeces were also collected for consecutive 5 days. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to chemical composition of feed ingredients commonly being fed to Indian rhinoceros in different zoos are presented in Table 1. Data pertaining to feed consumption, nutrient utilization, and diet adequacy are presented in Table 2.

Feed consumption and digestibility of dry matter, and gross energy was similar among all the groups. However, digestibility of crude protein, and fibre fractions were significantly lower ($P<0.05$) in group C which was fed a very high concentrate diet. All the diets supplied adequate amount of protein than recommended for horses (NRC.1989) However, digestible energy intake in the 3 respective zoos was 10, 3 and 25% higher than recommended for horses.

Table 1: Chemical composition of feed ingredients commonly fed to Indian Rhinoceros in captivity

Food items	Nutrient content (DM basis)							
	DM (%)	CP (%)	GE (kcal/ kg DM)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Banana	17.03	5.41	4005	0.11	0.18	32	14	6
Concentrate	90.45	23.45	4150	0.85	0.78	72	68	12
Cabbage	16.12	26.20	3880	0.31	0.37	148	33	10
Carrot	09.12	10.17	4120	0.31	0.19	182	42	15
Peas	12.58	25.23	4380	0.37	0.44	74	49	17
Dal grass	21.45	7.41	3575	0.38	0.18	312	18	9
Star grass	24.42	8.81	3770	0.43	0.26	340	46	11
Jowar	18.90	7.84	3680	0.64	0.19	250	17	11
Paddy straw	78.12	3.14	3450	0.14	0.01	218	11	2.5

DM, dry matter; CP, crude protein; GE, gross energy kcal/kg DM

From the perusals of the data, it is evident that diets A and B supplied digestible energy very close to requirements. Diet in Patna zoo supplied 25% higher energy than the recommended value. All the diets supplied adequate amount of crude protein to meet requirements. All the diets were also adequate in Ca and P content. NRC (1989) recommends 0.21-0.62% Ca and 0.15-0.30%, of P for equids. In most of the captive facilities in India, green fodder is the main component of rhinoceros diet which is rich source of Ca. These diets are supplemented with various cereal and pulses and their by-products which are good sources of P. In practical feeding situation, deficiency of Ca and P is unlikely. If these data are compared with NRC (1989) requirement of 50 ppm of Zinc and 10 ppm of Cu, diet of Kanpur and Patna zoo was deficient in Cu. All the diets were also deficient in zinc. However, not all the research on hindgut fermenters does agree with higher requirement of zinc. As a safe guard, however, we recommend that the diet may be supplement with a suitable trace element mixture.

Table 2: Feed consumption and nutrient utilization in Indian rhinoceros (*Rhinoceros unicornis*) kept on different dietary regimes

Paramater	Kanpur (A)	Guwahati (B)	Patna (C)
Feed consumption (kg/d)			
Concentrates	1.54±0.49	2.37±0.10	8.61±0.27
Produces	0.49±0	1.00±0.01	0
Green fodder	23.30±0.76	23.64±1.49	10.93±1.06
Straw	-	-	6.62±0.39
Total DMI	25.32±0.64	26.26±3.88	26.16±2.38
Digestibility of nutrients (%)			
Dry matter	53.52±1.23	50.63±2.11	50.80±2.09
Crude protein	52.23±3.39	51.04±0.46	46.84±0.78
Neutral detergent fibre*	43.30^{a}±0.89	41.29^{a}±2.87	36.36^{b}±0.93
Acid detergent fibre*	37.47^{a} ±1.21	36.57^{a} ±0.86	30.74^{b} ±1.78
Hemicellulose*	48.17^{a} ±1.02	50.07^{a} ±1.31	41.15^{b} ±2.10
Gross energy	55.05±1.28	52.91±2.48	55.28±0.62
Nutritional adequacy of diet			
CP (% diet)	9.73 ±0.06	9.96±0.48	9.38±0.68
Digestible energy intake			
(Kcal /kg $BW^{0.75}$)*	158^{a} ±9.29	148.6^{a} ±1.57	178^{b} ±3.1
Mineral content			
Ca (%)*	0.77^{a} ±0.005	0.45^{b}±0.013	0.44^{b} ±0.04
P (%)	0.28±0.007	0.32±0.001	0.33±0.04
Fe (ppm)	169.6±2.81	293.3±0.39	180.7±2.41
Cu (ppm)	8.6±0.19	10.6±0.18	6.6±0.74
Zn (ppm)*	29.8^{a} ±0.54	35.5^{b} ±1.66	27.4^{a}±2.01

* Values bearing different superscript in a row differ significantly $P<0.05$

Suggested guidelines for feeding

1. A diet containing 2 kg of concentrates (see Appendix I) and 110 kg of green fodder (25% DM) should be adequate for a female weighing 1600 kg. However, a male weighing 2200 kg may require 3 kg of concentrates and 150 kg of green fodder to fulfill its requirements. Indian rhinoceros are very prone to obesity. Body condition score should be regularly monitored. The amount of roughages may also be restricted. The concentrates should not provide more than 30% of the dietary energy. The concentrate portion should actually be used as a mean to supply minerals and vitamins. Concentrate ingredients should be supplemented with a good quality mineral mixture (see Appendix VI) @ 2% on dry matter basis.

2. Feeding of fruits and vegetable are not nutritionally important. If fed, they must not contribute more than 2% of the diet on dry matter basis.
3. Food should not be offered on ground. Sand colic has been reported in Indian rhinoceros. They should be either fed on sturdy trough or on concrete pads.
4. To reduce competition, it would be desirable to feed them individually (at least the concentrate portion). Food may be offered in different feeding stations if the animals are kept in a group.
5. Feeding of excessive leguminous fodder should not be encouraged. Use of sugarcane as a roughage source may be reassessed.
6. Indian rhinos are not exclusive grazer like white rhinos. It would be desirable to include some browses in their diet.

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3.17 Asian Elephant

Order	:	Proboscidae
Family	:	Elephantidae
Genus	:	*Elaphas*
Species	:	*E. maximus*

Asian elephant (*Elaphus maximus*) is a highly endangered species and are protected under the Schedule I of Wildlife Protection Act of India, 1972. Asian elephant (*Elephas maximus*) is one of the three living species of elephants. Other two species are African savannah/bush elephant (*Loxodonta africana*) and African forest elephant (*Loxodonta cyclotis*). There are three subspecies of Asian elephant viz. *Elephas maximus indicus* (Indian elephant), *Elephas maximus maximus* (Sri Lankan elephant) and *Elephas maximus sumatranus* (Sumatran elephant). Asian elephant is distributed in South and Southeast Asia. The Asian elephant are comparatively smaller in size than African elephants. An adult male Asian elephant (bull) can reach a height of 3.5 m at shoulder and body weight reaches upto 4000 kg (Santipillai and Jackson, 1990). A cow can grow up to 2.1 - 2.7 m height at shoulder and body weight may range from 2500 to 3500 kg (Panicker and Cheeran, 1997). Gestation length is 20 to 22 months and usually only one calf is born (Panicker and Cheeran, 1997). Female Asian elephants can usually breed by the age of 14 years and give birth to one young every four years. Lifespan in the wild is about 60 years but in captivity they may live upto 80 years (Shosani and Eisenberg,1982).

Elephants belong to the group of mega-herbivores (Owen-Smith, 1988). The most striking advantage of large body size is reduced relative energy requirement for maintenance and a relative increase in gastro-intestinal capacity. Thus, they can fulfill their nutritional needs from inferior quality roughage. Further, elephants also have an access to feed resources (tree, bark, top feed) which other smaller herbivores do not have. Finally, big size gives them protection from predation. On the other hand, elephants bear fewer offspring, mature sexually at a later age and have a longer gestation period, all of which drastically prolongs the evolutionary reaction time. In evolutionary term the species can be termed as "inert" (Clauss *et al.*, 2003). Captive breeding of such an inert species pose special challenge. Nutritional imbalances are one of the major factors contributing to reproductive disorders. Benign uterus tumors (leimyomas) occur frequently in both Indian rhinoceros and elephant (Clauss *et al.*, 2005). Such tumors may reduce fertility because they can be mechanical obstacle to natural insemination and the affected animals cease to come to estrus. Hormonal changes have been implicated in the etio-pathology of leimyoma in elephant, and a correlation between the occurrence of leiomyoma and nutritional imbalances has been demonstrated. Another problem associated with nutritional disorder in elephant is foot lesion. Although providing an appropriate substrate and access to a water basin are considered to be of major importance in preventing foot lesion, it has also been reported that nutritional imbalances triggered by unnecessary concentrate feeding will exacerbate this problem. Excessive concentrate feeding may induce laminitis lesion and thus contribute to the phenomenon. Additionally, potential mineral imbalance, especially in zinc supply is suspected to be a contributing factor. It is difficult to assess the nutritional status of very large animal as the animal cannot be weighed on a regular basis. Although body condition scores for large animals have recently made available (Wemmer *et al.*, 2006), an obese condition may go unnoticed due to large size of these animals.

Digestive morphology and function

The elephant has a separate distensible pharangeal pouch that terminates into sphincter from which it can control the flow of food or fluid into the oesophagus. Elephant stomach is about 100 cm long with distinct cardiac and pyloric end. The cardiac end is long and tapering. The interior end is lined by mucous membrane and number of transverse folds. Small intestine of an adult Asian elephant could be 2 m long, large intestine 12.8 m long and caecum 0.6-1.5 m long (Fowler,1986). The large intestine has got sacculated caecum and colon. The sacculation is achieved by longitudinal band of muscles. The histological finding in stomach and oesophagus of elephants were similar to those in mono-gastric species like human and pig (Aswegen *et al.*, 1994). In the mucosa of the stomach, endocrine cells were immunoreactive to gastrin, somatostatin, chromogranin A and serotonin. In the stomach, absence of glucagons cells and presence of immuno-reactive endocrine cells are in contrast to other mammals. The relative capacity of large intestine is 60-65% of total digestive tract.

Chewed food, mixed with saliva, passes down the oesophagus to a simple stomach, connected, in turn to the small intestine, which then joins with the colon. At this latter juncture, there is a caecum of considerable proportions. The colon is sacculated but not compartmentalized, and the majority of the digesta is located in the proximal two-thirds. Two-thirds to three-quarters of the wet digesta were found in the caecum and colon, where microbial fermentation is particularly prominent.

Elephants are mono-gastric animals with a hind gut fermentation chamber. Bacterial counts of 10^7 to 10^{12}/g have been reported in the hind gut fermenters like elephant (Stevens and Hume, 1995). Substantial numbers of protozoa were also found in the hind gut of elephants. The bacterial species isolated from elephant were more or less similar to those isolated from horses (Stevens and Hume, 1988). Microorganisms in hind gut ferment sugars, starches, cellulose, hemicellulose, and pectin into short chain fatty acids, CO_2, CH_4 and H_2. Extra-cellular microbial enzymes digest polysacharrides into monosacharrides, which are converted to pyruvate by intracellular enzymes. In the anaerobic condition of hind gut, pyruvate is deduced to short chain organic acids, principally acetate, propionate and butyrate plus CO_2, CH_4, H_2 and water. The total concentration of volatile fatty acids (VFA) in the hindgut was 120 and 75 mmol/l of elephant and rhino, respectively. The methane productions in both these species were much lower than ruminant livestock. The proportion of different VFA was about 70:15:15. The VFA contribute to the maintenance requirement and an Asiatic elephant can derive 100% of its maintenance energy from VFA (Jenson, 1986). The VFA concentrations and proportions in faeces of the elephants were reported to be similar to that recorded for horses (Drochner and Meyer, 1991). An increased VFA concentration after concentrate supplementation, as had been observed in horses (Gunther, 1984), was also observed in elephant (Clauss *et al.*, 2003).

Urea is released into all segments of the elephant intestine, but nitrogen recycling is most effective in the hindgut. Major substrate degraded for the production of ammonia and synthesis of protein include endogenous nitrogen contained in the urea, creatinine, enzyme, mucus, sloughed cells and nitrogen contained in feed residue. Even though there is no direct evidence/experimentation on elephant, it can be easily assumed from the studies conducted in other hindgut fermenters that most of the ammonia is either incorporated into microbial protein or absorbed and recycled to the liver for synthesis of non-essential amino acids. Urea nitrogen was extensively recycled through the hindgut of equids and rock hyraxes (Hume *et al.*, 1980), which is the closest relative of elephants.

In comparison to other herbivores, elephants have comparatively faster digesta passage rate and low digestibility coefficient. This is an adaptive mechanism to survive on poor quality roughages. Because of their enormous size, elephants will require large amount of food even though their relative requirement per unit body size is comparatively lower than other herbivores. There is a point where there is no further benefit in keeping the digesta in GIT and the losses due to methane formation starts accentuating. Elephants have surprisingly faster passage rate for their body size (Lohlein *et al.*, 2003). It has been further observed that in free range, larger size male elephants have more retention time and therefore more fibre digestibility (Stokke and du Toit, 2002). An elephant weighing about 3 t has MRT of about 25 h (Foose, 1982). This is achieved by shortening of GIT, an increase in GIT diameter and reduced caecum size (Clauss *et al.*, 2003). Benediet (1936) stated that residue of any given food pass out of the body in about 24 h and completely disappear in about 50 h.

Feeding of Elephants in Captivity

In most of the studies, dry matter intake (DMI) in captive elephants varied from 1-1.5% of BW (Ullrey *et al.,* 1995), young animals show little more DMI up-to 2% of body mass (Loehlein *et al.,* 2003). Clauss *et al.* (2003) studied the digestibility in captive Asian elephant (n=6) fed on different diets using double marker method (acid detergent lignin as internal and chromium oxide as external marker). Dry matter intake (kg/d) was 32.04, 34.4, 37.98 and 35.39 in hay only diet, hay plus pelleted feed based diet, hay plus oat based diet and hay plus beet based diet, respectively. Apparent digestibility of organic matter (OM) was 35.53, 38.25, 38.16 and 35.1%: apparent digestibility of crude fibre (CF) was 31.8, 32.76, 24.52 and 22.88%, in the four respective diets.

The maintenance energy requirements of a wide range of animals vary in relation to $BW^{0.75}$, where BW represents body mass. This means that the maintenance energy requirements of a 5000 kg elephant should be 180 times that of a 5 kg dik-dik, and not 1000 times, as expected. The energy requirements are measured in Joules/kcal. Ananthasubramaniam *et al.* (1982) worked out that an adult Asiatic elephant (2500-6000 kg) required 18 g DM, 6 g DCP, 237 kcal of ME and 5 g of Ca per kg metabolic body size.

In most of the western zoos, elephants are, however, fed mainly on hay. The Washington State Zoo had successfully kept and bred elephants on a diet of 45 kg of Timothy hay, 1.5 kg of completely digestible rolled oat, 23 kg of lettuce and 23 kg of carrots which was supplemented with 180 g of balanced mineral-vitamin mixture and a treat of 0.5 kg of rock salt 3 times in a week

Table 1: Feeding schedule of captive Asian elephant in different Indian zoos

Sanjay Gandhi Biological Park, Patna

Deer mash	Paddy straw mash	Sudan grass/berseem	Sugar cane (Nov – Feb)
7 kg	35 kg	50 kg	150 kg

Zoological Garden, Alipore

Wheat bran	Soaked gram	Paddy	Boiled rice	Boiled pulses	Roti	Banana	
	4 kg	4.5 kg	4.0 kg	1.5 kg	1.0 kg	1.25 kg	2.5 kg
	Jaggery	Salt	Sattu	Paddy straw	Tree leaves/ branches	Sugarcane top	
	300 g	200 g	300 g	6 kg	150 kg	40 kg	

Nehru Zoological Park, Hyderabad

Morning						
Cattle feed	Reed grass	Lucerne	Bud stem leaves	Rageshaw*	Jaggery	Salt
8 kg	100 kg	10 kg	20 kg	1 kg	250–500 g	100-150 g
Afternoon	Kadvi	50 kg	Hay	50 kg	* cooked ragi with jaggery	

Assam State Zoo, Guwahati

Carrot	Lassara	Banana	Sugar cane	Black salt	Molasses	Common salt	Bread	Rice Adult
1 kg	100 g	10 nos	4 kg	50 g	500 g	50 g	1 kg	3 kg
Paddy	Gram	Mung	Green fodder	Banana	Local tree leaves	Mustard oil	Peanut	Sub-adult
2 kg	1 kg	2 kg	1.5 q	7 Nos.	50 kg	1 lil/ m	200 g	2 kg

Bhagwan Birsa Biological Park, Ranchi

Rice	Lentil	Gram	Jaggery	Salt	Banana	Sugar cane	Mahua	Fodder
1 kg	1 kg	3 kg	1 kg	50 g	2 kg	10 kg	59 g	1 q

National Zoological Park, Delhi

Green fodder	Jaggery	Mung bean	Rice	Bajra	Haldi
200 kg	1 kg	1 kg	2 kg	1 kg	100 g
Salt	Tree fodder	Dry fodder	Mustard oil	Banana	
100 g	60 kg	15 kg	500 g	24 nos.	

MC Zoological Park, Chhatbir

Cereals	Soaked gram	Jaggery	Seasonal fruit	Green fodder
2 kg	2 kg	1 kg	500 g	2.5 q

Zoological Garden, Lucknow

Salt	Black salt	Green fodder	Barley flour	Tree leaves	Sugar cane	Jaggery
25 g	25 g	50 kg	5 kg	50 kg	75 kg	1.25 kg

Sepahijala Biological Park, Tripura

Banana	Bengal gram	Wheat flour	Paddy	Rice	Banana plant
25 Nos	1 kg thrice	6 kg weekly once	8 kg weekly thrice	6 kg weekly	300 kg

High fibre forage materials are the main stay in an elephant's diet. Nutrient deficiencies of poor quality forages can only be detected through laboratory analysis of a representative sample. These deficiencies can then be balanced with the provision of specific supplements, such as limited amount of concentrate feeds. Ideally, every forage should be analyzed for a set of nutrients (Ullrey, 1997) and concentrate feeds or mineral supplements should be provided accordingly. When choosing components to supplement a high forage ration, it is necessary to consider what nutrients really need to be added to the diet.

Regardless of the forage chosen, several nutrients are likely to be in short supply. As previously noted, the nutrient requirements of the elephant have not been defined. The dietary concentrations of micronutrients recommended for horses should also be adequate for elephants (Ullrey *et al.*, 1997; Ange *et al.*, 2001). Mineral deficiencies have rarely been reported in elephants in captivity, with the exception of a zinc deficiency (Schmidt, 1989) and several cases of a calcium deficiency (Dierrenfeld, 1999). However, a survey by Ange *et al.* (2001) demonstrated that, when compared to the standards for horses, the diet for elephants in many zoos was deficient in several vitamins and minerals. The adequate use of a supplemental feed based on a ration calculation, will balance out such deficiencies. The diets of elephants are supplemented with various amounts of cereals and pulses. This however is not safe always. Excessive feeding of concentrates may lead to obesity, infertility and chronic foot lesion.

Materials and Methods

During the present investigation we conducted feeding trials on 28 elephants in 4 different zoos. They were fed their respective zoo diets. The animals were fed on their normal zoo diets for more than 1 year. Four digestion trials of 5 days collection period involving 10 animals in Guwahati, 8 animals in SCZC, Mysore, 5 animals in MCZP, Chattbir and 5 animals in Hyderabad was conducted. All the animals were fed individually. During the trial period measured amount of food was offered and all the refusals and faeces were also collected for consecutive 5 days. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to chemical composition of feeds and fodders fed to captive Asiatic elephant in different Indian zoos are presented in Table 1a-1d. Data pertaining to feed consumption, diet digestibility, and nutrient supply in adult and sub-adult elephants are presented in Table 2 and 3.

Table 1a: Chemical composition of elephant feeds and fodder at Hyderabad Zoo

Food items	Nutrient content (% dry matter basis)							
	DM (%)	CP (%)	GE Kcal/kg	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Reed grass	9.47	5.76	3410	0.42	0.08	230	6	22
Para grass	15.28	8.85	3775	0.54	0.11	280	8	21
Lucerne	24.45	20.45	3800	1.78	0.22	195	14	42
Banana	31.07	5.12	3990	0.06	0.24	85	12	28
Sugarcane	43.44	3.88	4050	0.28	0.19	75	11	22
Rice	52.52	9.74	4240	0.08	0.78	45	13	18
Ragi	47.76	10.81	4010	0.14	0.84	65	16	34

DM, dry matter; CP, crude protein; GE, gross energy

As per the NRC (1989) requirement for horses, DE requirement is 144 kcal/kg $BW^{0.75}$. Digestible energy intake was satisfactory in all the zoos. Ullrey (1997) recommended that the adult Asiatic elephant diet should contain 8-10% CP, 0.3% Ca, 0.2% P, 50 ppm Fe, 10 ppm Cu and 50 ppm Zn. The CP content of the diet fed in Mysore and Chattbir was higher than requirement. It would be desirable to reduce the amount of concentrates by 20-25% in the diet of adult elephants in those zoos. The diet used in Guwahati and Hyderabad were perfectly matching the recommended requirement of protein.

Table 1 b: Nutritional characteristics of feeds and forages fed to captive Asian elephant in Assam Zoo

Food item	Banana fruit	Banana stem	Banana leaves	Dal grass	Local grass	CM1	CM2	CM3	Carrot	Sugar cane	Tree leaves
DM (%)	21.24	6.63	18.03	15.58	20.50	45.63	45.11	45.52	8.95	21.64	31.34
Nutrient content (on DM basis), OM to P in % DM, Fe-Mn in ppm, GE in kcal/kg DM											
OM	92.89	84.98	90.15	88.45	90.42	91.94	91.88	91.48	90.51	92.57	91.23
CP	6.24	3.80	18.50	7.30	9.40	29.98	26.11	8.42	6.80	3.42	14.25
EE	1.15	0.58	1.48	1.42	1.50	8.12	7.14	6.81	2.14	1.87	1.53
NDF	5.01	48.47	65.88	65.72	70.45	18.05	23.29	28.52	9.11	62.45	68.25
ADF	2.11	18.32	41.33	34.81	37.73	13.37	14.82	18.05	3.14	48.25	44.58
Hemice-llulose	2.90	10.15	24.55	38.91	32.72	4.68	8.47	10.47	1.97	14.20	23.67
Cellulose	0.65	14.22	32.68	26.42	23.12	10.82	12.74	16.05	6.45	34.28	35.12
Ca	0.07	0.32	1.14	0.28	0.43	0.32	0.38	0.37	0.43	0.38	1.32
P	0.32	0.17	0.45	0.18	0.26	0.67	0.72	0.81	0.19	0.17	0.42
Fe	27	312	482	512	540	158	160	162	182	118	579
Zn	9	43	48	18	26	40	43	45	14	18	56
Cu	5	15	14	9	11	12	12	13	14	6	11
Mn	8	21	51	32	45	38	42	41	29	38	54
GE (kcal/kg)	4025	3915	3870	3575	3770	4080	4120	4220	4120	3970	3945

CM1, CM2, CM3, concentrate mixture of calf, juvenile, and adult elephant , DM dry matter,; OM, organic matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre; GE, gross energy; ppm, parts per million

Table 1c: Chemical composition of feeds and fodder at SCZG, Mysore

Food items	Nutrient content (on dry matter basis)							
	DM (%)	CP (%)	GE Kcal/kg	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Rice	48.45	10.41	4190	0.09	0.69	58	14	15
Horse gram	51.45	28.45	3990	0.14	0.42	45	12	58
Ragi	52.11	14.03	4010	0.12	0.85	65	15	29
Napier grass	21.48	8.97	3670	0.51	0.14	280	9	22
Reed grass	12.15	5.27	3380	0.42	0.12	240	6	14
Ficus tree	35.29	14.43	3575	0.84	0.39	180	8	34
Carrot	8.91	5.61	4010	0.07	0.19	100	14	18
green gram	48.48	24.23	3900	0.18	0.47	58	15	69

DM, dry matter; CP, crude protein; GE, gross energy

Table 1d: Chemical composition of feeds and fodder fed to Asiatic Elephants in Chattbir

Feed		(%)Nutrient content (% dry matter basis)						
	DM (%)	CP (%)	GE Kcal/kg	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm
Jowar	18.97	9.18	3740	0.44	0.17	235	19	8
Roti	61.14	12.47	4080	0.12	0.98	50	29	14
Soaked gram	44.34	27.25	4090	0.32	0.54	65	68	16
Papaya	10.3	5.88	4010	0.14	0.24	80	85	14

DM, dry matter; CP, crude protein; GE, gross energy

Table 2: Feed consumption, diet digestibility and nutrient content of captive Asiatic elephant diet in different Indian Zoos

Parameter	Guwahati	Chattbir	Hyderabad	Mysore
DMI (kg/100kg BW)	1.16±0.03	1.05±0.04	1.12±0.03	1.27±0.08
DMD (%)	41.94±1.17	39.7±0.97	38.2±1.13	37.2±3.94
Nutrient content of the consumed diet (on dry matter basis)				
CP (%)	7.89±0.16	9.73±0.01	8.01±0.13	10.82±0.17
Ca (%)	0.49±0.018	0.43±0.001	0.44±0.008	0.54±0.01
P (%)	0.30±0.012	0.20±0.001	0.24±0.001	0.29±0.003
Fe (ppm)	423.3±2.03	273.1±0.29	204.4±2.64	197.07±5.0
Cu (ppm)	11.17±0.09	8.41±0.10	8.56±0.08	8.25±0.06
Zn (ppm)	33.5±1.18	20.91±0.05	31.06±0.53	28.23±0.29
DEI (Kcal/kgBW $^{0.75}$)	153.9±1.08	141.7±4.88	142.0±5.10	145.5±8.31

DMI, dry matter intake; DEI, digestible enrgy intake; DMD, dry matter digestibility; CP, crude protein

Table 3: Feed consumption diet digestibility and nutrient content of sub-adult Asian Elephants diet in Indian Zoos

Parameter	Guwahati	Mysore
DMI(%BW)	1.2±0.052	2.00±0.04
Dry matter digestibility (%)	45.4±0.36	36.0±1.42
Nutrient content of the consumed diet (on dry matter basis)		
CP (%)	11.03±0.02	11.36±0.30
Ca %)	0.50±0.03	0.51±0.02
P (%)	0.32±0.004	0.29±0.007
Fe (ppm)	394±3.67	208.4±2.39
Cu (ppm)	11.90±0.04	8.76±0.17
Zn (ppm)	38.0±0.62	29.21±0.58
DE intake (Kcal/kgw$^{0.75}$)	184.8±0.16	192.0±4.18

DMI: dry matter intake, DE: digestible enrgy

All the diets supplied adequate amount of Ca, P, and Fe to fulfill requirements. In most of the captive facilities in India, green fodder is the main component of the elephant diet which is rich source of Ca and Fe. These diets are supplemented with various types and proportions of cereal, pulses and their by-products which are good sources of P. In practical feeding situation, deficiency of Ca and P is unlikely. Copper was deficient in all but Guwahati zoo diet. All the diets contained less Zn than recommended (Ullrey 1997). However, not all the research on hindgut fermenters does agree with higher requirement of zinc. As a safe guard, however, we recommend that the diet may be supplemented with a suitable trace element mixture. In sub-adult elephants, digestible energy intake and crude protein content of the diets of both the zoos were similar. The diets of Guwahati were deficient in protein by 8%, whereas, Mysore diet was deficient in protein only by 3%. Such marginal deficiency may not warrant any immediate attention. Both the diets provided adequate Ca, P and Fe to meet requirement for growing elephants.

Suggested Guidelines for feeding

1. Use of fruits and vegetables should be reassessed.
2. Elephants are very prone to obesity. Body condition should be regularly monitored.
3. Grasses should be the main component of elephant diet. Leguminous fodder may be included in the diet of young animals to increase the protein content of the diet. Low calorie roughages like reed grass and banana stem may be fed *ad lib*. Other roughages and concentrates should be restricted. For an adult male weighing 4 ton, 6 kg of concentrates ingredients (air-dried, 10% moisture) and 225 kg of green fodder (75% moisture) will be adequate. Similarly, for a female cow weighing 3.5 ton, 5 kg of concentrates and 165 kg of green fodder would be adequate.
4. Some amount (10-20% of total diet on DM basis) of browses is to be added in the diet.
5. Growing animals require more protein and other nutrients in comparison to adult animals. Hence, proportion of concentrates should be higher in the diet of growing elephants. A calf diet may contain 30% of concentrates on dry matter basis, whereas, 10% of concentrates in the diet of adult elephant is sufficient of meet nutrient requirements.

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3.18 Indian Giant Squirrel

Order	:	Rodentia
Family	:	Sciuridae
Genus	:	*Ratufa*
Species	:	*R. indica*

Indian giant squirrel is an arboreal species. Its distribution is endemic to deciduous, mixed deciduous and evergreen forest of peninsular India (Datta and Goyal, 1996). *Ratufa indica* has dorsal coloration that varies from creamy beige, buff, ton to brown, the ventral parts and front legs are usually creamy in colour and the head is brown (Tritisch, 2001). They have short, round ears, a broadened hand with an expanded inner paw for gripping, and large, powerful claws used for gripping tree bark and branches. Females can be distinguished from males by their three sets of mammae. Total body length could be upto 36 cm and tail length is approximately the same as body length. These squirrels weigh approximately 1.5 to 2 kg (Nowak 1999). They seldom come down from the tree. They can jump up to 6 m with the help of the 2 ft long tail. They make sphere shaped nest with twigs and leaves. They are solitary animals living alone or in pair. Their natural diet consists of fruits and leaves (Paulraj, 1988). Reproductive behavior of *R. indica* is poorly known. There is some evidence that breeding occurs throughout the year, or several times during the year. Litter size is usually 1 or 2 young, but may be as many as 3. Gestation period of a close relative, *Ratufa bicolor*, was recorded to be 28 to 35 days (Pai, 2008). Giant squirrels spend most of their time in trees, where they gather their food. Giant squirrels are omnivorous, feeding on fruits, flowers, nuts, bark, bird eggs, and insects. They feed by standing on the hind legs and using their hands to handle food. Giant squirrels also use their large tail as a counter-weight, improving their balance (Nowak 1999).

Protein level is, sometimes, but not always correlated with food choice in captive Malabar giant squirrel (*Ratufa indica*) (Borges, 1992). Protein utilization is also influenced by secondary metabolites like tannins. However, some mammalian species are well adapted to high tannin diets. It was suggested that squirrel do prefer low tannin diet, but can also tolerate high level of tannins. Many mammalian species including goat and other browsing species which consume tannin rich food produce saliva rich in salivary proteins which bind the tannins. As this protein-tannin complex bind together and undigested tannin cannot bind with dietary proteins. Thus, the adverse effects of tannins on protein utilization are overcome. Like artiodactylids, rodents, primates, lagomorphs and some marsupials are able to produce salivary protein rich in proline to overcome the adverse effect of tannins on protein utilization (Berthelmess, 2001). Overall protein requirement for maintenance of rodents are moderate i.e.15% of CP on DM basis (NRC, 1995). The maintenance energy requirement for a 500 g squirrel has been reported to be 137 kcal ME/day. This requirement could be met by providing 33.3 g of food on dry matter basis. The metabolizabilily of gross energy was 72%. Voluntary feed consumption always exceeded calorie requirement (Ludwick *et al.* 1969).

Feeding in Captivity

Diet schedule of giant squirrels practiced in some of the Indian zoos are presented in Table 1.

Table 1: Diet schedule of giant squirrel in Indian zoos

Fresh food offered (g)	Name of the zoo		
	Thiruvananthapuram	**Lucknow**	**Delhi**
Banana	100	250	2 numbers
Papaya	-	50	100
Singada	-	50	-
Apple	40	50	-
Guava	20	-	-
Grape	50	-	-
Orange	70	-	-
Melon	-	-	50
Egg plant	-	50	-
Spinach	-	50	-
Bread	10	25	100
Bengal gram	40	50	50
Carrot	-	50	-
Cucumber	-	-	50
Peanut	20	60	50
Boiled egg	-	-	1 number
Milk	-	-	100

Materials and Methods

During the present investigation, we conducted feeding trials on 4 giant squirrels in Lucknow zoo and 1 giant squirrel in Thiruvananthapuram zoo. All the animals were fed their respective zoo diets. During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Results are given in Tables 2-4.

Table 2: Actual consumption (g/day) of different food items by Giant squirrels (g/day) on fresh matter basis

Food item	Name of the zoo	
	Thiruvananthapuram	Lucknow
Banana	79±6.6	97±13.4
Papaya	-	33±5.1
Singada	-	28±5.1
Apple	24±3.8	31±7.2
Guava	16±1.77	-
Grape	38±1.77	-
Brinjal	-	27.8±7.2
Spinach	-	42.8±1.93
Bread	25±2.0	17.5±1.4
Bengal gram	22±0.9	40.2±4.0
Carrot	-	31.8±4.9
Peanut	16±3.6	20.3±3.4

Table 3: Nutrient composition of feeds and fodder fed to Giant squirrels in Indian zoos

Food item	Nutrient composition (on dry matter basis)							
	DM (%)	GE (kcal/kg)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Thiruvananthapuram zoo								
Soaked gram	51.42	3990	27.65	0.43	0.51	75	12	54
Guava	14.34	3680	7.82	0.16	0.24	68	11	27
Grape	4.98	3880	6.74	0.08	0.36	42	8	15
Peanut	81.28	5320	28.44	0.10	0.24	71	11	67
Apple	15.83	3670	5.64	0.11	0.19	72	14	28
Bread	52.14	4010	13.11	0.19	0.28	65	8	24
Plantain	17.14	3480	8.28	0.08	0.12	330	12	17
Lucknow Zoo								
Banana	25.18	4040	5.12	0.09	0.19	23	9	28
Papaya	11.05	3870	7.43	0.18	0.14	20	8	22
Singhada	8.49	3440	8.14	0.18	0.14	68	9	34
Apple	15.39	3680	5.63	0.09	0.07	33	7	22
Brinjal	17.41	3340	18.84	0.26	0.18	55	8	26
Spinach	8.89	3530	18.11	0.88	0.1	262	8	22
Bread	51.34	4000	13.73	0.29	0.41	65	11	22
Soaked gram	49.87	3970	23.14	0.54	0.41	75	12	53
Carrot	8.86	3640	8.27	0.16	0.21	114	10	32
Groundnut	78.99	5410	29.44	0.42	0.24	72	12	69

DM, dry matter; CP, crude protein; GE, gross energy; ppm, parts per million

Table 4: Feed consumption, diet digestibility, nutrient supply in diet of giant squirrels

Parameters	Name of the zoo	
	Thiruvananthapuram	Lucknow
Dry matter intake (g/d)	77.2±2.11	92.15±8.0
Dry matter digestibility (%)	85.2±1.37	86.17±3.74
Digestible energy intake		
(Kcal/kg $BW^{0.75}$)	154.5±1.34	190.8±6.5
Nutrient supply of the diet		
Crude protein (%)	16.14±0.32	15.24±0.31
Ca (%)	0.24±0.003	0.28±0.001
P (%)	0.32±0.003	0.25±0.001
Fe (ppm)	58.3±1.37	56.5±1.23
Cu (ppm)	11.41±0.71	9.96±0.048
Zinc (ppm)	34.4±0.67	39.4±0.47

From the perusals of the data, it is evident that energy intake was higher in the squirrels of Lucknow zoo than those in Thiruvananthapuram zoo. The diet of Thiruvananthapuram zoo provided 154 kcal/kg$BW^{0.75}$ DE. Similarly, Schitoskey and Woodmansee (1978) had reported that net energy requirement for maintenance of a 500 g squirrel would be 92 kcal/day. Converting net energy to digestible energy would translate into 190 kcal DE/kg $BW^{0.75}$. Husband (1976) had reported that ME requirement for California ground squirrel was 162 kcal ME/kg $BW^{0.75}$, which would be equivalent to 180 kcal DE/kg $BW^{0.75}$. The diet of the Lucknow zoo provided DE in adequate to fulfill requirements. The diet of the Thiruvananthapuram zoo was deficient in energy by14 %. Considering the less activity in captive animals, such moderate reduction in calorie intake may not warrant any immediate action. However, we would suggest continuous monitoring of the body condition. If any deterioration in body condition is noted, than calorie intake may be increased by 15-20%. NRC (1995) recommended 12% crude protein, 0.5% Ca, 0.4% P, 35 ppm Zn, 50 ppm Fe and 5 ppm Cu for rodents. Diet in both the zoos provided adequate amount of crude protein, Fe, Cu and Zn. As per the results of the present investigation, diets of both the zoos were deficient in Ca. Further, proportion of P was also higher and inappropriate. Although Lucknow zoo provided some amount of spinach (a good source of Ca) to their squirrels, but it was not adequate. One possible option would be to decrease the proportion of fruits (particularly soft fruits) in the diet. It is to be remembered that in nature giant squirrels also consume a lot of foliages and vertebrate prey. All these are good source of Ca. In addition, nutritional composition of wild and cultivated fruits is completely different. Cultivated fruits are higher in soluble sugar content, whereas, wild fruits are rich in fibre and minerals.

Suggested guidelines for feeding

1. Nuts are important sources of ALA. However, their proportion should not be more than 5 % of the total diet on dry matter basis. Real nuts i.e. almond, walnut may be used instead of peanut. Peanuts are susceptible to

aflatoxicosis. Any fungal mould should be monitored regularly and feed should be got tested for aflatoxins on regular basis.

2. Nuts should be given only after the vegetables have been consumed.
3. Proportion of soft fruits could be curtailed by 25% with an equal increase in the proportion of vegetable (carrots, cabbage, and spinach). A diet containing 50 g banana, 50 g other hard fruit (pear/apple/ guava), 100 g vegetables (cabbage/carrot/ beans/ eggplant/ other), 50 g spinach, 25 g bread, 40 g soaked gram and 4 g of peanut will be adequate.
4. The whole ration may be divided into 2 or more meals.
5. Bread could be replaced with equal amount of grains.

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3.19 Crested Indian Porcupine

Order	:	Rodentia
Family	:	Hystricidae
Genus	:	*Hystrix*
Species	:	*H. indica*
Common name	:	Sahi (Hindi)

The crested porcupine is widely distributed in south Asia and the Middle East. It is well adapted to diversified ecological regions ranging from scrubland, tropical and sub-tropical grassland and mountains. Upward quills cover every part of the body except ventral parts, muzzle and ears of porcupine. Quills are modified hairs. They are much thicker than normal hairs and are filled with a spongy matrix. Porcupine quills are not hollow. Body length of an adult porcupine ranges from 70-90 cm and body weight ranges from 11-18 kg (WAZA, 2012). The porcupine bears one precocial offspring after a long gestation period of 209-217 days (Shadle, 1948). They are nocturnal animals and make burrows. Porcupines are generalist feeder. They can thrive well on a variety of plant materials including fruits, grains, and roots. They also raid on crops. Occasionally they have been reported to gnaw on deer bones to extract minerals (Roze, 1989). Bone contains calcium, phosphorus and sodium, as well as protein. On a DM basis, deer antlers contained 52-56% ash, 45% protein, and 1% fat (Hyvarinen, *et al.,* 1977). It is unclear as to whether porcupines gnaw on bones for minerals or for protein.

Porcupines can survive on diet containing low levels of protein (Felicetti *et al.,* 2000). Most closely related species is the guinea pig. Their digestive system is similar to that of guinea pigs. However, there are some major physiological differences between the two species. Guinea pigs cannot synthesize Vitamin C, whereas, porcupines are capable of synthesizing it. Porcupines can utilize fibrous diets more efficiently than guinea pigs. A porcupine is a hind gut fermenter, but not cecotrophic. Generally the digestive efficiency of fore-gut fermenters (ruminants) is more efficient than hind-gut fermenters. However, porcupine is an exception. Large caecum, separation chamber in caecum, resorption of Na, efficient mastication of food to very small particles, large distal colon and reduced metabolic faecal nitrogen excretion are some of the mechanisms adapted by porcupine to utilize fibrous materials more efficiently. Fournier and Thomas (1997) reported that porcupine reduces the protein loss in faeces and thus improve the efficiency of utilization of dietary proteins. Their natural diet may contain considerable amount of tannins, lignin and arabinose which are known to impair protein utilization. Using the models of Robbins (1993), a hindgut fermenter of porcupine's weight would retain particulate digesta for 21 h and liquid digesta for 28 h; however, on actual experimentation porcupine retained digesta twice as long. Further, porcupine has been reported to be efficient in mastication which might help them in achieving higher fibre digestibility. Porcupines are well adapted to subsist on low protein diet. Their metabolic faecal nitrogen (MFN) loss was 2.8 g N/kg DM, whereas, the interspecies mean range is 1-9 g/kg DM. The enogenous urinary nitrogen (EUN) loss was 160 mg/kg $BW^{0.75}$ which were higher than the ruminant value of 93 mg/$kgW^{0.75}$.

Free ranging porcupines prefer high energy nut and fruit diet, but they can also consume variety of plant materials containing higher level of tannins. The mechanism of overcoming the adverse impact of tannins on protein utilization as discussed in section for squirrels may also be applicable for porcupine. The maintenance energy requirement was similar in both summer and winter season. It was estimated that 106 kcal ME/kg $BW^{0.75}$ was adequate for maintenance of body mass. The average water consumption was 137 and 53 ml kg BW/day during summer and winter, respectively (Alkon *et al.,* 1986). Average dry matter digestibility in crested Indian porcupine was 76.5%.

Feeding in Captivity

Table 1: Diet schedule of crested Indian porcupine in different zoos

Fresh food offered (g/day)	Name of the zoo					
	Jaipur	Trivandrum	Delhi	Bhubaneswar	Hyderabad	Gwalior
Banana	-	150	-	150	1 number	-
Mixed fruits	250	-	-	-	-	500
Guava	-	-	-	-	-	-
Egg plant	-	-	-	50	-	-
Spinach /Veg	-	300	-	-	-	-
Maize	-	-	-	50	-	-
Rice	-	-	-	100	-	-
Bread	-	-	-	100	-	-
Bengal gram	125	50	200	50	100	50
Carrot	-	200	50	-	-	-
Tapioca	-	300	-	-	-	-
Sweet potato	-	-	200	100	-	-
Peanut	-	-	100	100	-	100
Boiled egg	-	-	1	-	-	-
Milk	-	-	-	10 ml	-	-

Materials and Methods

During the present investigation, we conducted feeding trials on 4 porcupines each in Sepahijala Biological Park, Thiruvananthapuram zoo, and Jaipur zoo. Besides, feed consumption was also recorded in Hyderabad Zoo All the animals were fed their respective zoo diets (Table 2). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Discussion

Data pertaining to feed consumption, diet digestibility, and nutrient supply are presented in Tables 2-4.

Table 2: Consumption of different food items by porcupines (g/d) on fresh matter basis

Food item	Name of the zoo			
	Sepahijala	Hyderabad	Trivandrum	Jaipur
Banana	239±3.9	54±7.6	114±7.7	95±10.7
Apple	74±4.8	-	-	76±6.9
Spinach /Veg	134±11.3	-	144±21.6	-
Maize	-	-	-	97±11.5
Bengal gram	173±8.8	170±9.2	87±4.1	203±8.6
Carrot	-	45±0.45	159±8.8	54±9.4
Tapioca	-	-	260±17.8	-
Potato	-	77±6.8	-	-
Colocassia	78±6.3	-	-	-
Peanut				42±3.0

Table 3: Nutrient composition of feeds and fodder fed to Crested Indian porcupine in Indian zoos

Food items	Nutrient composition (on dry matter basis)							
	DM (%)	GE (kcal /kgDM)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Sepahijala Biological Park, Tripura								
Banana	24.8	4070	5.22	0.11	0.17	23	8	26
Soaked gram	51.4	4010	23.43	0.43	0.53	74	11	52
Spinach	8.9	3560	16.84	0.88	0.14	286	8	23
Apple	15.1	3670	5.81	0.1	0.08	33	7	24
Colocassia	26.1	3590	11.14	0.18	0.54	55	8	33
Nehru Zoological Park, Hyderabad								
Soaked gram	51.3	3980	23.77	0.48	0.51	68	12	49
Potato	25.3	3890	8.34	0.04	0.16	31	8	32
Carrot	7.4	3690	8.04	0.17	0.22	118	11	33
Banana	25.1	4050	5.33	0.12	0.16	33	8	27
Thituvannathapuram Zoo								
Soaked gram	52.4	4030	24.98	0.44	0.47	75	11	53
vegetables	22.1	3710	6.18	0.22	0.17	41	9	26
Plantain	18.1	3550	8.14	0.07	0.12	368	8	21
Carrots	7.1	3650	8.24	0.19	0.24	94	10	29
Tapioca	38.1	3870	3.14	0.13	0.11	25	8	21
Jaipur Zoo								
Maize	90.5	3970	8.45	0.11	0.24	32	8	19
Bengal gram	52.4	4030	23.98	0.44	0.47	75	11	53
Banana	51.9	3980	32.44	0.48	0.39	78	2	49
Apple	26.1	4010	5.22	0.09	0.14	34	9	26
Carrot	15.3	3640	5.64	0.09	0.11	35	8	26
Peanut	82.1	5400	28.14	0.33	0.24	70	12	68

DM, dry matter; GE, gross energy

Table 4: Feed consumption, diet digestibility and nutrient supply in diet of porcupines in different zoos

Parameter	Name of the Zoo		
	Sepahijala	**Trivandrum**	**Jaipur**
DM intake (g/d)	193.49±4.461	203.60±8.497	305.22±12.235
DM digestibility (%)	84.96±0.91	88.16±1.74	86.93±0.95
DEI (kcal/kg $BW^{0.75}$)	101.64±2.64	103.74±0.84	172.87±6.06
Nutrient supply			
Crude protein (%)	18.13±0.435	10.20±0.306	21.47±0.404
Ca (%)	0.31±0.004	0.21±0.004	0.31±0.006
P (%)	0.37±0.005	0.21±0.004	0.33±0.002
Fe (ppm)	67.98±1.152	77.31±3.099	58.93±0.826
Cu (ppm)	9.31±0.061	8.92±0.040	8.59±0.109
Zinc (ppm)	38.33±0.469	29.27±0.361	41.89±0.744

DM, dry matter; DEI, digestible energy intake

From the perusals of the data, it is evident that the dry matter intake was highest in Jaipur, followed by Thiruvannathapuram and Sepahijala Biological Park. Dry matter digestibility was similar among the zoos. Trials conducted by Felicetti *et al.,* (2000) revealed that drymatter digestibility ranged from 45 to 91% when browse, alfalfa, and acorns were fed. However, drymatter digestibility ranged from 83-96% when rodent chow and apples were fed. Fournier and Thomas (1997) determined that the high fiber diet (11%) had a lower apparent digestibility (80%), compared to that of the 5% fiber diet (95-97%). Digestible energy intake was also found higher in animals in Jaipur zoo. Johnson and McBee (1967) recommended caloric intake of 435 kcal/day for a 10 kg porcupine and 262.5 kcal/day for a 5 kg porcupine. If we convert the DE to ME, the ME supply would be 92, 94 and 155 Kcal/kg $BW^{0.75}$ ME in Sepahijala, Thiruvananthapuram and Jaipur zoo, respectively. As per this estimate, ME supply was short by 12 and 10% in Sepahijala and Thiruvananthapuram, respectively. Such marginal deficit of energy would not cause any problem as these animals are in captivity and are at lower level of activity. However, the diet of Jaipur zoo supplied energy in excess of requirement and it would be desirable to reduce the feed by 25%. Grant (undated) had suggested that the diet of porcupine should contain 6-10% crude protein, 0.2-0.5% Ca and 0.2 -0.5% P. Fournier and Thomas (1997) indicated that porcupines achieved a positive nitrogen balance on a tannin-free diet with 10% crude protein (CP). The diet of Thiruvananthapuram zoo was lowest in CP content, yet it was adequate to fulfill the requirement of CP. The species has adapted itself to survive on low protein diet. Most of the captive diets, however, contain CP much higher than the requirement. It is of particular interest to ascertain how such high protein diet influences the health of captive porcupines. Felicetti *et al.* (2000) indicated that tannins did decrease digestibility of protein. From a captive management perspective, it would be prudent to investigate whether tannins are required in the porcupine diet to reduce protein absorption and possible toxicity, or if protein levels need to be increased when tannins, in the form of browse, are included in the diet. All the diets supplied adequate amount of Ca and P to meet requirements.

Suggested guidelines for feeding

1. Porcupine should be fed at least twice daily to maintain gut health. Usually hindgut fermentation is reduced after 12 h of feeding.
2. They can conserve fat very efficiently, so diet should contain very less amount of fat. Browses and grasses could be included in the diets.
3. Use of items like bread, milk, and egg should be stopped.
4. Feeding of excessive amount of pulses is not necessary. An amount of 50 g of Bengal gram on dry matter basis would suffice. This much amount may be soaked overnight in water and then fed to porcupines.
5. The diet schedule practiced at Thiruvananthapuram zoo was quite satisfactory in nutrient make-up.

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www.waza.org

3.20 Rhesus Macaque

Order	:	Primates
Family	:	Cercopithicidae
Genus	:	Macaca
Spcies	:	*M. mullata*
Common name	:	Rhesus monkey

Rhesus monkeys are widely distributed in South and South-East Asia and also in southern China. They are brown in colour with a red face having no hair. An average adult male is 53 cm long and may weigh 7.3 kg. The tail length varies from 20.7 to 22.9 cm. An average female is 47 cm long and may weigh 5.3 kg (Cawthan Lang, 2005). A female monkey is capable of reproduction from 3-20 years. Male is reproductively mature at 4 years of age. However, their success rate in breeding is less until they attain 8 years of age when they are sexually mature and also attain mature body size (Cawthan Lang, 2005). The oestrus lasts for 12 days, ovulation takes place at the mid of the cycle. Gestation length is 164 days (Fooden, 2000). There is distinct pattern of seasonally in breeding. Most of the mating takes place during October–December (Lindburg, 1971). The average lifespan in free range is 25 years. In captivity, they can live upto 40 years (Cawthan Lang, 2005).

They are found in broad geographic areas. They are well adapted to dry deciduous forest, semi-desert, bamboo forest, tropical evergreen forest, mangrove swamps and are also found in temperate climate (Rowe, 1996). They are well distributed from sea level to 2000 m above msl (Fooden, 2000). They are exceptionally well adapted to co-exist with human and thrive well near human habitat. *M. mullate* are diurnal in nature. They form multi-male and multi-female group of various sizes (10-200). Their natural diet consisted of fruits 24%, flowers 5%, leaves 47%, bark, pith etc. 11%, herb or grass 9%, fungi 1% and prey 6% (Malik, 1986). They readily consume temples offering, steal human food, or even scavenge. NRC (2003) classification includes them as omnivorous but predominantly frugivorous primate.

Cercopethicine monkeys have cheek pouches where they can store the harvested food for a short time. The stomach of all the species are simple, smooth and followed by a short small intestine. Their caecum can support some amount of microbial fermentation. The enlargement of colon is consistent with the fermentation of leaf material (Brorton *et al*., 1991).

Feeding in Captivity

Fruits are the main component of wild cercopethicine diet and will continue to remain the mainstay in zoo diet as well. However, it is noteworthy that nutritional composition of wild fruits and common fruits available at market are completely different. Cultivated fruits contain more sugar, less fiber and minerals. Vitamin C is essential for collagen formation, biosynthesis of carnitine, catecholamine synthesis, peptide amidation and tyrosine metabolism. Vitamin C also aids in absorption of non-heme iron. Many mammals have the ability to synthesize ascorbic acid from glucose.

But most primates lack the enzyme gluconolactone oxidase to synthesize ascorbic acid from glucose. It is to be remembered that most prosimians, lemurs, bushbabies, and lorises do have the enzyme and do not require exogenous sources of vitamin C.

Diet schedule of Rhesus monkey in some of the Indian zoos

Nehru Zoological Park, Hyderabad	
Bengal gram	75 g
Apple	½ in number
Banana	2 in numbers
Carrot	50 in numbers
Cabbage	25 g
Sweet lime	1 no
Spinach	50 g
Jaipur Zoo	
Fruits	500 g
Rice	125 g
Milk	250 g
Bread	100 g
Roasted peanut	150 g
Alipore Zoo, Kolkata	
Seasonal fruits	150 g
Bread	70 g
Banana	200 g
Sweet potato/carrots	250 g
Lucknow Zoo	
Seasonal fruits	2.5 kg
National Zoological Park, Delhi	
Banana	2 in numbers
Leafy green vegetable	100 g
Onion	25 g
Tomato	25 g
Bread	100 g
Milk	100 g
Gram	50 g
Carrot	100 g (1st Nov – 31st Mar)
Sweet potato	100 g (1st Dec – 31st Jan)

In male, dry matter intake was 11.6 g/kg BW. In female, dry mater intake was 12.0 g/kg BW and ME intake was 42.2 kcal/kg BW (Robbins and Gavan, 1966). The digestibility in Macaques varied from 80-87% (NRC, 2003). ME requirement in younger animals are usually higher. A young monkey of 1 m age growing at 6.6 g/d would require 272 kcal ME/kg BW/d, whereas, one at 1 yr of age growing at 3.8g /d would require 226 kcal/kg BW (Kerr *et al.,* 1975). Body weights were sustained in adult male and female Rhesus monkeys when they were fed a commercial diet (3.47 kcal ME/g) targeted to meet maintenance requirement of 93 kcal/kg $BW^{0.75}$ (Robbins and Gavan, 1996). A diet comprising of 8% CP, 2% essential fatty acids, 10% NDF 0.55% Ca, 0.33% P, 15 ppm Cu, 100 ppm iron, 20 ppm Zinc and 110 ppm of vitamin C would be adequate for maintenance. The nutrient requirement for growing animals are, however much higher. The diet of growing primates should contain 15-22% CP, 10-30% NDF, 0.5% ω-3 fatty acids, 0.2% ω-6 fatty acids, 0.8% Ca, 0.6% P, 100 ppm iron, 20 ppm Cu, 100 ppm zinc and 200 ppm of vitamin C. In addition, growing animal's diet requires to be supplemented with taurine @ 70µmol/dl upto 1 year of age. Once monkeys attain 1 year of age, they no more require exogenous source of taurine (Struman *et al.,* 1988).

Rhesus monkeys fed diet containing 0.15% Ca developed osteoporosis (Griffiths *et al.,* 1975). The minimum dietary concentration of 0.55% is recommended by NRC (2003) provided the diet is adequate in P and vitamin D content. Most of the natural food items of Rhesus monkeys are deficient in calcium. To overcome this problem, some zoos include spinach in their diet. However, most of the calcium in spinach are bound to oxalate and are not available. Sprinkling of Ca to the food items is not going to help either, because most of the supplement may not adhere to the food, or animal may refuse to eat such food. A dietary Ca:P ratio between 1:1 and 2:1 is to be maintained.

Nutritional disorders

Only adult and aged animals are susceptible to obesity. Macaques are also prone to human diseases like atherosclerosis, hyperlipidemia, diabetes mellitus, rheumatoid arthritis, and osteoporosis (NRC, 2003). Bonnet, stump-tailed and pig-tailed macaques are also susceptible to obesity. Social hierarchy in primates contributes to the obesity. The dominant animal eats first. The submissive and low-ranked members of the group had access to food only after the higher ranked members of the troop had fulfilled their satiety. Such problem has been handled by introduction of a new male to destabilize the rank. However, practicality of such measure would be doubtful. The food may be scattered throughout the enclosure. Calorie restriction (upto 30%) provides beneficial effects to a variety of physiological systems and appears to have potential benefits on delaying aging and improving male reproductive performance, reducing the risk of cardiovascular diseases, diabetes and tumour (Roth *et al.,* 2004)

Suggested guidelines for feeding

1. A typical diet should contain about 800 g of fresh food. The diet containing at least 400 g of vegetables should be fed. The amount of fruits should be 200 g. Rest of the diet should comprise of other items like cooked/ processed cereals, soaked/ germinated pulses, tubers etc.. This guideline is for adult maintenance.
2. Food should be provided at least 3 times a day.
3. Uniformity should be maintained in feeding schedule.

4. Browses should be added in the diet.
5. Behavioural enrichment could be provided by supplying food in puzzle box, wire ball and other innovative devices.

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3.21 Bonnet Macaque

Order	:	Primate
Family	:	Cercopithecidae
Genus	:	*Macaca*
Species	:	*M. radiate*
Common name	:	Bonnet monkey

Bonnet macaque is found in peninsular India. The diurnal animal is 35-60 cm long with an equal size of tail. The fur of the animals are arranged in a manner that gives the appearance that the animal is wearing a hat. The male weighs 5.5 to 9 kg, whereas, female weighs 3.5 to 4.5 kg (BBC, undated). The average lifespan is 30 years. Sexual maturity is attained at 3-4 years of age in female and 5-6 years of age in male. Gestation length is 165 days (BBC, undated). They are unique in formation of large group with balanced sex ratio, in having affiliation among males and failure of emigration in natal males. They are true omnivores and are known to feed on buds, leaves, stems, tendrils, fruits, seeds, flowers and leaves of 86 species in dry deciduous forest (Ali, 1988) and 39 species in tropical evergreen forests (Krishnani, 1994). Insects may contribute up to 13% of their total diet.

They are also diurnal in nature, take shelter on trees during night and also seen on ground during day-time. Much of the feeding behaviour, digestive tract anatomy and digestive function are similar among the Macaques. In most of the zoos, they are also fed with similar kind of diet. Thus, guidelines for feeding of Rhesus macaque could be followed in Bonnet and Assamese Macaque as well.

Table 1: Feeding schedule of Bonnet moacaque in different Indian zoos

Food	Nandankanan	Hyderabad	Lucknow	NZP, Delhi
Mixed fruits	-	-	2 kg	-
Bread	30 g	50 g	-	100 g
Boiled rice	50 g		-	
Bengal gram	50 g	75 g	-	50 g (roasted)
Milk	-	-	-	100 g
Peanut	50 g	-	-	50 g
Potato	-	-	-	100 g
Sweet potato	100g (Oct.- March)	-	-	100g (1st Dec to 31st Jan.)
Turnip	-	-	-	100 g (1st Jan. 30th June)
Pumpkin	50 g	-	-	-
Okra	50 g	-	-	-
Brinjal	100 g	-	-	-
Tomato	-	-	-	25 g
Onion	-	-	-	25 g

Tomato	-	-	-	25 g
Apple	-	1 number	-	
Pears	-	-	-	100g (1st July to 30th Sep.)
Orange	-	1 number	-	-
Pineapple	100 g (May-July)	-	-	-
Banana	250 g	4 numbers	-	2 in numbers
Guava	-	-	-	100 g (1st Oct. to 31st Jan.)
Water melon	150 g (April-May)	-	-	100g (1st April to 30th June)
Bel fruit	-	-	-	100 g (1st April to 30th June)
Mask melon	-	-	-	100 g (1st April to 30th June)
Corn cob	100 g (Sep-Oct.)	-	-	100g (1st June to 31st July)
Singhada	-	-	-	100 g (1st Oct to 30th Nov.)
Chicku	-	-	-	100 g (1st Jan. 30th June)
Ber	-	-	-	100 g (1st Feb to 31st March)
Green peas	50 g (Dec-Feb)	-	-	-
Green mango	50 g (April-May)	-	-	-

Suggested guidelines for feeding

A typical diet should contain about 800 g of fresh food. The diet containing at least 400 g of vegetables should be fed. The amount of fruits should be 200 g. Rest of the diet should comprise of other items like cooked/ processed cereals. This guideline is for adult maintenance.

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3.22 Assamese Macaque

Order	:	Primate
Family	:	Cercopithicidae
Genus	:	*Macaca*
Species	:	*M. assamensis*

Assamese macaque is found in the North-Eastern states of India. The IUCN has listed the species as near threatened since 2008. The colour of the animal is yellowish-grey to dark brown and head to tail length measures from 51-73.5 cm, with tail length of 15 to 30 cm. Adult weight varies from 5-10 kg. Gestation period of Assamese macaque is 165 days, after which one singular baby is born (Francis, 2008). There are two recognized sub-species of the species. *M. assamensis assamensis* is found in Bhutan, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. This sub-species is also found in Burma, Thailand, Tibet, Laos, Vietnam and China. The Western Assamese macaque is found in Uttar Pradesh, Sikkim, Bhutan and Sunderban (Groves, 2001). Their habitat range varies from dry deciduous forest to evergreen forest and montane forest. They are well adapted to altitude range of 200-1800 m above msl and can be found at even higher altitude (Chaudhury, 2001). They prefer primary forests to degraded forests. Assamese macaques are diurnal in nature. At time they are both arboreal and terrestrial. They are omnivores eating fruits, leaves, buds, tubers, grasses, insets, other invertebrates, and also raid crops.

Table 1: Feeding schedule of Assamese macaque in different Indian zoos

Food	Nandankanan Zoological Park	Assam State Zoo
Bread	30 g	25 g
Boiled rice	50 g	-
Bengal gram	50 g	50 g
Soya flakes	150 g	150 g
Peanut	50 g	200 g (with hull)
Sweet potato	100g (Oct.- March)	-
Pumpkin	50 g	50g
Okra	50 g	-
Brinjal	100 g	-
Carrot	50 g (Oct-March)	100 g
Cucumber	-	200 g
Apple	-	100 g
Plum	-	100g (seasonal)
Orange	-	1 in number
Pineapple	100 g (May-July)	—

Banana	250 g	8 in number and one local banana (Athia)
Jackfruit	-	150 g (seasonal)
Water melon	150 g (April-May)	100g (seasonal)
Pomegranate	-	100 g (seasonal)
Corn cob	100g (Sep-Oct.)	-
Guava	-	100 g (seasonal)
Chicku	-	50 g (seasonal)
Pear	-	50 g (seasonal)
Green peas	50 g (Dec-Feb)	-
Green mango	50g (April-May)	-
Sugar cane	-	200 g
Grape	-	50 g (seasonal)

Suggested guidelines for feeding

Diet schedule similar to Rhesus macaque may be followed.

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3.23 Pig-tailed Macaque

Order	: Primate
Family	: Cercpithicidae
Genus	: Macaca
Species	: *M. nemestrina*

The pigtailed macaque is an endangered species of monkey. It is protected under Schedule I of Wildlife Protection Act, 1972 of India. It is listed as a vulnerable species in the IUCN Red Data Book (ICUN, 2003). The Pigtailed macaque is one of the biggest members of the monkey family. As the name suggests, this monkey has a short tail, which is often rolled up and raised in the air giving resemblance to the tail of a pig (Chaudhury, 2003). It is found in the NE India and South-East Asia. Adult male measures from 49.5 to 55.6 cm and body weight ranges from 6.2 to 14.5 kg. Body length of adult female ranges from 46.7 to 56.4 cm and body weight ranges from 4.7 to 10.9 kg (Fa, 1989). The body is covered with olive brown fur, underside is white in colour. The fur on the top of the head is dark brown or black in colour. The furs on the head are arranged in such a manner that it seems that there is a depression on top of their head (Groves, 2001). Their build is stocky. Average lifespan is about 26 years (Cawthan Lang, 2005).

Pig-tailed macaques can breed round the year; however, there is a peak from January to May (Rowe, 1996). Females attain sexual maturity at 3 years of age, whereas, males attain it between 3 and 4.5 years (Sirianni and Swindler, 1985). These monkeys live in groups of 16-18 individuals each. Gestation length is 170 days. Young one is nourished for one year. Sexual maturity is attained at 3 years of age. Three weeks after birth, the young macaque starts taking walks on his own, while the mother still keeps feeding and looking after him for about six months. During infancy, pig-tailed macaque babies are vulnerable to "kidnapping" by other high-ranked females (Cawthan Lang, 2005).

Among the monkeys, they are reported to be most arboreal (Clutton-Brock and Harvey, 1977; Ross, 1996). Yet they come down on to the ground and sometimes raid crops. They are very sensitive to soluble sugar content of the diet and prefer high sugar fruits to low sugar fruits (Laska, 2000). In another study (Laska, 2001), it has been demonstrated that food preference of these monkeys are positively correlated with fructose content of the fruit, but not with the energy content of the diet. It seems that pigtailed macaques are least opportunistic among all the macaques and depend largely on fruits to fulfill their energy requirement (Caldecott, 1986). In fact, their natural diet consists 74% of fruits and 26% of other ingredients (Laska, 2001).

Feeding in captivity

In most of the zoos, they are fed diet very similar to rhesus monkey. Diet schedule of pig-tailed monkey in some of the zoos are listed in table 1.

Table 1: Feeding schedule of pigtail monkey in different Indian zoos

Food (g/day)	Assam	Sepahijala	Lucknow	MCZP
Seasonal fruit			2000	-
Bread	35	-	-	50
Bengal gram	50	100	-	-
Soya bean	150	-	-	-
Black gram	-	-		50
Peanut	200	-		50
Apple	100	100	-	250
Guava	-		-	50
Grape	-	100	-	25
Orange	50	-	-	½ number
Banana	10 numbers	100	-	2 numbers
Chikoo	50	-	-	-
Fodder	-	Ad lib	-	-
Onion	-	-	-	20
Garlic	-	-	-	10
Pumpkin	50	-	-	-
Leafy veg	-	250	-	50
Potato	-	-	-	50
Turnip	-	-	-	100

Materials and Methods

During the present investigation, we conducted feeding trials on 3 pig-tailed macaques in Assam zoo. All the animals were fed their respective zoo diets (Table 1). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, lignin was used as an internal marker. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to feed consumption and diet digestibility are presented in Tables 2-4. From the perusals of the data, it is evident that dry matter intake was higher than those reported in other species of macaques. Dry matter digestibility was similar to those reported in other species of monkey (NRC, 2003). DE intake was 1077 kcal/day. This would translate to metabolizable energy (ME) intake of 969 kcal ME/ day or 85.7 Kcal/kg BW/day. These values are higher than those reported in other species of Macaques (Lane *et al.,* 1995: Henderson *et al.,* 1993).

NRC (1989) recommended that the diet should contain at least 8% crude protein. The diets of Guwahati zoo provided adequate amount of protein to meet this requirement. Requirements of Ca, P and Fe are 0.53%, 0.43%, and 100 ppm. The diets provided adequate amount of Fe, but was deficient in Ca and P. The diets provided adequate amount of fibre recommended by NRC (2003).

Table 2: Composition of feed ingredients fed to pig-tailed Macaque in Assam zoo

Food items	Nutrient composition (on dry matter basis)						
	DM (%)	GE (kcal/kg DM)	CP (%)	NDF (%)	Ca (%)	P (%)	Fe (ppm)
Banana	27.18	3950	5.15	12.4	0.04	0.11	25
Orange	9.18	4070	4.82	14.5	0.11	0.12	38
Bread	57.15	4050	10.42	4.5	0.12	0.72	52
Carrot	7.88	3850	9.81	10.5	0.38	0.41	218
Cucumber	6.02	3760	8.0	4.2	0.44	0.22	78
Pomegranate	15.15	3810	5.23	14.9	0.18	0.21	41
Chickoo	18.45	4140	5.89	5.2	0.11	0.24	70
Apple	14.87	4040	4.99	7.5	0.09	0.16	39
Green pea	21.45	3910	21.84	16	0.29	0.23	88
Soaked gram	51.76	3950	26.18	32.4	0.52	0.27	260
Sugarcane	40.15	3780	5.01	62	0.41	0.14	118
Spinach	7.44	3640	18.55	33.4	0.88	0.15	480
Peanut	88.15	5450	35.28	19.8	0.41	0.24	88
Aamla	18.8	3100	2.66	14.8	0.27	0.12	20

DM, dry matter; CP, crude protein: GE, gross energy: ppm, parts per million

Table 3: Consumption of different food items and NDF by Pig-tailed macaque in Assam zoo

Items	Intake (g/d)	NDF intake (g/d)
Banana	238±56.70	8.02±1.91
Orange	219.83±21.51	2.93±0.29
Bread	85.33±10.40	2.19±0.27
Carrot	123.00±4.04	1.02±0.03
Cucumber	94.83±24.99	0.24±0.06
Pomegranate	37.00±2.89	0.84±0.07
Chickoo	53.00±12.50	0.51±0.12
Apple	52.00±8.72	0.58±0.10
Green Pea	38.33±0.67	1.32±0.02
Soaked Gram	54.67±12.02	9.17±2.02
Sugarcane	144.33±37.97	35.93±9.45
Spinach	64.67±4.81	1.13±0.08
Peanut	5.00±5.00	0.87±0.87
Amla	4.33±5.46	1.23±0.15

Table 4: Feed consumption, diet digestibility and nutrient supply in Pig- tailed macaque at Assam zoo

Dry matter intake (g/d)	284.18±39.88
Dry matter digestibility (%)	86.32±1.41
DE (kcal/d)	1077±4.54
Diet adequacy	
NDF (%)	22.77±1.70
CP (%)	10.06±0.29
Ca (%)	0.32±0.007
P (%)	0.27±0.022
Fe (ppm)	92.80±1.68

DE, digestible energy; NDF, neutral detergent fibre

Suggested guidelines for feeding

1. Hard fruits may be preferred over soft fruits.
2. An adult should be fed about 1000-1200 g of fresh food depending upon the size. Two-third of the ration should comprise of fruits.The ration should not contain more than 100 g of processed cereals and 50 g of soaked gram.
3. Forages may be fed *ad libitum*.
4. Use of ingredients like soybean flakes and peanut may be reassessed.
5. Other general guidelines and feeding practice recommended for lion-tailed monkey may also be followed.

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3.24 Stump-tailed Macaque

Order	:	Primate
Family	:	Cercopithecidae
Genus	:	Macaca
Species	:	*M. arctoides*

Stump-tailed macaque is protected under Schedule I of WPA, 1972 of India. It is listed as vulnerable in Red Data Book of IUCN. Stump tailed macaques have thick, long, brown fur covering their bodies and a very short tail. Stump-tailed macaques have bright pink or red faces which darken to brown or nearly black as they grow and are exposed to sunlight (Fa, 1989). Males are much larger than females, measuring between 517 and 650 mm (20.4 to 25.6 in) and weighing between 9.9 and 10.2 kg. Females have an average weight between 7.5 and 9.1 kg and measure between 485 to 585 mm (Fa, 1989). Male stump-tailed macaques have elongated canine teeth compared to females (Cawthan Lang, 2005). Like other macaques, stump tailed, have pouches in their cheeks to store food for short periods of time. Stump tailed macaques have lower reproduction rate in comparison to other species of macaques. Sexual maturity is attained at the age of 4. Females are reproductively active till 17 years of age (Fooden, 1990). Gestation length varies from 177 to 185 days, after which one singular baby is born (Cawthan Lang, 2005). Stump-tailed macaques are found in subtropical and tropical broadleaf evergreen forest of the North-Eastern India, Southern Burma, Thailand, Vietnam, and Eastern Bangladesh (Groves, 2001). Although they are both arboreal and terrestrial, they prefer to stay on ground. Average life span is about 30 years (Cawthan lang, 2005).

They are frugivorous omnivores. Their main diet comprise of fruits which they supplement with seeds, roots, tubers, frogs, insects and other invertebrates (Fooden, 1990). They also raid crop (Cawthan Lang, 2005).

Table 1: Feeding schedule of stump-tailed moacaque in different Indian zoos

Food (g/day)	Assam	Aizwal	Lucknow	Delhi
Seasonal fruit			2000	-
Sugar cane	200	100	-	-
Carrot	100	50	-	50
Cabbage	-	100	-	-
Maize	-	100	-	-
Beans	-	50	-	-
Okra	-	50	-	-
Tomato	-	50	-	25
Cucumber	200		-	50
Pumpkin	50	300	-	
Apple	100	-	-	250
Papaya	-	100	-	-

Orange	50	-	-	½
Pineapple	-	100		-
Banana	10 numbers	300	-	2 numbers
Bread	35	2 pc	-	100
Gram	50	-	-	50
Soya bean	150	-	-	-
Peanut	200	-	-	-
Chikoo	50	-	-	-
Leafy vegetables	-	-	-	100
Grape	-	-	-	25
Ground nut	-	-	-	50
Onion	-	-	-	25
Garlic	-	-	-	10
Black gram	-	-	-	50
Potato	-	-	-	100
Turnip	-	-	-	100
Milk		-		100
Guava	-	-	-	50

Suggested guidelines for feeding

1. Similar feeding schedule as that of pig- tailed macaque may be followed.

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3.25 Lion-tailed Macaque

Order	:	Primate
Family	:	Cercppithicidae
Genus	:	*Macaca*
Species	:	*M. silenus*

The Lion-tailed Macaque (LTM) is the most endangered species of monkey in India. It is protected under Schedule I of WPA, 1972 of India. It is listed as an endangered species in the IUCN Red Data Book (IUCN, 2003). It is highly endemic in the Western Ghats of Southern India. Hair colour is dark brown to black. It has got characteristic silver-coloured mane from cheek to chin. An adult monkey is 40-61 cm in length; the tail is comparatively shorter than other monkeys with a length of 24-38 cm which forms a tuft at the end. Average range of male body weight is 5-10 kg and average body weight of female ranges from 3-6 kg (BBC, undated).

Lion-tailed macaque are canopy dweller, they live in small group. Depending upon the habitat quality group-size may vary from 6-53 (Sharma, 2002). Birth is observed throughout the year, peak season of birth being January to April (Sharma, 2002). Gestation length is 162-186 days (BBC, undated). Young one is nourished for 1 year. Males are sexually mature at 6 years of age. Female attains sexual maturity at 4 years of age. The age of female at first birth is 80 months in wild and 48 months in captivity (Lindburg *et al.,* 1989). Reproductive efficiency in term of age at first birth and birth rate is inferior in LTM in comparison to other macaques (Kumar, 1987). Average lifespan is 20 years in wild and 30 years in captivity (BBC, undated).

Fruits, seed and flowers (particularly during scarcity) are the main component of LTM diet. Menon and Porier (1996) reported that LTM spend 18% of their time in active foraging. Similarly, Dierenfeld and McCann (1999) reported that LTM spend 19% of their time in active foraging. In other studies, it has been reported that LTM can spend as much as 42% of time in active foraging (Sushma, 2004). It is evident that active foraging is influenced by season and availability of food. Maximum foraging activity was observed in August and minimum foraging activity was observed during May. August was the month when variability of food item was the maximum (Dierenfeld and McCann, 1999). Kumar (1987) reported that LTM used 81 plant species as food. In another study, the variability observed was much less at 41 plant species. Sushma (2004) reported that 78% of their food consisted of floral and 22% of the diet comprised of faunal component.

Lion-tailed macaque has got a simple stomach, relatively smaller small intestine, and haustrated colon adapted for their herbivorous diet (Stevens and Hume, 1985). LTM can tolerate diet containing medium to high amount of fibre. It was demonstrated that animals fed diet containing 30% NDF (neutral detergent fibre) were able to maintain body mass.

Feeding in Captivity

Table 1: Feeding schedule of Lion-tailed macaque in different Indian zoos

Food (g/day)	MCZP	Assam	Trivandrum	Delhi	Nandankanan	Hyderabad
Banana	2 in number	10 in number	150	2 in number	250	4 in number
Plantain	-	-	150	-	-	-
Papaya	200	-	-	-	-	-
Melon	200	100	-	-	-	-
Orange/ Sweet lime	½	50	150	-	-	1 in number
Onion	20	-	-	25	-	-
Garlic	10	-	-	-	-	-
Carrot	50	-	100	-	50	25-50
Peanut	50	200	50	50	50	
Black Gram	50	200	60	-	-	-
Grapes	25	50	200	-	-	-
Spinach/ cabbage	50	-	-	100	-	50
Apple	250	100	100	-	-	1 no.
Pine apple	-	-	40	-	-	-
Turnip	100	-	-	-	-	-
Guava	50	100	50	-	-	-
Bread	50	35	80	100	30	50
Potato	50	-		100	-	-
Coconut	-	-	75	-	-	-
Sugarcane	-	200	-	-	-	-
Carrot	-	100	-	100	-	-
Tomato	-		50	25	-	-
Pumpkin	-	50	-	-	50	-
Bengal gram	-	50	20	50	50	75
Soya bean	-	150	-	-	-	-
Plum	-	100	-	-	-	-
Mango	-	100	-	-	-	-
Jackfruit	-	150	-	-	-	-
Pomegranate	-	150	-	-	-	-
Wood apple	-	½	-	-	-	-
Chickoo	-	50	-	-	-	-
Egg	-	-	50	1 in number	-	-
Beans	-	-	-	-	50	-
Milk	-	-	-	-	100	10
Brinjal	-	-	-	-	-	100
Okra	-	-	-	-	-	50
Rice	-	-	-	-	-	150

*All diets are supplemented with seasonal fruits

The captive lion-tailed macaque diet contains much less fibre. Thus, it is possible and desirable to increase the fibre content of captive lion-tailed macaque diet (Conklin-Britain *et al.,* 1999). Even though natural diet of LTM contain a lot of fruits, it would not be desirable to feed similar amount/ proportion of fruits to the captive population. Cultivated fruits contain more soluble sugars and less fibre. Fruits also contain lesser amount of proteins in comparison to leaves and grains. Further, fruits and seeds are notoriously low in calcium, Na, and P content than woody and leafy portion of the plants (Dierenfeld and McCann, 1999). Leaves, buds, and barks are better source of these nutrients. Thus, many a nutritional problem related to lion-tailed macaque could be overcome by feeding a combination of these two categories of food.

Materials and Methods

During the present investigation, we conducted feeding trials on 9 monkeys each in Thiruvananthapuram and Mysore zoo. In Mysore, 2 animals were fed individually, 2 in a pair and 5 animals in a group. Animals kept as pair and group, were considered as 1 animal unit. In Thiruvananthapuram, all the animals were fed individually during the period of experimentation. All the animals were fed their respective zoo diets (Table 2). During the period of investigation measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory method.

Results and Interpretation

Data pertaining to feed consumption, diet digestibility, and nutrient supply are presented in Tables 3-4.

Table 2 a: Nutrient composition of feed ingredients fed to Lion-tailed Macaque in Thiruvananthapuram zoo

Food Items	Nutrient composition (on dry matter basis)								
	DM %	CP (%)	GE (kcal/ Kg DM)	NDF %	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Thiruvananthapuram zoo									
Green Veg	10.42	18.45	3650	35.4	0.83	0.04	541	8	22
Bread	56.12	14.3	3950	4.5	0.14	0.48	67	2.2	8
Egg	26.28	49.91	6120	-	0.19	0.77	69	12	48
Banana	25.11	5.15	3950	12.4	0.10	0.21	23	8	22
Grapes	8.15	7.2	4050	4.8	0.11	0.36	38	8	14
Carrot	8.85	9.27	3850	18.5	0.15	0.22	216	10	28.8
Tomato	5.98	13.11	3610	16.5	0.45	0.22	175	9	38
Pineapple	14.15	5.78	3940	15.8	0.12	0.08	35	11	35
Cucumber	6.21	9.84	3140	4.2	0.17	0.38	64	11	36
Guava	18.15	7.13	3670	14.3	0.22	0.23	70	12	25
Coconut	58.18	5.17	6150	-	0.24	0.98	45	11	28
Soaked gram	52.14	25.15	3990	32.4	0.32	0.39	75	12	52

DM, dry matter; CP, crude protein; GE, gross energy; ppm, parts per million

Table 2 b: Nutrient composition of feed ingredients fed to Lion-tailed Macaque in Mysore zoo

Food Items	Nutrient composition (on dry matter basis)								
	DM %	CP (%)	GE (kcal/ Kg DM)	NDF %	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Bread	62.11	14.15	3950	4.5	0.13	0.68	30	9	23
Sweet potato	28.44	5.89	3880	22.5	0.22	0.38	80	12	48
Apple	15.14	5.01	3850	7.5	0.04	0.09	110	8	31
Carrot	8.95	7.04	3750	16.5	0.15	0.32	90	7	28
Cabbage	6.78	18.15	2340	17.5	0.58	0.29	115	8	35
Tomato	5.98	14.18	3770	16.5	0.45	0.22	175	9	38
Egg	26.28	49.91	6120	-	0.19	0.77	69	48	12
Pine apple	14.15	5.23	2340	15.8	0.11	0.08	35	9	34
Musk Melon	12.45	6.18	3950	13.6	0.3	0.19	110	9	29
Okra	14.15	15.98	3680	32.5	0.42	0.24	145	10	32
Green Gram	39.85	28.45	4100	28.5	0.32	0.39	75	11	52
Bengal gram	52.03	27.45	4230	32.4	0.42	0.31	70	12	58
Peanut	82.14	28.14	5400	19.8	0.33	0.24	70	12	68
Banana	25.11	5.12	3950	12.4	0.06	0.14	22	8	19

DM, dry matter; CP, crude protein; GE, gross energy; ppm, parts per million

Table 3: Consumption (fresh basis) of different food items in Lion-tailed Macaque at Thiruvanathapuram and Mysore zoo

Food items	Thiruvananthapuram		Mysore zoo	
	Food Intake (g/d)	NDF intake (g/d)	Food Intake (g/d)	NDF intake (g/d)
Bread	115.44±6.10	2.82±0.17	49.75±4.55	1.39±0.13
Sweet potato	-	-	29.25±3.64	1.87±0.23
Apple	-	-	87.25±9.39	0.99±0.11
Tomato	49.33±4.28	0.46±0.05	12.25±2.66	0.12±0.03
Carrot	43.00±4.13	0.38±0.04	31.50±3.80	0.30±0.04
Cabbage	-	-	27.25±4.05	0.23±0.03
Grapes	121.11±10.88	0.44±0.04	-	-
Egg	34.11±5.77	0.00±0.00	47.25±8.78	0.00±0.00
Pineapple	28.56±2.77	0.61±0.06	28.00±4.24	0.63±0.09
Green vegetables	24.40±2.70	0.38±0.04	-	-
Banana	329.78±22.93	10.39±0.68	31.75±5.25	0.99±0.16
Musk melon	-	-	49.00±7.25	0.83±0.12
Guava	26.44±1.92	0.65±0.06	-	-
Cucumber	35.00±2.99	0.09±0.01	-	-
Okra	-	-	20±4.08	0.52± 0.11
Green gram	-	-	15.75±2.95	1.79±0.34
Coconut	37.22±1.38	0.00±0.00	-	-
Soaked gram	40.11±7.26	6.04±1.39	90.25±8.98	15.21±1.51
Peanut	-	-	17.00±5.31	2.76±0.86

NDF, neutral detergent fibre

From the perusals of the data, it is evident that dry matter intake was higher in LTM of Thiruvananthapuram zoo in comparison to those of Mysore zoo. Higher food consumption in Thiruvananthapuram zoo could be due to very high proportion of banana in the diet.

Table 4: Feed consumption, diet digestibility and nutrient supply in Lion-tailed Macaques at Thiruvanathapuram and Mysore zoo

Parameters	Thiruvananthapuram	Mysore
Dry matter intake (g/d)	228.77± 12.705	158.30±14.893
GE intake (kcal/kg DM)	4161.94±18.73	4131.01±39.85
Dry matter digestibility (%)	83.15±0.63	86.32±1.42
DE intake (kcal/kg $BW^{0.75}$)	155.8±10.4	139.7±9.5
Diet adequacy		
NDF (%)	10.16±1.41	17.46±0.27
CP (%)	12.02±0.540	21.58±0.342
Ca (%)	0.23±0.007	0.30±0.003
P (%)	0.40±0.007	0.38±0.009
Fe (ppm)	56.27±1.793	67.19±1.526
Cu (ppm)	7.35±0.083	13.21±0.273
Zn (ppm)	17.86±2.649	39.84±0.292

DM, dry matter; CP, crude protein; GE, gross energy; ppm, parts per million

Dry matter digestibility was similar in both the zoos. DE intake was 561 and 805 Kcal/day in LTM of Thiruvananthapuram and Mysore zoo, respectively. This would translate to metabolizable energy (ME) intake of 505 and 725 kcal ME/day or 79 and 80 kcal/kg BW/day in LTM of 2 respective zoos. These values are similar to those reported in other species of macaques (Lane *et al.,* 1995: Henderson *et al.,* 1993).

However, Robbins and Gavan (1966) reported that the ME requirement in monkey was 93 Kcal/kg $BW^{.0.75}$. NRC (1989) recommends that the diet should contain at least 8% crude protein. Both the diets provided more protein than requirement. We would suggest that high protein contributed by pulses in the diet may not be essential. It may cause extra stress to kidney and liver. Requirements of Ca, P, Fe and Zn are 0.53%, 0.43%, 100 ppm and 20 ppm, respectively. Both the diets provided adequate amount of Zn and P; however, both the diets were deficient in Ca and Fe. Further, Ca:P ratio was also not favourable. Both the diets provided minimum amount of fibre recommended by NRC (1989). However, NDF content was much lower than the 30% recommended by Conklin-Britain *et al.* (1999) for better health. It would be desirable to reduce the proportion of fruits in the diet and to increase the proportion of forages and vegetables in the diet.

Suggested guidelines for feeding

1. Fruits are the main components in the natural diet of LTM. Considering the difference in nutritional composition of wild and cultivated fruits; it would not be wise to feed higher proportion of fruits to captive lion-tailed macaque.
2. An adult should be fed about 700-800 g of fresh food depending upon the size.
3. A typical day could be started with cooked cereals (~50 g) and soaked pulse (~ 50 g) at 8 a.m., which could be followed by some seeds and insects at 11 a.m. Then in the afternoon 200 g of leafy vegetables may be

offered at 2 p.m. Finally, before the closure of the zoo, a mixture of fruits, vegetables and other foods may be provided. This meal should comprise of 225 g of vegetable, 200 g of fruits and 50 g of other products like meat/ egg/ chicken.

4. Fruits and vegetables may be changed on alternate day to provide variety. Similarly, animal products can also be changed on alternate day. Curd could be a good option to provide probiotics and calcium.
5. Lion-tailed macaque spends a lot of time on active foraging. So, for behavioural enrichment, food should be scattered throughout the enclosure and could be concealed. Sometime the dominant male would consume more food and nutritious portion of the ration which may cause obesity. Segregation is not the solution to solve such problems. The answer is to disperse the food in most scattered manner so that all individuals get sufficient amount of food.
6. Accurate weighing of food is essential. So also is body condition scoring of the animal. Amount of food can be changed gradually according to the body condition.
7. Branches, twigs, fodder should be provided *ad libitum*.
8. Hard fruits should be preferred over soft fruit.
9. Some fruits require processing. It is better to provide unprocessed fruits. It provides behavioural stimulation (Smith *et al.*,1989).

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3.26 Common Langur

Order	:	Primates
Family	:	Cercopithecidae
Genus	:	*Semnopithecus*
Species	:	*S. entellus*
Common nam	:	Hanuman langur, sacred langur, Indian langur

Common langur is one of the most commonly sighted primates in the country. The species is protected under Schedule II of WPA, 1972 of India. The body colour is silver gray with black face and limbs. The tail is always larger than the body (Groves, 2001). Sexual dimorphism is prominent, males are larger than females. Average weight ranges from 12.5 to 17.7 kg (Gron, 2008). Females can conceive at an age of 35 months (Sommer *et al*., 1992). Gestation length is about 200 days after which a singular baby is born (Gron, 2008). Weaning starts at an average age of 6.7 months and is complete by 13 months (Rajpurohit and Mohnot, 1991). In free range, male can survive upto 18 years, whereas, female may survive upto 30 years. In captivity, life span is usually more than 30 years (Gron, 2008).

They are well adapted to live in all forest types ranging from, scrub forests of Western Rajasthan, mountain forest of the Himalayas and throughout the deciduous forests of peninsular India, excepting dense rain forest and range higher than 4000 m. They are very arboreal in nature. They spend most of their time feeding on leaves, flowers, fruits and berries. Most feeding activity takes place in the morning and late afternoon, with the langurs resting during the hotter part of the day. In free range, the diet is composed of leaves (52-61%), fruits (15-25%), flowers (4-13%), insects (0.4-3%), and other foods such as bark, gums, and soils (9-16%) (Sayers and Norconk, 2008).

Langurs have a large sacculated stomach which harbours microflora. The colobine digestive system could be divided into saccus gastricus, tubus gastricus and pars pylorica. In some colobines, saccus gastricus is preceeded by pre-saccus. The Indian colobines (Semnopethicus and Trachypathicus), however, do not possess pre-saccus. Bacterial fermentation takes place in the saccus gastricus, whereas, enzymatic digestion takes place in tubus gastricus and pars pylorica. The colobus fore stomach comprised 6-8% of the body weight which is lower than other foregut fermenters. Chivers (1995) stated that folivores have more voluminous fore-stomach than essential frugivores, which have more voluminous small intestine. The cellulytic bacteria present in the foregut break down the cellulose to produce volatile fatty acids which are utilized by the langur to derive energy (Chivers, 1995). The pH of the fore stomach varies from 5.0-7.5. Sutherland-Smith (1998) reported that pH ranged from 6.5-8.0 in healthy and 4.5-8.5 in non-healthy animals. Kay *et al.* (1976) noted that volatile fatty acid concentration in hindgut was more than that in foregut. Thus, it seems that fermentative digestion takes place at both the site (Caton, 1990). Inspite of their smaller body size, digesta retention time in langur is higher than 40 h (Nijboer, 2006).

Study of the Milton (1998) had demonstrated that langurs are not particularly fond of sugary fruits. Their natural diet contained 17% crude protein, 40-50% neutral detergent fibre (NDF) and 15-28% lignin. The natural diet of langurs also contain higher amount of tannins (Burgress and Chapman, 2005). While tannins may hamper utilization of protein their beneficial effect such as suppression of pathogenic bacteria and parasites are also documented (Clauss, 2003). Presence of significant amount of these compounds in the natural diet of colobines implies that they have mechanism to handle such substances (Kool, 1992). Like ruminants, langurs have very large parotid gland. It was indicated that they can produce tannin binding salivary proteins to detoxify tannins (Clauss, 2003). According to Schmidt (2002), vegetables and leafy greens provide high amount of neutral detergent fibre (19% DM), whereas fruits supply only 13%. Fruits are higher in sugar content. Rapid consumption of high amount of fruits will release a lot of sugars in the fore-stomach. This will lead to drop in pH which in turn will slow down fermentation. Thus, the diet of langurs should be balanced with regard to fibre and soluble sugar content.

Feeding in Captivity

Diet schedule followed in different Indian zoos are presented in Table 1.

Table 1: Feeding schedule of Common Langur in different zoos

Food items	Name of the zoo					
	NKBP	Manglore	SJBP	Chattbir	TVC	Alipore
Banana	250 g	-	80 g	2 nos	150 g	200 g
Apple	-	-	100 g	-	100 g	-
Bengal gram	50 g	-	100 g	-	20 g	-
Grape	-	-	100 g	25 g	200 g	-
Vagatables	-	200 g	250 g	-	-	-
Seasonal fruits	-	100 g	-	-	-	-
Okra	50 g	-	-	-	-	-
Bread	30 g	100 g	-	-	-	100 g
Rice	50 g	-	-	-	-	-
Groundnut	50 g	50 g	-	50 g (roasted)	60 g	-
Groundnut	-	-	-	-	-	-
Blackgram	50 g	-	-	-	-	-
Beans	50 g	-	-	-	-	-
Cucumber	-	-	-	50 g	100 g	-
Green peas	-	-	-	50 g	-	-
Spinach	-	-	-	50 g	-	-
Guava	-	-	-	250 g	50 g	-
Plantain	-	-	-	-	150 g	-
Carrot	-	-	-	-	50 g	200 g
Egg	-	-	-	50 g	150 g	-
Orange	-	-	-	-	40 g	-
Pineapple	-	-	-	-	50 g	-
Tomato	-	-	-	-	-	200 g
Red potato	-	-	-	-	-	150 g

NKBP, Nandankanan biological park; SJBP, Sepahijala biological park ; TVC, Thiruvanthapuram

The average dry matter digestibility in captivity ranged from 59-89%. (Nijboer, 2006). Such higher variation had been attributed to the variation in NDF content of the diet. Most zoo diet contained 9-15% of acid detergent fibre (ADF), which could have attributed to higher digestion coefficient. However, natural diet of langur contained more than 30% ADF. When such higher level of ADF was fed DM digestibility was 60%. In a survey (Nijboer *et al.,* 1996), it was found that 149 different food items were used in feeding programme of Asian Colobines in American and Asian Zoos. Some of the commonly fed items were fruits (Apple, banana, grape, pear etc), vegetable (bean, carrot, celery, cucumber, onion, green pepper, potato, yam etc.), animal products (egg), leafy vegetable (broccoli, cabbage, fennel, kale, lettuce, spinach etc.), browses (poplar, maple, rose, willow etc.) and others (bread, primate pellet). Natural diet of langur contains much more fibre and less sugar than the zoo diet. Due to this, captive langurs often suffer from diarrhea (Hill, 1964). Significant improvement in stool quality could be achieved by increasing the fibre content of the diet (Nijboer, 2006).

Materials and Methods

During the present investigation, we conducted feeding trials on 2 common Langurs in Sri Chamarajendra Zoological Garden Mysore. As the number of animals was limited, we used the repeated measurement technique to obtain 4 observations. All the animals were fed their respective zoo diets (Table 2). During the period of investigation measured amount of food was offered and all the refusals were collected for consecutive 3 days during each observation. For determination of intake and digestibility, lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of feedstuff, consumption of different feed items and diet adequacies are presented through Tables 2-4.

Table 2: Nutrient composition of feed ingredients fed to Common Langur in Mysore zoo

Food Items	Nutrient composition (on dry matter basis)								
	DM %	GE (kcal/kg)	NDF (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Bread	58.12	4080	4.5	14.11	0.12	0.39	65	8	24
Sweet potato	26.46	3880	20.5	5.74	0.44	0.16	81	11	33
Apple	14.97	3480	7.5	5.22	0.09	0.22	38	9	28
Carrot	8.85	3680	10.5	9.27	0.14	0.23	216	10	31
Sprouted Green Gram	39.14	3740	28.5	28.14	0.45	0.51	68	12	54
Soaked Bengal gram	51.84	3990	32.5	27.54	0.49	0.38	77	12	55
Leafy green vegetables	10.14	3680	37.45	18.57	0.83	0.11	380	8	24
Peanut	82.14	5400	19.8	28.14	0.33	0.24	70	12	68
Okra	14.15	3680	38.5	15.98	0.42	0.24	145	10	32

DM, dry matter: CP, crude protein: GE, gross energy: ppm, parts per million

Table 3: Consumption (fresh basis) of different food items by Common Langur in Mysore zoo

Food items	Intake(g/d)
Bread	51.67±2.91
Sweet Potato	69.67±10.73
Apple	44.67±2.03
Carrot	37.00±2.65
Sprouted green gram	16.67±1.76
Soaked Bengal gram	80.33±4.81
Leafy green vegetables	76.67±4.91
Peanut	41.00±2.31
Okra	16.00±1.15

DM, dry matter, CP, crude protein; GE, gross energy; ppm, parts per million

Table 4: Feed consumption, diet digestibility, and nutrient supply in Common Langur at Mysore zoo

Parameters	(Mean±S.E.)
Dry matter intake (g/d)	150.31±6.13
GE (cal/kg DM)	4249.19±14.60
Diet adequacy	
NDF%	19.31±0.24
CP (%)	21.32±0.23
Ca (%)	0.40±0.002
P (%)	0.30±0.002
Fe (ppm)	91.23±1.35
Cu (ppm)	10.66±0.03
Zn (ppm)	45.31±0.11

CP, crude protein; GE, gross energy; ppm, parts per million; NDF, neutral detergent fibre

Dry matter intake was 1.25% of body weight in the present experiment. Total DMI was similar to 1.4% reported for black and white colobus monkey (Edwards, 1997). Nutrient requirement of langurs are not known. Based upon the NRC requirements for Non-human primates (NRC, 2003), it was suggested that diet should contain 16.7% CP, 0.56% Ca, 0.43% P and 100 ppm of Fe. The diet presently being fed to common Langur in SCZG, Mysore was marginally deficient in Ca and Fe. In this experiment NDF content was only 20%. Thus, it would be necessary to increase the proportion of browses and to decrease the proportion of fruits in the diet.

Suggested guidelines of feeding

1. Amount of fruits should not exceed 25% of the diet dry matter.
2. A diet containing 50 g bread, 50 g tubers, 100 g apple, 100 g pear/guava/

other fruit, 50 g sprouted pulses, 100 g soaked gram, 300 g mixed vegetables (cabbage/ carrot/ beans), 200 g leafy vegetable and 50 g okra may be fed. Browses should be fed ad lib. (at least- 400 g /langur/d).

3. Peanuts or other nuts can be given as treat, not as regular food.

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3.27 Nilgiri Langur

Order	:	Primates
Family	:	Cercopithicidae
Genus	:	*Trachypithecus*
Species	:	*T. Johnii*
Common name	:	Indian hooded leaf monkey, John's langur

Nilgiri langur is an endemic species of primates belonging to the group of leaf-eating monkeys of Asia. The species is protected under Schedule I of Wildlife Protection Act of India (1972). IUCN Red Data Book (2003) lists the species as vulnerable. The pelage colour is glossy black; furs on head are golden in colour. The average body mass for an adult male and female Nilgiri langur is 9-14.8 and 11- 12.0 kg, respectively. The average head-body length is 78 and 58 cm in male and female, respectively (Parthasarathy, 1995). Tail length is 69 to 97 cm. Most of the births occur during may-June and September-November. The seasonality in birth pattern could be correlated with abundance of food. Gestation length is not known, but assumed to be about 200 days, after which a singular baby is born (Malviya *et al*., 2011).

Nilgiri langurs are distributed from Kanyakumari in the south to Koorg in the North. The troop size may vary from 5-24 individual in uni-male troop. They are strictly arboreal and prefer tropical evergreen forest (Sunderraj, 2001). They spent 44% of their time on feeding. Most of the feeding activities take place during early morning and late afternoon. Number of plants eaten by Nilgiri langurs varied from 29-102 in different studies. Out all these plants, *Terminalia bellerica* and *Derris pinnata* were most important food resources for the Nilgiri langur. Their natural diet consisted of young leaves (44%), mature leaves (4%), flowers (8%), unripe fruit (11%), ripe fruit (5%), seeds (19%) and other (9%) minor food items (Sunderraj, 2001).

In another study (Roy *et al.,* 2012), it was reported that Nilgiri langur diet conoisted of 97 plant species. They preferred tree species (84%), followed by climbers (7.5%), shrubs (6.5%) and grasses and herbs (1%).

They preferred foliages of many different tree species like *Xylia xylocarpa*, *Melia dubia*, *Tectona grandis*, *Acacia concinna*, *Embilica officinalis*, *Terminalia tomentosa*, and *Ficus bengalensis* (Roy *et al.,* 2012).Their diet choice was also influencd by habitat type and nutrient content of the feedstuff. When available, they preferred young leaves to mature leaves because young leaves contained more crude protein and less neutral detergent fibre.

Feeding in Captivity

In India most of the zoo feed fruits and vegetables to the langur which contain more soluble sugar and such kind of diets may cause dietary distrubance.

Table 1: Diet chart of Nilgiri langurs in different Indian zoos

Food items	Name of the Zoo	
	Nandankanan	Tiruvananthapuram
Bengal gram	50 g	20 g
Brinjal	100 g	-
Okra	50 g	-
Bread	30 g	80 g
Pumpkin	50 g	-
Tomato	-	50 g
Bean	50 g	-
Milk	10 g	-
Rice (parboiled)	50 g	-
Ripe banana	250 g	150 g
Plantain	-	150 g
Carrot	50 g (Oct.-March)	50 g
Sweet potato	100 g (Oct-March)	-
Crab	50 g (June- Sept.)	-
Amla	25 g (Nov-Dec.)	-
Green pea	50 g (Dec.-Feb.)	-
Mango	50 g (Apr-May), green	100 g
Green maize	100 g (Sept.-Oct.)	
Pine apple	100 g (May-July)	40 g
Water melon	150 g	-
Coconut	-	80 g
Cucumber	-	100 g
Egg	-	50 g
Grapes	-	20 g
Ground nut (hull less)	50 g	30 g
Ground nut (hull)	-	30 g
Guava	-	50 g
Orange	150 g	-

Materials and Methods

As the number of animals was limited, we used the repeated measurement technique to obtain 4 observations. All the animals were fed their respective zoo diets (Table 2).During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 3 days during each observation. For determination of intake and digestibility, lignin was used as an internal marker. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of feedstuff, consumption of different feed items and diet adequacies are presented through Table 3-5.

Table 2: Feed Chart of Common and Nilgiri Langurs at Sri Chamarajendra Zoological Garden, Mysore

Food item (g/day)	Nilgiri Langurs	Common Langurs
Bread	50	50
Potato	0	25
Apple	100	50
Cabbage	50	0
Tomato	30	0
Seasonal fruits	100	50
Beans	25	50
Green gram	0	25
Mixed Vegetables	100	100
Soaked gram	100	100
Peanut	100	100
Banana	50	0
Okra	50	20

Table 3: Nutrient composition of feed ingredients fed to Nilgiri langur in Mysore zoo

Food Items	Nutrient composition (on dry matter basis)								
	DM (%)	GE (Kcal/kg	NDF (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Bread	58.12	4080	4.5	14.11	0.11	0.39	65	8	24
Sweet potato	26.46	3880	20.5	5.74	0.14	0.16	81	11	33
Apple	14.97	3880	7.5	5.22	0.14	0.22	38	9	28
Carrot	8.85	3680	10.5	9.27	0.18	0.23	216	10	31
Sprouted green gram	39.14	3740	28.5	28.14	0.45	0.51	68	12	54
Soaked Bengal gram	51.84	3990	32.5	26.54	0.49	0.38	77	12	55
Leafy green vegetables	10.14	3680	37.45	18.57	0.83	0.11	380	8	24
Peanut	82.14	5400	19.8	28.14	0.33	0.24	70	12	68
Okra	14.15	3680	18.5	15.98	0.42	0.24	145	10	32

DM, dry matter: CP, crude protein: GE, gross energy: ppm, parts per million

Table 4: Consumption (fresh basis) of different food items by Nilgiri langur in Mysore zoo

Food items	Intake (gram/d)
Bread	49.67±4.91
Apple	78.33±6.39
Carrot	48.33±0.88
Cabbage	45.33±2.19
Tomato	20.67±4.06
Soaked Bengal gram	75.00±5.13
Leafy green vegetables	89.33±4.67
Peanut	46.33±8.67
Banana	50.00±0.00
Okra	103.67±9.87

Nutrition Advisory Group (Edward, 1997) recommended that the diet of leaf eating primates should contain at least 30% neutral detergent fibre (NDF). In this experiment, NDF content was only 20%. Thus, it would be necessary to increase the proportion of browses and to decrease the proportion of fruits in the diet. Results of the present investigation suggest that apple and banana could be reduced in Nilgiri langur diet.

Table 5: Feed consumption and nutrient supply in Nilgiri Langur

Parameter	Mean±S.E.
Dry matter intake (g/d)	163.19±7.95
Diet adequacy	
Neutral detergent fibre (%)	19.87±0.19
Crude protein (%)	20.27±0.32
Ca (%)	0.37±0.003
P (%)	0.30±0.006

Suggested guidelines of feeding

1. Amount of fruits should not exceed 25% of the diet dry matter.
2. Proprtion of green leafy vegetables should be increased.
3. A diet containing 50 g bread, 50 g tubers, 100 g apple, 100 g pear/guava/ other fruit, 50 g sprouted pulses, 50 g soaked gram, 200 g mixed vegetables (cabbage/carrot/beans), and 200 g leafy vegetable may be fed. Browses should be fed ad lib. (at least 400 g /langur/d).

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3.28 Phayre's Leaf Langur

Order	:	Primates
Family	:	Cercoithicidae
Genus	:	*Trachypithecus*
Species	:	*T. Phayrei*
Common name	:	Spectacled langur

Leaf langur or spectacled langur is an endangered species (IUCN, 2003) and is protected under Schedule I of the WPA, (1972) in India. Phayre's leaf-monkey is found in the countries of Bangladesh, Burma, China, India, Thailand, and Vietnam (Srivastava, 1999; Stanford, 1988). In India, this species is found in Tripura, Mizoram, and Assam (Gupta, 2002). The body length ranges from 42-63 cm. The average body weight of an adult male is around 7.3 kg and for the female it is around 6.2 kg (Fleagle, 1988). The hair color is dark ashy brown on the dorsal side and whitish on the ventral side (Choudhury, 1994). They become sexually mature at 3-4 years of age (Yeggar and Kirkpatrick, 1998). Mean cycle length is 28.4 days, of which duration of follicular and luteal phase is 15.4 and 12.5 days, respectively. Phayre's leaf-langur gives birth to a single offspring, after a gestation period of 205 days (Lu *et al.,* 2010). Data regarding lifespan is not known, but is assumed to be 20-30 years (Cantwell, 2011).

Leaf-langur is a folivorous species (Bose and Bhattacharjee, 2002). In the Inner Line Reserve Forest of Assam, this species was reported to consume bamboo shoots (Srivastava, 1999). In southern Assam, the three most preferred food items were *Teinestachum dulloea*, *Dendrocalamus griffithii*, and *Mokania micrantha* (Bose and Bhattacharjee, 2002). Feeding activity is maximum during early morning and late afternoon (Srivastava, 1999). Their natural diet consisted of young and mature leaves, ripe and unripe fruits, seeds, petioles, flowers, and gums (Gupta and Kumar, 1994). The most important food resources for spectacled langur were *Albizzia procera*, *Melocanna bambusoides*, *Callicarpa arborea*, *Albizzia stipulata*, and *Albizzia lebbek* (Gupta and Kumar, 1994). Among these, young leaves, pods and seeds, and gum of *Albizzia procera* was utilized most (Gupta and Kumar, 1994).

Feeding in Captivity

Feed chart of Phayre's Leaf Langur at Sepahijala Biological Park

Food item	Adult	Sub-adult
Banana (numbers)	7	4
Soaked Bengal gram (g/d)	100	50
Green vegetables (g/d)	250	150
Apple (g/d)	100	50
Grape (g/d)	100	50
Fodder	*Ad lib.*	*Ad lib.*

Being predominantly folivore, leaf langurs have to adopt digestive strategy to extract nutrients from fibrous material. Their fore-stomach is sacculated which harbours cellulolytic microorganisms like ruminants. The microbial enzymes degrade the fibrous material and volatile fatty acid is produced which are absorbed from the foregut. They also have very large parotid glands like ruminants. However, they do not ruminate. Unlike, more carnivorous, cercpethicine monkey, they do not have cheek pouch. The sacculated stomach includes a gastric canal which connects to the presaccus. This arrangement is similar to reticular groove of ruminants to protect milk being fermented by microbial enzymes (Ankel Simon, 2000).

Materials and Methods

During the present investigation, we conducted feeding trials on 4 Spectacled langurs in Sepahijala Biological Park, Tripura. All the animals were fed their respective zoo diets (Table 1). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory method.

Results and Interpretation

Data pertaining to nutrient composition of feedstuff, consumption of different feed items and diet adequacies are presented through Tables 2-3.

Table 1: Feed consumption (fresh basis) of different food items in Leaf monkey at Sepahijala Biological Park

Food items	Intake (g/day)
Bottle gaurd	127.75±16.75
Cucumber	60.25±10.77
Apple	87.75±27.10
Mosambi	68.50±9.65
Bean	57.25±16.44
Soaked Bengal gram	68.00±5.72
Banana	304.25±33.22
Gul mohar leaves	40.50±2.06
China rose leaves	30.50±3.77

Dry matter intake was found to be 2.5% of BW in the present experiment. Total DMI was lower than 3.2% of BW reported for Francois Langur (Edwards, 1997). This difference could be due to slightly smaller body size of Francois Langur. Smaller animals are known to consume more food as proportion to body size. Dry matter digestibility was similar to those reported in other species of monkey (NRC, 2003). DE intake was 1077 kcal/day. Metabolizable energy (ME) intake was 121 Kcal/kg $BW^{0.75}$/day. These values are higher than those reported in other species of Macaques (Lane *et al.,* 1995: Henderson *et al.,* 1993).

Table 2: Nutrient composition of feed ingredients fed to leaf langur in Sepahijala Biological Park

Food items	Nutrient composition (on dry matter basis)								
	DM (%)	GE (kcal/kg DM)	NDF%	CP (%)	Ca (%)	P %	Fe (ppm)	Zn (ppm)	Cu (ppm)
Bottle guard	5.23	3450	36.4	4.11	0.43	0.24	85	32	12
Cucumber	5.23	3140	15.2	5.88	0.31	0.19	74	11	9
Apple	15.82	4040	17.5	4.99	0.09	0.16	110	34	8
Mosambi	6.05	4000	13.2	5.04	0.08	0.21	22	21	9
Bean	31.23	3670	22.5	26.47	0.52	0.33	110	51	11
Soaked gram	52.42	3990	27.5	31.42	0.35	0.26	50	65	14
Banana	25.14	4100	12.5	5.12	0.09	0.17	60	25	8
Gold mohar	23.81	3750	41.5	20.48	1.22	0.31	580	28	8
China rose	24.85	3890	38.6	18.57	1.1	0.28	470	35	9

DM, dry matter; CP, crude protein; GE, gross energy(kcal/kg DM); ppm, parts per million

Nutrient requirement of leaf langurs are not known. Based upon the NRC requirements for Non-human primates (NRC, 2003), it was suggested that diet should contain16.7% CP, 0.56% Ca, 0.43% P and 100 ppm of Fe. The diet presently fed to leaf langurs in Sepahijala Biological Park was deficient in protein and Ca. Nutrition Advisory Group (Edward, 1997) recommended that the diet of leaf eating primates should contain at least 30% neutral detergent fibre (NDF). In this experiment, NDF content was only 21.4%.

Table 3: Feed consumption, diet digestibility, and nutrient supply in Leaf langur at Sepahijala

Parameters	Mean ±S.E.
Dry matter intake (g/day)	175.09±18.042
ME (kcal/kg BW $^{0.75}$)	121±3.5
Dry matter digestibility (%)	83.2±2.2
Diet adequacy	
NDF%	21.43±0.26
CP (%)	14.08±0.303
Ca (%)	0.37±0.003
P (%)	0.30±0.006
Fe (ppm)	99.01±2.211
Cu (ppm)	10.35±0.077
Zn (ppm)	43.46±1.117

DM, dry matter; CP, crude protein; GE, gross energy; ppm, parts per million

Thus, it would be necessary to increase the proportion of browses and to decrease the proportion of fruits in the diet. In the present investigation, 54% of total DMI was from fruits, which is exceptionally higher for folivores.

Suggested guidelines for feeding

1. Commercial fruits could be even eliminated. If not possible, the amount may be restricted. Amount of banana may be reduced by 25% with addition of equal amount of browses.
2. A diet comprising of 150 g bottle gourd, 100 g cucumber, 100 g apple, 100 g beans/cabbage, 75 g soaked Bengal gram, 200 g (maximum) banana, 100 g spinach/ amaranthus/ leafy vegetables, 100 g leaves twigs of China rose and 100 g browse of gul mohur would fulfill the requirements.
3. Any dietary changes should be made gradually. Animal's response to such changes should be critically observed before progression of further change.
4. In free range, they spend considerable time in foraging. Food may be spread throughout the enclosure to provide behavioural stimulation. This would also reduce over feeding by the dominant male.
5. They should be fed throughout the day. At least 3 meals should be provided.
6. Too much experimentation with browse species is not encouraged. Only those species which have been tested earlier and were found to be satisfactory should be used. China rose and gul mohur is excellent in nutritional make-up.

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3.29 Capped Langur

Order	:	Primates
Family	:	Cercopithecidae
Genus	:	*Trachypithecus*
Species	:	*T. pileatus*
Common name	:	Bonneted langur, Capped leaf monkey

Capped langur is an endangered species of primates found in Bangladesh, Nepal, Bhutan, India and Myanmar. It is protected under Schedule I of WPA (1972) of India. The species is listed as vulnerable in the IUCN Red Data Book (IUCN, 2003). It is one of the largest leaf eating colobines of Asia. Adult male weight is 11 kg and female weight is 10-11 kg. The fur on the back is dark grey to black in colour. The fur on the belly is white or golden yellow in colour. The characteristic feature of the species is a dark grey cap of erect hairs and wide laterally protruding cheek tuft (Stanford, 1991). This colobine langur is found in all the North-Eastern states of India. It is the most common langur in the region (Choudhury 2001). It is distributed from flood plains of Assam to an altitude of 2800 m above msl in the Eastern Himalayas. Most mating takes place during September and January, but a smaller peak also occurs during April and May. Most of the birth takes place between December and April, with majority occurring during March. Gestation length is about 200 days after which a singular baby is born (Primata, 2006). Maximum longevity recorded in the species is 25.2 years in captivity (Weigel, 2005).

Capped langurs like other species of the genus *Trachypethicus* are folivore and their fore-stomach is sacculated. Islam (1982) reported that capped langurs spent 30% of their time on foraging, 42% on resting, and 19% on other activities like playing, grooming etc. Their natural diet comprised 60% of leaves, 30% of buds, flowers, and seeds and rest 10% was other items. Proportion of young leaves, mature leaves, and fruits in capped langur diet was 11, 42, and 24%, respectively. Considerable amount of seasonal variation in diet selection was also observed. During winter, mature leaves comprised 80% of the total diet, whereas, proportion of fruits may go up to 50% of the total diet during monsoon. It seems that they are adapted to cope with seasonal food scarcity (Islam, 1982). In another study, it was reported that proportion of leaf, flower and fruit was 68, 16 and 16%, respectively (Solanki *et al*., 2008).

Feeding in Captivity

Table 1: Diet Chart of Capped langur at Sepahijala Biological Park

Banana* (number)	Bengal gram (g)	Vegetable (g)	Apple (g)	Grape (g)	Fodder (g)	Leaves (g)
8	100	250	100	100	Ad lib	Ad lib

Materials and Methods

During the present investigation, we conducted feeding trials on 5 Capped langurs in Sepahijala Biological Park, Tripura. All the animals were fed their zoo diets (Table 1). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of feedstuff, consumption of different feed items and diet adequacies are presented through Tables 2-4.

Table 2: Nutrient composition of feed ingredients fed to Capped Langur in Sepahijala Biological Park

Food items	Nutrient composition (on dry matter basis)								
	DM (%)	GE (kcal/kg DM)	NDF (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Bottle guard	5.23	3750	36.4	4.11	0.43	0.24	85	32	12
Cucumber	5.23	3740	15.2	5.88	0.31	0.19	74	11	9
Apple	15.82	4040	17.5	4.99	0.09	0.16	110	34	8
Mosambi	6.05	4000	13.2	5.04	0.18	0.21	22	21	9
Bean	31.23	3670	22.5	26.47	0.52	0.33	110	51	11
Soaked gram	52.42	3990	32.5	27.42	0.41	0.26	50	65	14
Banana	25.14	4100	12.5	5.12	0.09	0.17	60	25	8
Gold mohar	23.81	3750	41.5	20.48	1.22	0.31	580	28	8
China rose	24.85	3890	38.6	18.57	1.1	0.28	470	35	9

DM, dry matter; CP, crude protein; GE, gross energy (kcal/kg DM); ppm, parts per million

Table 3: Consumption of (fresh basis) different food by capped Langurs at Sepahijala Biological Park

Feed consumed	Intake (g/day)
Bottle guard	231.4±5.81
Cucumber	141±5.94
Apple	118.8±0.66
Mosambi	99.8±7.98
Bean	85.2±4.66
Soaked Bengal gram	106.4±4.15
Banana	421±28.85
Gold Mohar	106.4±6.70
China rose	95±8.04

DM: dry matter, CP: crude protein, GE: gross energy, ppm: parts per million

Dry matter intake was 2.8% of body weight in the present experiment. Total DMI was lower than 3.2% reported for Francois Langur (Edwards, 1997). This difference could be due to slightly smaller body size of Francois Langur. Smaller animals are known to consume more food as proportion to body size. However, DMI was higher than spectacled langur at the same location on same diet.

Dry matter digestibility was lower than spectacled langur. However, wide variations in diet digestibility among colobines have been reported (Nijboer, 2006). It is interesting to note that capped langur consumed more browses and more fibre than spectacled langur. Metabolizable energy intake was 123.7 kcal/kg BW $^{0.75}$/d. These values are higher those reported in Macaques (Lane *et al.,* 1995: Henderson *et al.,* 1993).

Table 4: Feed consumption, diet digestibility and nutrient supply in apped Langur at Sepahijala Biological Park

Parameters	Mean±S.E.
Dry matter intake (g/d)	281.47±10.350
ME intake (kcal/kg BW $^{0.75}$)	123.7±1.7
Dry matter digestibility%	73.7±1.05
Diet adequacy	
Neutral detergent fibre (%)	23.85±0.57
Crude protein (%)	14.85±0.309
Ca (%)	0.41±0.006
P (%)	0.23±0.002
Fe (ppm)	147.94±3.284
Cu (ppm)	10.20±0.099
Zn (ppm)	36.98±0.521

Nutrient requirement of capped langurs are not known. Based upon the NRC requirements for non-human primates (NRC, 2003), it was suggested that diet should contain 16.7% CP, 0.56% Ca, 0.43% P and 100 ppm of Fe. The diet presently fed to Capped langurs in Sepahijala Biological Park was only marginally deficient in Ca and protein and was adequate in all other aspects. It was interesting to observe that Capped langurs were able to extract more nutrients than spectacled langurs on same diet plausibly by applying their nutritional wisdom.

Suggested guidelines of feeding

1. Natural diet of langur can contain up to 80% leaves. In the present feeding schedule browses comprised only 17% of the total diet on dry matter basis. These browses can be fed unrestricted amount.
2. Consider, addition of locally available green vegetables like amaranthus, spinach and poi. Also consider addition of some flowers in the diet.
1. This diet was one of the best fed to colobines in Indian zoos. With the modifications suggested, this could be a model diet. A diet containing 250 g bottle gourd, 200 g cucumber, 100 g apple/ pear/ guava, 100 g beans, 200 g other vegetables (carrot/ cabbage/ pumpkin/ eggplant), 100 g soaked gram, 50 g bread , 200 g banana, 200 g gold mohur leaves , 100 g spinach and 200 g china rose would be adequate.
3. Feed browses *ad lib*.

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3.30 Golden Langur

Order	:	Primates
Family	:	Cercoithicidae
Genus	:	*Trachypithecus*
Species	:	*T. geei*
Common name	:	Gee's langur

The golden langur, is an endangered species endemic to India and Bhutan. Its distribution is limited to a small forest belt in Western Assam in Northeast India and Bhutan (Chaudhury, 1992). It is protected under Schedule I of WPA (1972) of India and is listed as endangered on IUCN Red Data Book (IUCN, 2003). they have golden hair, black face, and very long tail. Head to body length varies from 50 to 75 cm and body mass vary from 9.5 to 12 kg. After a gestation period of 6 months female will give birth to a single baby. The breeding season is January-February (Subba, 1989).

Mukherjee (2001) reported that leaves are the most important food item for golden langur. Gee (1961) found that the diet of the golden langur consisted mostly of fresh, tender leaves, buds, and fruits. The diet of this species consisted mostly of leaves and buds of *Bombax ceiba*, *Bahunia*, *Ficus*, *Acacia*, and *Terminalia* species (Khajuria, 1977). Their diet consisted of 74% leaves, 9% fruits, and 5% flowers (Biswas, 2002).

The stomach of colobine monkeys is large and multi-chambered The fore-stomach (presaccus plus saccus) harbours microflora that breakdown cellulose to produce volatile fatty acids (Davies and Oates, 1994) and detoxify possible toxic compounds found in cellulose rich diet (Calle *et al.,* 1995). Folivorious primates do not ruminate (Calle *et al.,* 1995). According to Davies and Oates (1994), colobines eat moderate to high quality leaves to mature leaves. Kool (1993) indicated that sweet fruits may cause hyperacidity. When large amount of fruits are consumed, large quantity of simple sugars are released. Amount of volatile acids produced by bacterial fermentation increase too quickly for the animal to absorb them, resulting in drop in pH and damage to the microflora, which may be injurious to the animal.

Feeding in Captivity

Table 1: Diet chart of Golden langur in Assam State Zoo

Sugarcane	Carrot	Cucumber	Pumpkin	Apple	Sweet lime
200 g	100 g	200 g	50 g	100 g	50 g
Banana	Athia banana	Bread	Bengal gram	Soy flake	Peanut
8 numbers	2 numbers	35 g	50 g	150 g	200 g
Seasonal food items					
Lassera	Amla	Wood apple	Guava	Mango	Pear
50 g	10 g	½ number	100 g	100 g	100 g
Seaonal foods					
Grape	Jackfruit	Pomegranate	Orange	Plum	Chicko
50 g	100 g	100 g	1 number	100 g	50 g

Materials and Methods

During the present investigation, we conducted feeding trials on 5 golden langurs in Assam State Zoo, Guwahati. All the animals were fed their zoo diets (Table 3). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, chromic oxide was used as an external marker and lignin was used as an internal marker. Samples of feed, faeces, and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of feedstuff, consumption of different feed items and diet adequacies are presented through Tables 2-4.

Table 2: Nutrient composition of feed ingredients fed to Golden Langur in Assam State Zoo

			on dry matter basis						
Food item	**DM (%)**	**GE(Kcal/kg DM)**	**NDF (%)**	**CP% (%)**	**Ca% (%)**	**P% (%)**	**Fe (ppm)**	**Zn (ppm)**	**Cu (ppm)**
Banana	24.18	3950	4.2	5.62	0.11	0.24	25	18	7
Orange	12.48	3680	12.4	5.8	0.15	0.12	17	18	8
Bread	59.14	3950	4.5	10.18	0.13	0.51	32	28	9
Carrot	7.89	3580	20.5	7.17	0.18	0.13	95	27	8
Cucumber	6.42	3740	24.2	5.88	0.31	0.19	74	11	15
Pome granate	23.14	3690	14.9	5.43	0.11	0.22	118	22	11
Chickoo	22.81	3690	5.2	3.88	0.14	0.18	48	17	8
Apple	15.87	3570	7.5	5.01	0.05	0.11	110	34	8
Mosambi	11.88	3570	12.2	4.97	0.16	0.21	22	21	9
Grape	7.6	4050	4.9	7.11	0.04	0.38	38	18	11
Coconut	58.18	6050	17.3	5.17	0.23	0.98	43	28	10
Sugarcane	39.45	3840	62.2	3.88	0.44	0.17	110	19	8
Peas	27.48	3950	16	28.88	0.21	0.31	80	52	11
Spinach	5.81	3180	23.4	16.45	0.83	0.21	383	22	8
Peanut	82.14	5510	19.8	28.14	0.39	0.27	75	68	11
Soaked gram	51.24	3910	22.5	26.25	0.55	0.37	78	51	12
Berry	16.66	3650	17.2	2.33	0.21	0.11	16	19	7

DM, dry matter; GE, gross energy (kcal/kf DM), NDF, neutral detergent fibre; CP, crude protein

Dry matter intake was 2.4% of body weight in the present experiment. Total DMI was higher than 1.4% reported for black and white colobus monkey (Edwards, 1997). This difference could be due to type of diet. In the previous experiment, a fibrous diet was used. In the present experiment the diet contained more amount of fruits which are more palatable than browses. Smaller animals are known to consume more food as proportion to body size. Dry matter digestibility was similar to those reported in other species of monkey (NRC, 2003). Metabolizable energy (ME) intake was 128 Kcal/kg $BW^{0.75}$/day. These values are higher those reported in macaques (Lane *et al.,* 1995: Henderson *et al.,* 1993).

Table 3: Consumption (fresh basis) of different food items by Golden Langur at Assam state zoo

Food items	Food intake (g/d)
Banana	288.25±43.60
Orange	40.67±4.37
Bread	28.83±1.83
Carrot	39.83±14.25
Cucumber	64.92±15.08
Pomegranate	44.75±9.13
Chickoo	44.63±1.72
Apple	50.67±8.17
Mosambi	37.75±3.68
Grape	73.53±8.15
Coconut	35.33±13.09
Sugar cane	35.42±6.21
Peas	66.00±10.97
Spinach	57.75±3.02
Peanut	21.17±4.78
Soaked gram	80.72±17.08
Berry	71.85±17.18

Table 4: Feed consumption, diet digestibility and nutrient supply in Golden langur at Assam State Zoo

Parameters	Mean
Dry matter intake (g/day)	267.16±28.00
GE (kcal/kg DM)	128 ±4.2
Dry matter digestibility (%)	76.6±1.95
Diet adequacy	
NDF (%)	16.55±0.10
CP (%)	14.17±0.02
Ca (%)	0.26±0.017
P (%)	0.35±0.02
Fe (ppm)	57.95±3.62
Cu (ppm)	10.40±0.94
Zn (ppm)	35.20±2.29

GE, gross energy; NDF, neutral detergent fibre; CP, crude protein

Nutrient requirement of golden langurs are not known. Based upon the NRC requirements for non-human primates (NRC, 2003), it was suggested that diet should contain16.7% CP, 0.56% Ca, 0.43% P and 100 ppm of Fe. The diet presently fed to golden langur was deficient in protein and Ca. Nutrition Advisory Group (Edward, 1997) recommends that the diet of leaf eating primates should contain at least 30% neutral detergent fibre (NDF). In this experiment, NDF content was only 17%. Thus, it would be necessary to increase the proportion of browses and to decrease the proportion of fruits in the diet. In the present investigation, 54% of total DMI was from fruits, which is exceptionally higher for folivores. Golden langurs are highly specialized folivores. Their digestive system is adapted to process fibrous food materials. When the diet is low in dietary fibre, their digestive system get disturbed causing loose stool and other gastro-intestinal disorder (Edwards, 1997). Yet, in most of the zoos they are being fed a diet similar to omnivorous monkeys. This practice should be discouraged.

Suggested guidelines for feeding

1. In nature, only 10% of golden Langur diet is comprised of fruits. It is recommended that 75% of the total diet dry matter should comprise of green leafy vegetables and browses. Fruits can be used as a supplement and for behavioural enrichment. In no case, fruits should contribute to more than 25% of the total dietary energy.
2. Animal managers and caretakers should be aware that some leaf-eating monkeys may initially be reluctant to accept new higher-fiber diets in place of traditional fruit based diets. With patience and persistence, most individuals can be managed in a healthier way on high fibre diet.
3. There is no need to make the diet too much complicated. Some tubers, 2 fruits, 2 coloured vegetables, and 3-4 green vegetable are realistic. A diet comprising of 100 g of apple/pear/ guava, 100 g of citrus fruits, 100 g of tubers, 100 g of beans, 100 g of cabbage, 200 g of other vegetables (carrot/ cauliflower/ pumpkin/eggplant), 200 g of spinach/leafy vegetables, 300 g of browses, 100 g of soaked gram and 50 g of bread is suggested.
4. Replace soft fruits with hard fruits.
5. Seeds can be given as a treat, not as a regular item.
6. It is mandatory to offer food at least 3 times to maintain proper gut health.
7. Raw tubers can be added to the diet by replacing bread. Such item should constitute 15% of the total diet
8. Any dietary change however should be implemented in a gradual manner.

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3.31 Slow Loris

Order	:	Primates
Family	:	Lorisidae
Genus	:	*Nycticebus*
Species	:	*N. bengalensis*

Slow lorises are a group of 5 species, of which Bengal Slow loris is listed as vulnerable in the IUCN Red Data Book (Streicher *et al*., 2012). The species is distributed in the North-East India, Bangladesh, Cambodia, Southern China, Laos, Myanmar, Thailand, and Vietnam. They are adapted to live in primary and secondary rainforest of tropical and sub-tropical region. The preferred habitat type includes tropical rainforest with thick canopy cover. Chaudhury (1992) mapped the distribution of the species based on the information collected from 43 protected areas in the North-east India.

Slow loris skull is shorter in comparison to other pro-simians. Compared to the slender loris, snout of the slow loris is less pointed. The skull is characterized by prominent crest, flattened and backwardly directed occipital bone and backwardly positioned foramen magnum (Ankel-Simmons, 2007). Recorded body mass of Bengal Slow loris ranged from 1134 to 1605 g (Nekaris *et al*., 2008). The female of related species *N. coucang* attains sexual maturity between 17-24 months of age. Males are capable of breeding at an age of 17 months (Nowak, 1999). Breeding is not seasonal; however, mating mostly takes place during June and September. Gestation length varies from 181-192 days (Weissensel *et al*., 1998). Due to their long gestation period, lower litter size (~1), lower birth weight (30-60 g), longer weaning time (3-6 months) and long intervals between births, Slow loris is one of the most inefficient breeders among the mammals of similar size. Lifespan is about 25 years in captivity (Weigel. 2005).

The natural diet of Bengal Slow loris comprised of shoots, fruits, insects, reptiles and birds (Gupta, 2001). In free range, Slow loris spent 22% of their time in feeding (Swapna *et al.,* 2008). Of the total feeding time, 86.5% was spent on eating exudates, 3.8% on nectar, 2.9% on insects, 1.9% on bark, 0.3% on fruits and 4.6% on other food items. Exudates are important component of Sunda Loris (94.3%) and pygmy loris (63%) diets (Weins, 2002: Streicher, 2004), On the contrary, only 2.8% of slender Loris diet comprised of exudates (Nekaris and Rasmussen, 2003). Basal metabolic rate (BMR) is very low in Lorises. This is an adaptive mechanism to eliminate the adverse effect of toxins (Nekaris, 2000: Weiner *et al.,* 2006). All lorisine have basal metabolic rate lesser by 60% of the inter-species mean i.e. 70 Kcal/kg $BW^{0.75}$ (Muller *et al.,* 1995).

Feeding in Captivity

Table 1: Diet chart of slow loris in different Indian zoos

Name of the zoo	Diet Scedule
MCZP, Chattbir	One boiled egg, 2 bananas or 200 g of papaya or 200 g of melon, 100 g of apple or guava, 50 g of turnip (seasonal) and 50 g of guava
NZP, Hyderabad	One boiled egg, 2 sweet potatoes, 4 carrots, 50 g banana, 50 g apple, 5 grapes, 2 slices of bread, 1/8 piece of orange, one chick on alternate day and 100 g of minced meat
Assam State Zoo, Guwahati	Two bananas, 20 g apple, 50 g grapes, one orange, 100 g bread, 10 g rice, 10 g soya flake , 50 g chickoo and one egg on alternate day
Sepahijala Biological Park	One boiled egg , 2 bananas, and 50 g apple
Itanagar Biological Park	Four bananas, 250 g apple, 250 g orange/guava/pine apple, 100 g sweet potato, 150 g minced meat and an egg once a week

In most of the Western zoos, *Slow loris* is fed on diet containing commercial complete food and produces. Produces contribute 50% of the total diet. A variety of produces including fruits, vegetables, starchy vegetables and leafy vegetables are fed to *slow loris*. Insects are also fed. A *slow loris* (N. cauganang) weighing 599-685 g was fed a ration containing 16 g banana, 8 g papaya, 13 g peeled orange, 3 g cooked carrot, 7 g cooked yam, 13 g apple, 9 g cucumber, 3 g folivore biscuit, 2 g mealworm, 2 g crickets, 13 g high protein biscuits and 13 g hard boiled eggs (Fitch-Snyder and Sculze, 2001).

Materials and Methods

During the present investigation, we conducted feeding trials on 9 *Slow loris* in Assam State Zoo. All the animals were fed their respective zoo diets (Table 2). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. The animals were kept and fed individually. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to chemical composition of feedstuff being fed to slow loris in different Indian zoos are presented in Table 2. Data pertaining to feed consumption and diet adequacy are presented in Table 3 and 4, respectively. In the present experiment, dry matter intake was 72.1 g/d or 34.6g /kg BW. Average dry matter intake in pygmy *Slow loris* was reported to be 14.9 g /day or 30 g/kg BW (Fitch-Snyder and Sculze, 2001). It seems that dry matter intake is similar among the species. However, DMI could go up to 5% of body weight in lorises. Pygmy *slow loris* (500g BW) consumed 57 kcal of ME which would translate into 97 kcal/kg $BW^{0.75}$ (Fitch-Snyder and Sculze, 2001). In the present experiment, daily average metabolizable energy intake was 125 kcal/kg $BW^{0.75}$., which was 28% higher than the requirement.

Table 2: Nutrient composition of feed ingredients fed to *Slow loris* in Guwahati zoo

Food items	Nutrient composition (on dry matter basis)								
Food item	DM (%)	GE (kcal/kg)	NDF (%)	CP (%)	Ca (%)	P% (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Banana	24.18	3950	12.4	5.62	0.11	0.24	25	18	7
Orange	12.48	3680	14.5	5.8	0.15	0.12	17	18	8
Bread	59.14	3950	4.5	10.2	0.18	0.51	32	28	9
Carrot	7.89	3580	18.5	7.1	0.18	0.13	95	27	8
Cucumber	6.42	3140	4.2	5.8	0.31	0.19	74	11	15
Pome granate	23.14	3690	14.8	5.4	0.11	0.22	118	22	11
Chickoo	22.81	3990	5.2	3.9	0.14	0.18	48	17	8
Apple	15.87	3870	7.6	5.0	0.05	0.11	110	34	8
Mosambi	11.88	3850	14.2	4.97	0.18	0.21	22	21	9
Egg	25.14	6120	0	48.8	0.17	0.84	69	48	12
Grape	7.6	4050	4.8	7.11	0.24	0.38	38	18	11

DM, dry matter; NDF, Neutral detergent fiber; CP, crude protein; GE, gross energy; ppm, parts per million

Table 3: Consumption of different food items by Slow loris at Guwahati zoo

Food items	Food intake (gram/day)
Banana	71.40±8.63
Orange	35.72±8.05
Bread	31.54±3.98
Carrot/ coconut	27.60±5.12
Cucumber	39.71±6.73
Pomegranate	32.27±2.81
Chickoo	35.82±4.84
Apple	31.92±2.86
Mosambi	25.94±2.51
Egg	34.34±5.83
Grape	24.37±3.38

Table 4: Feed consumption, and nutrient supply in Slow loris at Guwahati zoo

Parameters	Mean± S.E.
Dry matter intake (g/d)	79.37±10.51
Dry matter digestibility (%)	84.48±1.81
DE intake (kcal/kg BW $^{0.75}$)	139.1±6.62
Diet adequacy	
NDF (%)	8.07±7.74
CP (%)	13.05±2.14
Ca (%)	0.20±0.002
P (%)	0.34±0.01
Fe (ppm)	37.42±4.83
Cu (ppm)	8.36±0.077
Zn(ppm)	22.61±2.95

DM, dry matter; NDF, neutral detergent fiber; CP, crude protein; DE digestible energy; ppm, parts per million

Nutrient requirement of Slow loris are not known. Based upon the NRC requirements for non-human primates (NRC, 2003), it was suggested that Slow loris diet should contain 16.7% CP, 0.56% Ca, 0.43% P and 100 ppm of Fe. The diet presently fed to Slow loris in Assam State Zoo is deficient in terms of protein, Ca and Fe content. Supplementation with a whole chick may be beneficial to overcome deficiency of protein and Ca. Green leafy vegetables may also be tried. Slow loris had been reported to consume celery. Gums and barks are good source of Ca.

Suggested guidelines for feeding

1. The present diet in Assam state zoo provided 25% more energy than requirement; it is suggested to reduce the amount of fruits by 25%. A diet containing 50 g banana, 50 g citrus fruit, 50 g apple/pomegranate/ pear/ guava, 25 g bread, 25 g grape, 25 g chikoo, 50 g cucumber, 25 g carrot and 35 g egg may be fed.
2. Fruits and vegetables may be washed and peeled before use to reduce the pesticide residues.
3. Slow loris may be allowed to hunt live prey. Crickets and lizards may be allowed to graze in the loris enclosure.
4. They readily consumed commercial gums, spread it on foods, poles, tree branches or any other feeding devices.
5. Insects should constitute at least 5% of the total diet.
6. Liquid iron and calcium supplements may be spread over preferred food items like banana.

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3.32 Hoolock Gibbon

Order	:	Primate
Family	:	Hylobatidae
Genus	:	*Hoolock*
Species	:	*H. Hoolock*

Hoolock gibbon is one of the most endangered species of primates. Over the last 30-40 years, Hoolock gibbon numbers are estimated to have dropped down by more than 90%. The species is protected under Schedule I of WPA (1972) of India. The Red Data Book of IUCN (2003) has listed the species as endangered. They are now endemic in smaller pockets in Bangladesh, NE India, Myanmar, and South-West China. Habitat type of Hoolock gibbon may range from tropical evergreen forest, the wetter tropical semi-evergreen forests, sub-tropical monsoon evergreen broadleaf forests, to sub-tropical evergreen broadleaf hill or mountain forests (Choudhury, 1996; Lan, 1994). The species is found at altitudes of 80-1500 m (Choudhury, 1996; Mukherjee, 1986). Hoolock gibbon is an arboreal and diurnal species; it prefers the upper canopy of the forest (Leighton, 1987). They live in small, monogamous family groups of an adult pair with 0-4 immature offspring. Average group size ranges from 2.7 to 4 (Alfred, 1992).

Average height of an adult is 81.2 cm. Average body weight of male and female is 6.9 and 6.1 kg, respectively (Gron, 2008). Males are black colored with white brows, while females are grey-brown colored. Hoolock gibbons are monogamous. Sexual maturity is attained at an age of 5-8 years (Tilson, 1979; Feroz and Islam, 1992). Gestation length is between 6 and 8 months (Sati and Alfred, 2001). Their life expectancy in the wild is about 25 years. Most of the matings occur during March-May (Feeroz and Islam, 1992). Gibbons give birth to single offspring. Most of the births occur during November and February (Alfred, 1992; Alfred and Sati, 1990; McCann, 1933, Tilson, 1979). The birth interval in gibbons is about 2-3 years (Alfred and Sati, 1990).

Hoolock gibbons are frugivorous in nature. Of the total diet, 51-67% was fruit, 5-23% was leaves and buds and 0.1% insects (Alfred and Sati, 1990). They relish figs, berries, mango, litchi, jackfruit and other wild fruits. They are particularly a fig specialist. They prefer ripe fruits over unripe one. They spend 25-45% of their time in active foraging (Alfred and Sati, 1994). Gibbons are active from dawn (approx. 6.40 am) and retire to night several hours before dusk. They tend to forage during two main periods: 8.30 am to 11.00 and 12.30 to 4.30 pm. Mostly fruit is eaten during the first part of morning, which provides an immediate energy source following the fast overnight. Foliage is mostly consumed in the later part of the day (Gittens and Raemaekers 1984). Foraging for other items also correlates to certain periods of the day, such as arthropod hunting mostly occurs around mid-day (Ellefson 1984).

Basic frugivorous stomach is simple and glandular without much specialization (Hill, 1966). Proportion of colon is 19, 54 and 47%; proportion of small inteaine is 65, 27 and 28% of total GI tract in human, orangutan and gibbon, respectively. The enlargement of colon in gibbon is indicative of bacterial fermentation of leaf materials in the colon (Sakaguchi *et al.,* 1991). When feed of similar type was fed to frugivorous and folivorous primates, VFA concentration was also found similar (Hill, 1966). Gibbons are less efficient than cercopithecine in extracting energy from carbohydrates (Kay and Covert 1984).

Feeding in Captivity

Table 1: Feeding schedule of Hoolock gibbon in different Indian zoos

Food	Assam	Sepahijala	Lucknow	Itanagar	Delhi
Seasonal fruits	-	-	2000 g	200 g	-
Bread	100 g	-	-	200 g	100 g
Rice	100 g	-	-	200 g	
Gram	-	-	-	100 g	50 g
Soya bean	50 g	-	-	-	-
Peanut	-	-	-	-	50 g
Egg	1 in number	2 in numbers	-	-	1 in number
Milk	-	-	-	-	100 ml
Apple	200 g	150 g	-	-	100 g (except May-July)
Grapes	100 g	-	-	-	-
Orange	1 in number	-	-	-	100 g
Sweet lime	200 g	-	-	-	-
Banana	6 in numbers	10 in numbers		4 in numbers	2 in numbers
Chikoo	50 g				
(seasonal)	-	-	-	100 g (Feb.-April)	
Guava	-	-	-	-	100g (Oct.-Jan.)
Leafy veg	-	250 g	-	-	100g
Cabbage	-	-	-	100 g	-
Onion	-	-	-	-	25 g
Tomato	-	-	-		25 g
Carrot	-	-	-		100 g (Dec-Jan)
Cucumber	-	-	-	400 g	100 g (April-Oct)
Singara	-	-	-	-	100 g (Oct.-Nov.)
Beet root	-	-	-	-	100 g (Jan.-June)
Pumpkin	-	-	-	400 g	-
Potato	-	-	-	-	100 g
Sweet potato	-	-	-	200 g	-
Water melon	100 g	-	-	100 g	
(April-June)					
Mask melon	-	-	-	-	100 g (May-June)
Bel	-	-	-	-	100g (April- June)
Ber	-	-	-	-	100 g (Feb-March)
Jamun	100 g	-	-	-	-
Pear	100 g (Seasonal)	-	-	-	100g (July-Sep)

Materials and Methods

During the present investigation we conducted feeding trials on 4 Hoolock gibbons in Assam zoo. All the animals were fed their respective zoo diets (Table 1). During the period of investigation, measured amount of food was offered and all the refusals were collected for consecutive 5 days. For determination of intake and digestibility, lignin was used as an internal marker. Samples of feed, faeces and refusals were subjected to nutrient analysis following standard laboratory methods.

Results and Interpretation

Chemical composition of feed ingredients is presented in Table 2.

Table 2: Nutrient composition of feed ingredients fed to Hoolock gibbons

Food items	Nutrient composition (on dry matter basis)							
	DM (%)	CP (%)	GE (Kcal/kg	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Banana	24.18	5.62	3950	0.11	0.24	25	18	7
Orange	12.48	5.8	3980	0.35	0.12	17	18	8
Bread	59.14	10.18	3950	0.13	0.51	32	28	9
Carrot	7.89	7.17	3780	0.18	0.13	95	27	8
Cucumber	6.42	5.88	3740	0.31	0.19	74	11	25
Pomegranate	23.14	5.43	3890	0.11	0.22	18	22	11
Chickoo	22.81	3.88	3990	0.14	0.18	48	17	8
Apple	15.87	5.01	3970	0.05	0.11	110	34	8
Mosambi	11.88	4.97	3870	0.18	0.21	22	21	9
Egg	25.14	48.84	6120	0.17	0.84	69	48	12
Grape	7.6	7.11	4050	0.24	0.38	38	18	11
Coconut	58.18	5.17	6050	0.23	0.98	43	28	10
Sugar cane	39.45	3.88	3840	0.44	0.17	110	19	8
Peas	27.48	28.88	3950	0.21	0.31	80	52	11
Spinach	5.81	16.45	3780	0.83	0.21	383	22	8
Beans	32.45	17.57	3980	0.82	0.31	83.2	32.0	14.1
Sweet potato	28.45	3.85	4062	0.44	0.16	31.6	120.0	11.8
Browse	21.24	18.83	3770	1.32	0.40	320.0	56.0	18.0
Peanut	82.14	28.14	5510	0.39	0.27	75	68	11
Soaked gram	51.24	27.25	3910	0.55	0.37	78	51	12
Berry	16.66	2.33	3800	0.21	0.11	16	19	7

DM, dry matter: CP, crude protein: GE, gross energy: ppm, parts per million

Data pertaining to actual food consumption, diet digestibility and nutritional adequacy of the diet are presented in Tables 3-4. From the perusals of the data, it is evident that total dry matter intake was 178 g/day or 27.5g /kg bodyweight/day. King (1978) reported that dry matter intake was 9, 22 and 52 g/kg BW in Chimpanzee, lemur and marmoset, respectively.

Table 3: Actual consumption of different food items by Hoolock gibbon during the period of experimentation (g/d)

Food item	Mean±S.E.
Banana	214
Grape	121±22
Pomegranate	53±4.8
Mosambi	54±7.3
Apple	91±4.9
Sugarcane	24±1.2
Cucumber	77±6.3
Chickoo	40±2.5
Orange	36±5.3
Egg	34±0.9
Peas	50±12.2
Bread	40±5.7
Tomato	29±1.7
Carrot	20±2.2
Spinach	72±3.8
Coconut	6±1.3

It was further opined that inter-species average dry matter intake in primates could be better expressed as $BW^{0.67}$. The average daily dry matter intake in primates would be 34 g/ kg $BW^{0.67}$. In the present experiment, the daily dry matter intake was 51g/kg $BW^{0.67}$, which is higher than the inter-species mean. The average dry matter digestibility was 78% in the present study, which was probably lower than other primates fed similar kind of diet. Gibbons appear to be anatomically less efficient than cercopithecine in extracting energy from carbohydrates eaten (Kay and Covert 1984).

According to King (1978), maintenance energy requirement for adult would be 1.4 times BMR (basal metabolic rate) which will translate into 98 kcal/ kg BW $^{0.75}$. The diet fed to gibbons in Guwahati zoo provided 124 kcal/kg BW $^{0.75}$, which is 27% higher than the requirement.

Table 4: Feed consumption, and nutrient supply in Hoolock gibbon

Parameter	Value
Dry matter intake (g/day)	178.9
Dry matter digestibility (%)	78.2
Metabolizable energy intake (kcal kg BW $^{0.75}$)	124.3
Nutrient supply	
Crude protein (%)	10.2
Ca (%)	0.27
P (%)	0.30
Fe (ppm)	57

As the nutrient requirements of gibbons are not known, they are being fed on the basis of nutrient requirements of non-human primates (NRC, 2003). According to this, Macaques diet should contain 8% crude protein, 0.53% Ca, 0.33% P, 100 ppm Fe, and 11 ppm zinc. Protein recommended for Pongid, however, is higher at 14%. Hyalobates are more frugivorous than cercopethicine. Considering this, they might not require a very high protein diet. The diet fed to gibbons in Guwahati zoo contained more than 6 and 8% crude protein, recommended for human and macaques, respectively. The diet presently fed to gibbons, were inadequate in Ca, Zn and Fe content. It was deficient in Ca, if the value is compared with macaques. However the diet supplied more than 0.22% Ca recommended for human being.

Based upon the experiment conducted and review of literature we suggest that a diet should contain 150 g banana, 100 g soaked gram, 50 g apple, 100 g pomegranate/pear/guava/locally available fruit, 100 g cabbage or other cruciferous vegetables, 100 g beans, 50 g leafy vegetable, 100 g tubers, 50 g egg and browses *ad lib*. In primates, average dry matter intake ranges from 29-42 g/kg metabolic body weight (Arnheld *et al.* 2001). In this scale maximum amount of dry mater consumed by Hoolock gibbon (big male) would be 170 g. In our guidelines, we provided 233 g of Dry matter. This would allow 27% refusal by the animals. This would ensure that the weakest member of the group gets sufficient food.

The suggested diet would provide 3.6 kcal/g of energy. This is similar to that suggested by NRC (1989) and other guidelines for non-human primates including apes (Dierenfeld. 1997). At this energy density the calorie supply to the gibbon would be 610 kcal/d or 137 kcal/kg metabolic body weight. The highest ranges of ME requirement (105-140 kcal/kg $BW^{0.75}$) is 140 kcal/kg metabolic body size. Even if we consider that it is deficient by 2.1%, it is mention worthy, that caloric restriction up to 30% had no adverse effect on long-term reproductive performance of non-human primates (Sitzmann *et al.,* 2010). Further, calories restriction reduced morbidity and mortality (Hansen *et al.,* 1999) and improved longevity (Lane *et al.,* 1996). The suggested diet would provide 0.55% of Ca and 0.39% of P. NRC recommendation for non-human primate is 0.5% of Ca and 0.4% of P. Our diet supplied 44.9 ppm of Zn, 152 ppm of Fe and 10.6 ppm of Cu. This was similar or slightly higher than those recommended for other non-human primates (Oftedal and Allen, 1996). We did not estimate the vitamin C content of the diets. However, we calculated it from the reference value and were found to be adequate.

Suggested guidelines for feeding

1. A Hoolock gibbon may be fed 150 g banana, 100 g soaked gram, 50 g apple, 100 g pomegranate/pear/guava/locally available fruit, 100 g cabbage or other cruciferous vegetables, 100 g beans, 50 g leafy vegetable, 100 g tubers, 50 g egg and browses *ad lib*.
2. Gibbons have sensitive digestive systems and have an inability to cope with fruits with a high acid content such as tomatoes, grapes, pineapples, or citrus fruits. Large quantities of these fruits may result in severe physiological reactions.
3. Fruits and vegetables could be cut into 5 cm pieces to prevent choking. Browse with long fibres should also be avoided.
4. Peanuts are avoided because they can be a source of aflatoxin.

5. Fruit, tuber and pulses should be predominately fed in the morning and vegetables in the afternoon. Half of the foods may be fed on the platform not lower than 1.5 m. Rest of the food can be scattered throughout the enclosure.
6. Behavioural enrichment may be provided by scattering food, providing seeds in straws and placing it in cardboards boxes and smearing low calorie jams in utensils, poles etc.

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3.33 Jackal

Order	:	Carnivora
Family	:	Canidae
Genus	:	Canis
Species	:	*C. aureus*

Jackal is a widely distributed species. This species is closely related to grey wolf. An adult can grow upto 100 cm in length, 35-45 cm in height and 8-11 kg in body mass (Shrestha, 1997). The fur colour is reddish grey with blackish tone (Pocock, 1941). They molt during spring and winter. They live in family groups consisting of a breeding pair and their offsprings. Female attains sexual maturity at 1 year of age, whilst males are sexually mature at 2 years of age. Gestation length is 63 days after which 4–6 pups are born. Pups open eyes in about 10 days, weaned at 4 -6 weeks (BBC, 2012). They are omnivores and opportunistic feeder. They feed on birds, rodents, smaller ungulates, fruits and vegetation. In captivity, life span is 10-12 years (BBC, 2012)

Feeding in Captivity

Diet chart of jackal in different Indian zoos are presented in Table 1. From the perusals of the data it is evident that there is large variation in type and amount of feed being fed to jackals in different zoos.

Table 1: Feeding schedule of jackal in different India zoos

Sr No.	Name of the Zoo	Food items		
1.	Rajiv Gandhi Zoological Park Pune	Beef with bones 0.7 (kg)	Dog feed 50g	Chicken 0.7 kg (Sunday)
2.	V.J.B. Udyann, Mumbai	Beef 1kg	Liver 100 g	Vitamins 1 Tsp/ ¼ bolus
3.	Dr. Shivaram Karanth Pilikula Biological Park	Beef with bone 250 g	Beef (boneless) 2.00 kg	-
4.	Chhatbir Zoo	Buffalo meat 3 kg		
5.	Delhi Zoo	Buffalo meat (Summer= 2.0 kg)	(Winter= 2.5 kg)	
6.	Nandankanan Zoological Park	Buffalo meat 0.5 kg		
7.	Patna Zoo	Beef 0.8 kg	Turmeric Powder 35 g	
8.	Nehru Zoological Park	Beef : 1kg		
9.	Bhagwan Birsa Zoological Garden, Ranchi		Beef with bone 500g	Beef boneless 700 g
10.	Jaipur Zoo	Meat :1 kg/day		
11.	Shillong zoo	Beef : 1.00 kg		

Materials and Methods

We conducted feeding trial on 5 (3M, 2F) animals in Gwalior, 5 animals in Indore (2M, 3F) and 3 animals (1 M, 2F) in Jodhpur zoo. In Gwalior, 3 animals were housed together, whereas, 2 other animals were kept in independent enclosure. In Indore, 4 animals were housed in pair of 2; the third animal was kept in an independent enclosure. During the period of experimentation, measured amount of feed was given to all the animals, left over was also measured and faeces voided by each animal unit was collected, measured and sampled. Samples of feed, faeces and meat left-over were analyzed for nutrient content using standard laboratory methods.

Results and Interpretation

Data pertaining to feed consumption, diet digestibility and nutrient supply are presented in Tables 2-4.

Table 2: Nutrient composition (on dry matter basis)

Food items	Nutrient composition (on dry matter basis)								
	DM (%)	GE	Fat (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Gwailor Zoo (buffalo meat)									
Offered	38.42	5300	34.14	56.1	1.92	1.84	85	8	125
Residue	42.85	5100	29.79	59.8	2.14	2.24	80	7	120
Jodhpur Zoo (Buffalo meat)									
Offered	39.14	5200	32.44	58.14	1.92	1.42	95	9	125
Residue	43.44	4960	28.15	61.4	2.21	2.24	80	8	122
Indore Zoo (Buffalo meat)									
Offered	39.98	5450	37.24	53.4	1.84	1.52	88	6	145
Residue	44.53	5130	31.45	58.4	2.45	1.67	74	6	125

DM, dry matter; CP, crude protein; GE, gross energy (kcal/kg DM); ppm: parts per million

Table 3: Meat consumption, diet digestibility and nutritional adequacy of jackal diet

	Meat offered (g/d)	Meat residue (g/d)	DMI (g/d)	DMD %	DE intake (kcal/d)
Gwalior zoo					
Mixed	1085±24.7	374±24.9	240.0±22.1	82.4±6.6	1258±15.3
Jodhpur zoo					
Male	992	417	207.1	63.0	722.9
Female	892±108.5	459±41.4	147.6±26.6	63.4±10.8	548.8±172.9
Indore zoo					
Male	1756±43.5	1023 ±72.9	246.7±15.1	94.0±2.90	1408.9±28.9
Female	1420	817	203.9	94.8	1171.2

DMI (g), dry matter intake (gram), DMD, dry matter digestibility; DE, digestible energy

Table 4: Nutritional adequacy of jackal diet in different zoo

	Fat (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Gwalior Zoo							
Mixed	36.9±0.3	53.8±0.8	1.8±0.0	1.6±0.03	88.2±0.4	128.2±0.4	8.6±0.1
Jodhpur Zoo							
Male	36.2	55.3	1.7	0.7	108.1	127.6	9.9
Female	38.2±0.4	53.8±0.3	1.5±0.1	0.3±0.1	115.2±1.5	129.0±0.3	10.3±0.1
Indore Zoo							
Male	44.1±1.2	48.0±1.4	0.7±0.2	1.2±0.1	114.1±3.4	182.2±4.9	6.0±0.00
Female	44.5	47.6	0.8	1.3	113.0	180.7	6.0

CP, crude protein ; ppm, parts per million

The lower range of intake observed in the present experiment was expected because activity in captive animal is much lower than those in free range. Mukherjee *et al*. (2004) reported that dry matter intake by jackal in free range was 168-240 g/d, which is very similar to the findings of present investigation. Average daily DE intake in this experiment ranged from 672 to 1409 kcal/day. In carnivores, 90% of the digestible energy is utilized.

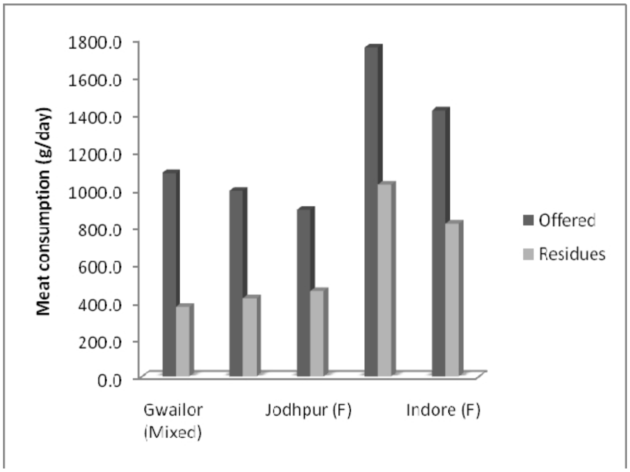

Figure 1: Actual consumption of meat by Jackal at different zoo

Thus, metabolizable energy intake would be 605 to 1268 kcal/day. Mukherjee (2004) reported that jackal in free range consumed 766 to 1095 kcal of ME/day. It seems that the diet of Indore zoo provided calorie in excess of requirement. The practice of feeding 1 kg of meat to male and 750 g of meat to female seems satisfactory. The minimum ME supply was observed in females in Jodhpur zoo. Sexual dimorphism is visible in jackal and female are smaller in size. When the ME intake was expressed in terms of metabolic body size, ME intake was 175 and 211 kcal/kg $BW^{0.75}$ in males and females, respectively. Higher calorie intake in male could be due to higher level of activity in male. Nutrient requirements for jackal are not known. Hence, we compared the value with NRC (1989) requirements for dog. According to this, diet must supply 0.8% Ca, 0.6% P, 80 ppm Fe, 30 ppm Zn and 5 ppm Cu. Animals in Indore Zoo received less calcium than requirement and Ca:P was also skewed. This is due to the fact that when more meat was offered they selectively consumed flesh and refused to chew bone. This is another disadvantage in feeding excess of meat.

Suggested guidelines for feeding

1. Feeding of 1 kg of meat is adequate for male and 750 g of meat is satisfactory for average sized female.
2. Variation could be provided by supplying equal amount of chicken *in lieu* of meat.
3. In nature, they prey on rodents, smaller vertebrates and also eat fruits and tubers. Fruits and tubers should be added in the diet.
4. Ensure that bone piece is attached to the chunk offered.
5. In nature, they have to take a number of meals in a day. Fasting is really not required.

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3.34 Tibetan Wolf

Order	:	Carnivora
Family	:	Canidae
Genus	:	*Canis*
Species	:	*C. lupus*
Common Name	:	Chanco

Tibetan wolf is also known as "wooly wolf". It is found in Central Asia and the Himalayan region of India, Nepal and Bhutan (Pocock, 1941). Tibetan wolves are the closest ancestors of domestic dogs on account of smaller size and mandible morphology. Unlike other related species of grey wolf, uppermost part of lower jaw is turned backward in both Tibetan wolf and domestic dogs. The colour of the Tibetan wolf's fur varies depending on the season. In the winter, its back and tail are black and white, usually with a black and white under saddle (Gray, 1963). A dark stripe may be sometimes seen on the forelegs. Their body weight hardly exceeds 45 kg (Gaptner *et al*., 1972). It is smaller than Eurasian wolf, but larger than Indian wolf. Mating season ranges from January to April. Gestation length is 60-63 days. Sexual maturity is attained at 2-3 yrs of age. In free range, life span is 6-10 years; in captivity life span could be double (Srivastav and Nigam, 2009).

Tibetan wolves do not form large peck as they usually travels in pairs or triples. Hare is their staple diet round the year. In summer, they eat marmots and during winter they predate on sheep, goat, horses and yaks. There are reports which indicate that closely related Eurasian wolves, feed on ungulates, rodents, fruits, berries and fish. Vegetations have been also reported in the diet of Tibetan wolf (Maheshwari *et al*., 2010).

Feeding in Captivity

In all Indian zoos, canids are fed with raw meat. Canids appear to retain a broader array of metabolic pathways for processing of nutrients, indicating a greater degree of dietary flexibility. In most of the US zoos maned wolves were fed with raw meat based diet (Allen, 1995). Fruits, vegetables, bread, whole prey and rice are also fed. Later on, dry dog food had been introduced, which is supplemented with omnivorous biscuits, fruits, vegetables and live prey (Chids-Sanford, 2005).

Table 1: Feeding schedule of Tibetan wolf in Indian zoos

Name of the zoo	Type of meat	Amount of meat offered
PNH ZP, Darjeeling	Beef	2.0 to 2.5 kg
Gangtok Zoo	Beef	3.0 kg
HNP, Kufri	Buffalo meat	2.0 kg
GBP High Altitude Zoo, Nainital	Buffalo meat	2.5 kg

Materials and Methods

During the present investigation, we conducted feeding trial in Darjeeling (n=6), Gangtok (n=4), Nainital (n=3) and Kufri (n=3). The amount of meat offered, refusals and faeces were collected and analyzed in the laboratory using standard methods.

Results and Interpretation

Data pertaining to chemical composition of meat offered and its residue is presented in Table 2.

Table 2: Chemical composition of diet fed to Tibetan wolf in different zoos

Food	On Dry matter basis								
	Dry matter%	GE (Kcal/kg DM)	CP (%)	Fat (%)	Ca (%)	P (%)	Fe ppm	Zn ppm	Cu ppm
Darjeeling zoo									
Beef									
Offered	42.11	5140	67.49	27.14	3.22	1.94	112	178	15
Residue	67.79	4110	70.4	14.14	7.93	5.01	78	210	15
Gangtok zoo									
Beef									
Offered	39.84	5160	68.04	27.14	3.24	1.98	98	210	17
Residue	60.18	4090	74.88	12.29	8.04	4.11	84	233	19
Nainital zoo									
Buffalo meat									
Offered	36.14	5120	65.73	28.41	3.74	1.91	94	105	16
Residue	52.16	4170	75.03	13.14	7.75	3.97	85	185	18
Kufri zoo									
Buffalo meat									
Offered	41.72	5220	65.03	29.19	2.99	1.61	98	121	17
Residues	58.14	4160	74.37	13.42	8.81	3.96	84	105	16

CP, crude protein; GE, gross energy; ppm, parts per million

Table 3: Feed consumption, diet digestibility and nutritional adequacy of Tibetan wolf diet in different zoos

Parameters	Name of the zoo			
	Darjeeling	Gangtok	Nainital	Kufri
Dry matter intake (g/d)	756.18±20.74	825	672±49.0	623±5.69
Dry matter digestibility (%)	90.93±0.51	92.84	92.5±3.77	94.0±0.75
Diet adequacy				
CP (%)	66.42±0.04	65.11±0.05	63.3±0.13	57.4±1.90
Fat (%)	31.91±0.18	33.51±0.11	319±.13	39.6±0.46
Ca (%)	1.49±0.06	0.96±0.04	1.49±0.00	1.80±0.14
P (%)	0.81±0.04	1.07±0.02	0.85±0.05	0.70±.0.07
Fe (ppm)	124.46±0.47	104.00±0.10	94.0±0.15	103.4±0.44
Zn (ppm)	166.27±0.44	200.14±0.17	134.9±0.37	121.5±2.96
Cu (ppm)	15.00±0.00	16.14±0.01	17.0±0.01	16.54±0.07
DE intake (kcal/kg $BW^{.075}$)	196.2±9.3	227.2±4.0	211.2±12.7	187±1.7

CP: crude protein, DE: digestible energy, ppm: parts per million

Data pertaining to feed consumption, diet digestibility and nutritional adequacies of the diet are presented in Table 3. From the perusals of the data, it is evident that dry matter consumption was higher in Gangtok than other zoos. Dry matter digestibility was, however, similar among the wolves in different zoos. Newton (1995) reported that feed consumption in maned wolf is around 1.8% body weight on dry matter basis. In the present experiment, feed consumption on dry matter basis ranged from 1.5 to 1.8% of body weight. Burboza *et al.* (1994) reported that dry matter intake ranged from 1.25 to 1.95% of body weight.

Specific nutrient requirements of Tibetan wolves are not known. Nutrient requirement of dogs (NRC, 1985) forms the basis of feeding wolves in captivity in most of the Western zoos. The diet must supply 1% Ca, 0.8% P, 100 ppm iron, 30 ppm zinc and 5 ppm Cu. The energy density of the diet should be 3.3 kcal ME/g. The diet must contain 9% fat and 28% crude protein. From the results of the present investigation, it is evident that diet of all the zoos supplied adequate nutrients to fulfill these requirements. Barboza *et al.* (1995) indicated that energy requirement of the maned wolves could be very similar to domestic dogs. They recommended that maximum energy requirement in the maned wolf would be 161 kcal ME /kg $BW^{0.75}$. Converting this to digestible energy (assuming that ME is 90% of DE), DE requirement for wolves would be 179 kcal/kg $W^{0.75}$. From the results, it is evident that the feeding practice of Darjeeling, Nainital and Kufri supplied energy closer to the requirement. Animals in Gangtok received surplus energy. In all Indian zoos, Tibetan wolves are fed on raw meat diet similar to that fed to felids. Until 1985 most of the US zoos fed their maned wolf with raw meat based diet (Allen, 1995). However, it is to be understood that cats have, adapted to a metabolic strategy of extreme carnivory, canids on the other hand have greater degree of metabolic flexibility. Hence, in US zoos, fruits, vegetables, bread, whole prey and rice are also included in the horse meat based basal diet. In India, however such vegetarian items are yet to be included in wolf's diet. Now-a-days, all US facilities feed their maned wolf with good quality dry dog food. The relative advantages/disadvantages of feeding dry dog food have been noted, but the feeding of this is generally accepted (Allen *et al.,* 1996).

An important health problem of wolves is cystine stone formation which leads to kidney, bladder and urethral stones. Maned wolves in captivity have historically been plagued by complications related to cystinuria such as cystic and renal calculi which caused significant morbidity and mortality (Mussart and Coppo, 1999). In studies with captive and free ranging maned wolves, 80% have been shown to excrete cystine and other dibasic amino acids in urine (Allen, 1995). This unusual pattern could be due to a metabolic defect. It was advocated that prevalence of cystinuria could be significantly reduced by feeding low protein diet and by increasing the urinary pH. In India, however, the prevalence of the disease is not studied. Hence, pathogenesis of cystinuria in Tibetan wolf and other canids and its possible amelioration through dietary manipulation needs to be studied elaborately.

Suggested guidelines for feeding

1. As indicated earlier a diet of 2.0 to 2.5 kg of meat would supply adequate amount of energy, Ca, P, Fe, Zn and Cu. However, all the diets contained more protein than recommended for domestic dogs and other canids. As

all the animals chewed significant amount of bone, deficiency of Ca is unlikely. All the diets supplied adequate amount of Ca to fulfill requirement.

2. Meat should be offered late in the evening/afternoon to avoid spoilage under high ambient temperature. Wolves should be fed approximately one/half hour prior to the end of the work of the day. Most wolves are reluctant to eat when personnel are around.
3. Feeding location should be protected from elements. There should be at least one feeding location per wolf for those housed together. Feeding station should be spatially and visually separated to discourage dominant animal to take more food. This would also encourage subordinate animal to consume more.
4. The one day fasting may be practiced. It gives good opportunity to give medication on the day following fasting.
5. Pregnant bitches may be fed 25% higher food during last trimester of pregnancy. Lactating animals would require 1.5 times more food than maintenance. Frequency of feeding may be increased to 2-3 feedings during these high demand periods.

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3.35 Tiger

Order	:	Carnivora
Family	:	Felidae
Genus	:	Panthera
Species	:	*P. tigris*

Royal Bengal tiger is the national animal of India. The census conducted by the government of India in 2008 revealed that tiger population in India is 1411. According to the latest census (2011), tiger population has increased to 1706. Royal Bengal tiger has been classified as endangered by the IUCN. According to the Central Zoo Authority (CZA) Inventory Report (Anonymous, 2008-2009), there are 254 tigers in different captive facilities in India. Primary goal of keeping this captive population is conservation breeding, besides education and animal welfare.

There is considerable variation in body size between male and female. The body length including tail of male is 270-310 cm, whereas, female body length is 240-265 cm (Mazak, 1981). Males are heavier at about 221 kg and females are lighter at 140 kg (Smith *et al*., 1983). The animals of the northern range are bigger and heavier than those in other region. In northern India and Nepal, average body weight of male and female is 235 and 140 kg, respectively. Males and females become sexually mature at an age of 3 and 3-4 years, respectively. Males are sexually active till 14 years of age, while female will remain sexually active till 12 years of age. Tigers are not seasonal breeder. They can breed any time of the year. Gestation length is 96-111 days (Mazak, 1981). In wild, they usually live 8-10 years. In captivity, typical life span is 16-18 years (Dacres, 2007).

Tiger selectively preferred prey weighing more than 176 kg. The average weight of main prey of tiger was 91.5 kg. Most preferred prey species are chital, sambar, wild boar and young gaur (Karanth and Sunquist, 1995). Tigers are intermittent feeder i.e. they can consume a very big prey over a few meals and then they may not eat at all for days together. Schaller (1977) suggested that a tiger would consume 10–12 kg of meat/day. Sunquist (1981) suggested that a tigress would consume 5-6 kg, whereas, a tiger will consume 6–7 kg of meat/day. Reddy *et al.* (2004) suggested that in tropical dry deciduous forests, tiger preferentially prey smaller species and avoid livestock. They also avoid peafowl and other birds because more energy is spent on catching such prey than what they supply. They also avoid mega-herbivores like elephant and rhino, but chance permitted they would prey on calves of these species. Tigers are not fish eaters except in the Sundarbans, where they have been reported to eat fish, crabs and frogs. Like other felids they will eat grass to cleanse their digestive system which does not have any nutritional importance *per se.*

Adaptation to obligatory carnivory

1. Dentition

Tigers are obligatory carnivore. Dental formula of tiger is I-3/3, C-1/1, P-3/2 and M-1/1. The upper canine is very long (2.5-3 inches), these teeth are used for killing the prey. The sharp smaller incisors are used for grasping the prey and to tear meat from bone. The fourth upper premolar and the first lower molar are positioned in such a way that it can cut slices just like a scissors, this arrangement is called carnassials teeth.

2. Digestive system

Their digestive system is simple. Digestion begins when food enters into mouth. Tigers tongue contains hard spiny projections which are useful for pulling out loose hairs. Relatively smaller gastrointestinal tract implies that the food is retained for a smaller period. Caecum is connected to ileum, not colon. Further, caecum is very small and has not much functional value. Hence, the felids have to depend on highly nutritious food. They do not have any taste for sweet, but have developed taste for some amino acids and peptides.

3. Metabolic adaptation

1) Unlike most other species, felids are not capable of conserving protein. As a result, urinary loss of protein is consistently higher. Felids derive most of their energy from amino acids. So, activity of enzymes involve in gluconeogenic process are higher in felids. These enzymes activity are constantly higher even when a low protein diet is fed.
2) They cannot convert β-carotene to vitamin-A.
3) Taurine is a dietary essential in tiger. Most mammals can synthesize taurine from sulphur containing amino acids. However, tiger's ability to synthesize taurine is very limited. Further, most other mammalians are capable of conjugating glycine to bile acids, felids are either incapable to do or their capability to do so is very limited. Taurine is not found in plant tissues. It is widely distributed in muscles, retina and central nervous system. Requirement of dietary taurine could be one of the reasons for obligatory carnivory in tiger.
4) Felids cannot synthesize arachidonic acids from linoleic acid. So, arachidonic acids must be supplied in felid diet through animal fat.
5) Felids cannot synthesize arginine.
6) Tigers cannot convert tryptophan to niacin.
7) Glucokinase activity in liver is negligible. Phosphoenol pyruvate decarboxykinase activity is very high in tigers.

Feeding in Captivity

Use of muscle meat as sole diet of carnivore was once widespread in US zoos. However, muscle meat is deficient in Ca, fat soluble vitamins and imbalanced in Ca:P ratio. Feeding of muscle meat without any supplement is reported to cause metabolic bone diseases. Considering these points, muscle meat is no longer used as sole feed of carnivores in US zoos (Allen *et al*., 1996), commercially manufactured complex carnivore diet which are similar to vertebrate prey in nutrient make up are being fed to captive tigers and other felids. Use of such diets has effectively tackled the problem of metabolic bone diseases. However, oral diseases associated with feeding of soft food have emerged as new problem. In Australian zoos such diets are not used. In Toronga zoo, carnivores are fed with various types of carcasses like horse, kangaroo, and beef with added minerals and vitamins (Baker, 2006). In Toronga zoo, tigers are fed 4-5 kg of raw meat 5 days a week. In Mogo zoo, 5-8 kg of meat on bone is offered to each tiger daily. The feeding schedule of Mogo zoo is quite similar to what is practiced in most Indian zoos. Diet schedule followed by different Indian zoos are presented in Table 1.

Table 1: Diet chart of tiger collected from different Indian zoos

Sr. No.	Zoo Name	Food/animal / day			
1.	MCZP, Chattbir	Eggs	Milk	Buffalo Meat (with bones)	
		2 Nos	½ l	15 kg	
2.	NZP, Delhi		Milk	Buffalo Meat	
	a. Ordinary Tiger		0.5 kg	10 kg (S)	12 kg (W)
	b. White tiger		0.5 kg	10 kg (S)	12 kg (W)
4.	Nandankanan Biological Park			Buffalo Meat	
	a. >2 ½ yrs			April-June	11.00 kg
				July-March	12.00 kg
	b. 1-2 ½ yrs			7 kg	
	c. 6 months-1 year			400 g	
5.	Thiruvananthapuram Zoo	Egg	Milk	Beef	Chicken (with bone)
		225 g	2.7 l	6.3 kg	4.5 kg
6.	Sephijala Biological Park, Tripura	-	-	Beef/ chevon	Chicken
		-	-	6.5 kg	2.5 kg
7.	Dr. Shivaram Karanth Biological Park, Pilikula			Beef (with bone)	Beef (BL) Chicken
				3 kg	5 kg 1.25 kg
8.	Nehru Zoological Park, Hyderabad	-	Milk	Beef (boneless)	Liver
		-	½ l	8 kg	250 g
9.	Bhagwan Birsa Zoological Garden, Ranchi	-	-	Beef (boneless)	Liver
		-	-	12 kg	1.0kg
				[Fri., Sat., Sun.]	[Tue., Wed., Thur.)
10.	Jaipur Zoo	Egg	Milk	Beef	-
		one	½ kg	8 kg	-
11.	Zoological Garden, Alipore			Buffalo meat	
		11 kg (S)			12 kg (W)
12.	Kanpur Zoo			Buffalo meat	
				8-10 kg	
13.	R.G. Zoological Park & Wildlife Research Center, Pune	Beef	8 kg (every day except monday)		
14.	Lucknow, Zoo			Buffalo meat	
				8-12 kg	
15.	V.J.B. Udyaan, Mumbai	Eggs		Beef	liver
		2 in numbers		16 kg	200 g

S, summer; W, winter

The perusals of the data indicate large variation in amount of meat fed and type of supplements used. A comparison with zoos abroad will indicate that many of our zoos fed higher amount of meat. However, it gives pleasure to note that our feeding system is most close to the natural feeding behaviour of tigers. Of late, a lot of attention has been paid on behavioural enrichment.

Materials and Methods

We conducted feeding trial on 81 tigers kept in different zoos. Zoo and sex-wise break up of tigers are detailed in Table 2. All the animals were fed their respective diet 6 days a week. Tigers in Nehru Zoological Park, Hyderabad were fed boneless meat supplemented with calcium. All other zoos fed raw beef or buffalo meat to their tigers. During the period of experimentation, all the animals were offered measured amount of food. The refusal and faeces voided by the animals were collected in full and suitable sample were taken for laboratory analysis. Energy, protein and mineral content of feed, faeces and refusals were analyzed using standard laboratory methods.

Table 2: Details of animals on whom feeding trial was conducted

Name of the zoo	Male	Female	Total Animals
National Zoological Park,Delhi	5	8	13
Lucknow Zoo	3	2	5
Banerghatta National Park	4	2	6
SCZG, Mysore	5	3	8
Nehru Zoological Park, Hyderabad	7	4	11
Nandankanan Biological Park, Bhubaneswar	5	7	12
MCZP,Chattbir	5	2	7
Indore Zoo	4	3	7
Vanvihar National Park, Bhopal	2	3	5
Assam State Zoo, Guwahati	3	4	7
Total	43	38	81

Results and Interpretation

Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Tables 3-5 and also presented in Figure 1. Minimum fat content was observed in the meat samples of Nandankanan Biological Park, whereas, maximum fat % was observed in meat samples collected from Mysore zoo. Ideally meat should contain ~30% fat on dry matter bais. As whole meat was fed in all but Hyderabad zoo, Ca content was quite satisfactory. Even boneless meat samples collected (after addition of supplement) from Hyderabad zoo contained adequate amount of Ca to support most of the life stages of tiger. Maximum amount of meat was offered to tigers in SCZG, Mysore, Banerghatta National Park and Nandankanan Zoological Park in order of amount of meat being fed to tiger; in other zoos amounts of meat offered were more or less similar. SCZG, Mysore and Indore zoo also fed chicken to their tigers. However, in nature bird is not in preferred menu of tigers. Hence, in normal feeding situation chicken feeding is not necessary.

Table 3: Nutrient composition of tiger diet in different zoo

Food	DM (%)	GE (Kcal/kg DM)	CP (%)	Fat (%)	Ca (%)	P (%)	Fe ppm	Zn ppm	Cu ppm
		On Dry matter basis							
SCZG, Mysore									
Meat offered	40.1	5500	38.2	52.1	3.29	1.91	78	6	125
Meat residue	60.1	4840	29.4	55.0	4.01	3.58	68	5	94
Chicken offered	27.3	4240	12.3	78.4	2.85	1.43	38	5	48
Indore zoo									
Meat offered	41.4	5260	34.1	55.3	3.43	1.94	88	7	138
Meat residue	48.7	4810	28.5	56.2	6.58	3.81	74	6	125
Chicken offered	28.9	4160	12.4	77.1	3.48	1.71	51	6	61
Chicken residue	34.2	3650	5.5	79.4	6.14	3.11	44	5	43
Lucknow Zoo									
Meat offered	41.7	5190	31.2	60.4	3.44	1.91	94	5	145
Meat residue	42.3	4440	21.8	62.2	7.91	3.49	85	5	135
MCZP, Chatbir									
Meat offered	40.4	5050	29.1	60.7	3.22	1.91	94	11	95
Meat residue	58.4	4400	21.4	62.9	6.22	3.47	85	14	100
NZP, Hyderabad									
Meat offered	39.4	5440	34.3	62.2	1.04	1.17	88	8	135
Meat residue	42.2	5330	28.4	70.3	0.99	1.23	74	7	115
Banerghatta National Park									
Meat offered	38.2	5530	36.7	55.1	3.25	1.94	91	8	130
Meat residue	43.4	4570	25	58.0	8.14	4.03	84	7	122
Vanvihar National Park, Bhopal									
Meat offered	42.5	5280	34.2	54.5	3.32	1.89	88	5	152
Meat residue	48.5	4720	27.6	55.0	8.04	4.13	74	4	140
Assam state Zoo, Guwahati									
Meat offered	42.1	5220	34.1	54.4	3.41	2.03	90	6	125
Meat residue	49.6	4630	27.5	54.8	8.24	3.97	85	5	115
National Zoological Park, New Delhi									
Meat offered	39.4	5206	32.4	57.2	3.44	1.87	80	9	180
Meat Residue	59.1	4370	21.4	62	7.72	3.88	75	10	170
Nandankanan Biological Park, Bhubaneswar									
Meat offered	41.4	4870	26.1	63.1	3.14	1.92	88	11	190
Meat residue	57.1	4410	21.4	63.1	7.08	3.88	81	12	180

DM, dry matter; CP, crude protein; GE, gross nergy (kcal/kg DM)

Table 4: Feed consumption and diet digestibility in captive tigers

	Meat (g/d)	Meat left (g/d)	Chicken (g/d)	Residue (g/d)	DMI (g/d)	DMD (%)	DEI (kcal/d)
SCZG, Mysore							
Male	15700	5200	1300	0.0	3455	90.00	19312
	±1966	±718	±200	0.0	±321	±0.4	±1994
Female	12167	3333	1333	0.0	3243	87.3	17482
	±2333	±882	±333		±682	±5.0	±4216
Lucknow Zoo							
Male	10000	2027	-	-	3315.7	92.0	18607
	±0.01	±677			±286	±2.4	± 2172
Female	9000	2235.0	-	-	2810.5	92.4	15295
Indore Zoo							
Male	8162	2611	1275	104	2357±	90.7	11964
	±714	±1	±157	±47	308	±1.1	±1329
Female	6072	2350	1105		1678±	87.4	79881
	±1878	±841	±237	5±5	405	±2.7	±792
MCZP, Chattbir							
Male	8065	2270	-	-	2055	91.2	10446
	±758	±278	-	-	±183	±4	±1126
Female	9618	2180	-	-	2613	91.4	13063
NZP, Hyderabad							
Male	7140	1093	-	-	2354	92.2	11860
	±693	±696	-	-	±39	±0.78	±237
Female	6242	494.4	-	-	2253	92.1	11410
	±310	±465	-	-	±136	±0.74	±687
Banerghatta National Park							
Male	15667	2815	-	-	4760	93.4	26409
	±3333	±219	-	-	±1346	±3	±7476
Female	12000	2734	-	-	3395	93.3	18394
Vanvihar National Park, Bhopal							
Male	7860	1286	-	-	2102	92.2	13644
	±259	±653	-	-	±1038	±1	±2012
Female	6848	1676	-	-	1829	91	10601
	±244	±446.1	-	-	±385	±1.3	±493
Assam State Zoo, Guwahati							
Male	10752	896	-	-	4086	96.2	17100
	±737	±401	-	-	±119	±16.7	±2536
Female	10019	1419	-	-	3518	95.4	18019
	±295	±149	-	-	±80.9	±2.01	±678
NZP, Delhi							
Male	7518	1784	-	-	1911	91.3	10012
	±649	±160	-	-	±182	±2.68	±741
Female	6677	1475	-	-	1762	85.9	8808
	±285	±150	-	-	±125	±1.62	±557
Nandankanan Biological Park							
Male	11002	3130	-	-	2771	91.3	13293
	±700	±377	-	-	±234	±2	±1124
Female	8852	2012	-	-	2518	89.4	11650
	±921	±387	-	-	±302	±1.6	±1400

DMI, dry matter intake; DMD, dry matter digestibility; DEI, digestible energy intake (kilo calorie per day)

Table 5: Nutrient content of captive tiger diets (on dry matter basis)

	Fat (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
SCZG, Mysore							
Male	43.0 ±1.3	52.6 ±1.02	2.6 ±0.04	0.45 ±0.10	82.5 ±1.85	6.8 ±0.09	143 ±4.3
Female	41.2 ±1.9	53.3 ±0.90	2.7± 0.14	0.7± 0.32	80± 2.30	6.6 ±0.20	137 ±6.6
Indore Zoo							
Male	34.5 ±0.8	57.8 ±0.3	1.6 ±0.4	0.84 ±0.3	91.4 ±1.9	7.4 ±0.1	135 ±1.9
Female	33.6 ±1.5	59.0 ±1.0	1.4 ±0.3	0.73 ±0.2	90 ±3.0	7.5 ±0.1	131 ±4.6
Lucknow Zoo							
Male	12.0 ±1.1	59.9 ±0.22	2.2 ±0.53	1.53 ±0.19	97.4 ±1.08	5.0 ±0.00	148 ±1.2
Female	12.5 ±0.6	59.8 ±0.12	2.0 ±0.29	1.44 ±0.10	97 ±0.59	5.0± 0.001	148 ±0.7
MCZP,Chattbir							
Male	34.1 ±0.4	59.3 ±0.10	1.3 ±0.14	0.9 ±0.07	100.2 ±0.42	9.1 ±0.14	92 ±0.24
Female	33.0 ±0.9	59.7 ±0.26	1.7 ±0.37	1.1 ±0.19	98 ±1.10	9.5 ±0.37	93 ±0.61
NZP, Hyderabad							
Male	35.5 ±0.8	60.65 ±1.06	1.05 ±0.01	1.16 ±0.01	91.4 ±1.84	8.2 ±0.13	139 ±2.6
Female	35.0 ±0.6	61.37 ±0.87	1.05 ±0.01	1.16± 0.01	90.3 ±1.51	8.1 ±0.11	137 ±2.1
Banerghatta National Park							
Male	41.4 ±1.8	64.5 ±4.0	1.56 ±0.8	1.22 ±0.33	93.3 ±1.10	8.3 ±0.16	133 ±1.2
Female	41± 0.52	64 ±1.12	1.52 ±0.22	1.20 ±0.09	93.4 ±0.31	8.4 ±0.04	133 ±0.3
Vanvihar National Park, Bhopal							
Male	36 ±1.0	54.31 ±0.09	2.12 ±0.74	1.32 ±0.35	92.4 ±2.19	5.3 ±0.16	155 ±1.88
Female	36.9 ±0.9	54.2 ±0.07	1.4± 0.63	1.0 ±0.30	94.2 ±1.86	5.4 ±0.13	157 ±1.59
Assam State Zoo, Guwahati							
Male	34.8 ±0.3	54.40 ±0.02	2.90 ±0.22	1.82 ±0.09	91.7 ±0.22	6.1 ±0.04	126 ±0.45
Female	35.4 ±0.2	54.4 ±0.01	2.44 ±0.12	1.64 ±0.05	91.0 ±0.1	6.2 ±0.03	127 ±0.25
NZP, Delhi							
Male	38.5 ±0.5	54.5 ±0.16	1.0 ±0.15	0.7 ±0.07	83.2 ±0.17	8.4 ±0.03	186 ±0.34
Female	38.1 ±0.4	54.7 ±0.32	1.2 ±0.29	0.8 ±0.14	83.4 ±0.34	8.5 ±0.07	185 ±0.68
Nandankanan Biological Park, Bhubaneswar							
Male	29.3 ±0.4	63.10 ±0.0	0.51 ±0.35	0.61 ±0.18	93.5 ±0.63	10.3 ±0.09	197 ±0.90
Female	28.4 ±0.5	63.1 ±0.00	1.3 ±0.39	0.98 ± 0.19	91.2 ± 0.68	10.5 ± 0.10	195 ±0.98

Dry matter intake ranged from 0.86 to 2.16% in male and 1.42-2.92 % in female tigers. Dry matter intake was a reflection of amount of meat being offered to the animals. It seems that proportionate to their body size, female animals were fed more meat than male animals. It further implies that in captivity, females are more likely to be overfed and hence would be more prone to obesity. Females are 35 to 45 % lighter than males; diet of male and female should be adjusted accordingly.

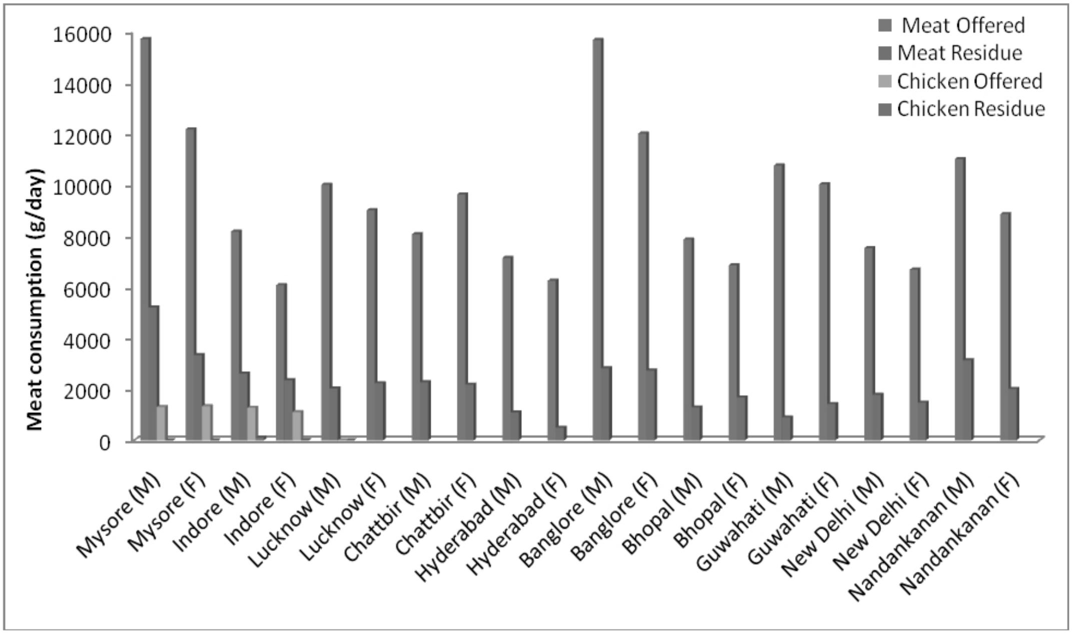

Figure 1: Feed consumption and refusals by tigers in different zoos

Among female tigers, minimum digestible energy intake was recorded in tigress of Delhi zoo that were fed 6.5 kg of meat. It was considered that the tigress was fed 6 days a week and she has to compensate for the calorie required for the seventh day. Thus, the tigress consuming 7988 kcal/d was receiving 47925 kcal of DE in a week or 6847 kcal of DE per day. Energy requirement of tigers like other animals are expressed as a function of metabolic body size i.e. Body Weight raised to the power by 0.75 ($BW^{0.75}$). Thus, a particular tigress weighing 120 kg will have a metabolic body size of 36.25. On this scale, she would receive 189 kcal DE/kg $BW^{0.75}$. Energy requirements of tigers are not clearly understood. However, leopards were able to maintain body mass when DE intake ranged from 166-182 kcal/kg $BW^{0.75}$ (Barbiers *et al*., 1982). Similarly, cheetah was able to maintain body mass on diet supplying 150-185 kcal DE/$kgW^{0.75}$ (Allen *et al*., 1995). It was suggested that DE requirements of these felids could range from 150-185 kcal/ kg $BW^{0.75}$, very similar to many of the tigress (fed ~6 kg of meat) during the present investigation. What we suggest is a diet containing 6 kg of good quality meat with bone would be adequate to fulfill energy requirement of an adult tigress. The tigress in Vanvihar National Park, Bhopal received 6.8 kg of meat which supplied 251 kcal/kg $W^{0.75}$ of DE. This could be the highest acceptable range suggested for tigers (Allen *et al*., 1995). All other female tigers received energy in excess of requirement. Digestible energy (DE) intake by male tigers of Delhi, Indore, Chattbir, Hyderabad, Bhopal and Nandankanan was 10012, 11964, 10446, 11860, 13644 and 13293 kcal/day, respectively. Converting these values in proportionate to metabolic body size, daily average DE intake would be 175, 179, 183, 178, 205 and 199.9 kcal/ kg $BW^{0.75}$, in the 6 respective zoos. All the male tigers in Nandankanan received calorie within the acceptable limit, however, refusal rate was higher than the others 5 zoos which also received adequate energy even with much less amount of meat being offered. Animals in other zoos received energy in excess of requirement. From the study, it was observed that female animals are more likely to be overfed and are more prone to obesity. Thus, it would be desirable if females are fed at least 20 % less meat than males. The boneless meat diet of Hyderabad zoo was adequate for male; however, female received excess of calorie. Female diet may be reduced by one kg. As the nutrient requirements of tigers are not known, we used NRC requirements for domestic cat (NRC 2006) to test the diet adequacy. According to this, diet must contain 0.8% Ca, 0.6% P, 80 ppm Fe, 50 ppm Zn and 5 ppm Cu. All the diets provided adequate amount of all the above mentioned nutrients. Four animals (2 each in Delhi and Chattbir) had significantly lower amount of Ca in their diet. Other animals in same location were able to maintain adequate Ca level. So it would be difficult to attribute the observed discrepancy to diet. Hence, we have not included these data in the presentations. Boneless meat diet of Hyderabad zoo was adequate in Ca, but it contained more P than Ca, which is not good. It is suggested that amount of $CaCO_3$ could be increased in the diet or long bone with shred of meat attached to it may be given on off day.

Suggested guidelines for feeding

Captive diet must be monitored constantly. Tiger diet must be worked out for individual animal considering its body size, physiological status, any special requirement and health. It is acknowledged that the following suggestion should be better treated as general guideline.

1. For an average sized male and female, 8 and 6 kg of meat on bone would be adequate.
2. Boneless meat must be supplemented with 7-10 g of $CaCO_3$/kg meat.
3. Vitamin fortification should be done to provide 9000 IU of vitamin A or 500 IU of Vitamin D per kg of meat on dry matter basis. Simplifying it, we can add 3000 IU of vitamin A and 150 IU of vitamin D to every kg of fresh meat.
4. Some zoo fed liver, egg and milk as a supplement to their tiger diet. Such practices should be stopped. It is better to use commercial vitamin supplement.
5. It is good that in all our zoos except one, we feed a chunk of meat, bone still attached on it. It is a great source of behavioural enrichment to tigers as it simulates natural feeding behaviour. The butcher may be asked to cut the pieces in a manner that requisite quota of a particular animal could be provided in a singular piece.
6. Further behavioural enrichment could be provided by innovative thoughts applicable at local level. The basic idea is that the tiger should actually

work out for the meat. Some zoo keepers do it by keeping meat in gunny bags suspended from the roof of the enclosure; others conceal the meat inside the enclosure or simply keep it in bags by tightly securing it with ropes.

7. Parasitic load could be significantly reduced by freezing the meat and thawing it before feeding.
8. Meat should be provided as late as possible. Indore zoo fed their tigers at night. This is tremendous source of behavioural stimulation and also good for maintaining general hygiene.
9. Feeding of chicken is not necessary under normal circumstance, however, it can be given to a particular animal which refuses to chew bones.
10. Use of milk, egg etc. are not encouraged.
11. Lactating animals and growing cubs do not require an off day. They should be fed *ad lib* every day. If possible lactating tiger's quota of meat should be spread over several meals.
12. Amount of meat could be increased by 10-20 % during severe cold.

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3.36 Lion

Order	:	Carnivora
Family	:	Felidae
Genus	:	Panthera
Species	:	*P. leo persicus*

The Asiatic Lion is an endangered species (IUCN, 2003) found only in Gir National Park in Gujarat (Singh, 1997). It is protected under Schedule I of WPA (1972) of India. The current population of Gir Lion is estimated to be 411. A male lion may weigh between 160 to 190 kg, whereas, female is lighter at 110-120 kg. Hair colour varies from reddish brown to highly mottled black to sandy grey (Nowell and Jackson, 1996). Females attain sexual maturity at an age of 2–4 years. Gestation length is 100-119 days after which 2-4 cubs are born (Meena, 2008). Meat eating starts at 3 months of age while continuing to suckle till 6 months of age. Asiatic lions are social animals living in pride. They are strictly carnivore. Main prey species are sambar, chital, nilgai, wild pig, chinkara and livestock. Average lifespan of female Asiatic lion is 17-18 years with a maximum of 21 years. Male Asiatic lion lives for 16 years (Harrington, 2004)

Lions like other felids are strict carnivores and lacks the flexibility of facultative carnivores. They can not conserve protein. When diet lower in protein is fed other animal conserve it by reducing the excretion of protein in urine. Lions and other felids lack this mechanisms and urinary loss continues to be high on low protein diet. To cope up, lions have to consume high amount of animal protein. Further they also can not synthesize sufficient amount of taurine. Taurine is available only in muscle. These and other mechanisms adapted by strict carnivores have already been discussed in the section for tiger.

Feeding in Captivity

Use of muscle meat as sole diet was once widespread in zoos across the world. In wild, lion will devour all part or most part of the prey that they capture. Muscle meats are, however, quite different from whole prey in nutrient composition. Muscle meat is good source of protein, Na, K, Fe, Se, Zn and B-Complex vitamins. But they are very poor source of Ca and Ca: P ratio is about 1:15 to 1:30. Desirable Ca: P would be 2:1 to 1:1. The imbalance in Ca and P nutrition is thus obvious, when only muscle meat is fed to carnivores. Pathological bone condition has been reported in captive carnivore fed un-supplemented muscle meat (Allen *et al*. 1995). Commercially manufactured carnivorous diet is fed to the carnivores in most of the US Zoos. However, feeding of soft food for longer period may cause dental problems like plaque, and calculus formation leading to gingivitis. In Bristol zoo, Asiatic lions are fed with 3–4 kg of meat with a weekly fasting day. In Australia, African lions (which are bigger than Asiatic lion) are fed only 5 days in a week. They are fed 4.5 to 6 kg of kangaroo, beef, goat, sheep, emu, horse, deer or chicken (Roe and Cleve, 2007). The basic idea is to provide different type of meat on different days. In most of the

Indian zoos meat on bone is offered to Asiatic lion. They are also sometimes supplemented with chicken, egg or even milk.

Very limited information is available on captive feeding of Asiatic lion. The diet chart of different Indian zoos is presented in Table 1.

Table 1: Feeding schedule of Asiatic lion in different Indian zoos

Sl. No.	Name of the Zoo	Diet Schedule			
1.	MCZP, Chattbir	Buffalo meat (with bones)		Milk	
		10 kg		0.4 kg	
2.	NZP, New Delhi	Buffalo meat			
		10 kg (Summer)		12 kg (Wwinter)	
3.	Sanjay Gandhi Biological Park, Patna			Beef	Chicken
				7 kg	2 kg
4.	Thiruvananthapuram Zoo	Beef		7 kg	
5.	Nandankanan Biological Park, Bhubaneswar			Buffalo meat	
		11 kg (April-June)		11 kg (July-March)	
6.	Sepahijala Biological Park, Tripura	Beef/ chevon		9 kg	
7.	Dr. Shivaram Karanth, Pilikula Biological Park, Manglore	Beef with bones	Beef boneless		Chicken [6days a week]
		6.00kg	2.00 kg		1.00 kg
8.	Nehru Zoological Park, Hyderabad	Milk	Beef (boneless)		Liver
		½ l	8 kg		250 g
9.	Bhagwan Birsa Zoological Garden, Ranchi	Beef with bones	Beef (boneless)		
		12 kg	10 kg		
10.	Jaipur Zoo	Meat	Milk		Egg
		8 kg	0.5 kg		1 in number
11.	Zoological Garden, Alipore	Buffalo Meat			
		9.00 kg (Summer)	12.00 (Winter)		
12.	Kanpur ,Zoo	Buffalo meat	8-12 kg		
13.	V.J.B. Udyaan , Mumbai	Eggs	Beef boneless		Liver
		2 in numbers	14 kg		200 g
14.	Lucknow Zoo	Buffalo meat			
		8-12 kg			

Materials and Methods

During the present investigation we conducted feeding trial on 15 lions. Zoo wise break up was 5 (4M, 1F), 4 (all male) and 6 (3M, 3F) lions in Delhi, Hyderabad and Junagarh, respectively. All the animals were fed their respective diet 6 days a week. Lions in Nehru Zoological Park, Hyderabad were fed boneless meat supplemented with calcium. All other zoos fed raw beef or buffalo meat to their lions. During the period of experimentation, all the animals were offered measured amount of food. The refusal and faeces voided by the animals were collected in full and suitable sample were taken for laboratory analysis. Energy, protein and mineral content of feed, faeces and refusals were analyzed using standard laboratory methods. All the animals were fed 6 days a week.

Results and Interpretation

Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 2-4 and also presented in Figure 1.

Table 2: Nutrient composition (on dry matter basis) of diet fed to lions in different zoos

Meat		On Dry matter basis							
	DM (%)	GE (kcal/kg DM)	CP (%)	Fat (%)	Ca (%)	P (%)	Fe ppm	Zn ppm	Cu ppm
				National Zoological Park, New Delhi					
Offered	39.45	5206	32.4	57.2	3.14	1.87	80	9	180
Residue	41.5	4660	26.4	57.7	5.22	2.88	75	9	170
Offered	28.99	4160	12.38	77.1	3.48	1.71	51	6	61
				Sakkarbaugh Zoo, Junagarh					
Offered	41.23	5160	32.14	57.1	3.41	1.91	85	5	115
Residue	45.72	4920	31.24	52.8	7.72	2.24	84	4	85
				National Zoological Park, Hyderabad					
Offered	39.43	5540	34.34	62.2	1.04	1.17	88	8	135
Residues	42.17	5330	28.44	70.3	0.99	1.23	74	7	115

DM, dry matter; CP, crude protein; ppm, parts per million; GE, gross energy (kcal/kg DM)

Table 3: Feed intake and digestibility of lion in different zoo

	Meat offered (kg/d)	Meat residue (kg/d)	Chicken offered (kg/d)	Chicken left (kg/d)	DMI (g/d)	DMD (%)	DE intake (kcal/d)
National Zoological Park, New Delhi							
Male	9.3±0.4	4.3±0.6	0.55±0.4	0.00	1984±147	89.4±0.8	10278±739
Sakkarbaugh Zoo, Junagarh							
Male	6.7±0.4	1.2±0.6	0.00	0.00	2217±226	94.7±0.5	11072±1088
Female	5.0±0.0	1.1±0.1	0.00	0.00	1547±40	94.4±1.0	7736±196
Nehru Zoological Park, Hyderabad							
Male	5.9±0.3	0.00±0	0.00	0.00	2312±114	90.7±20	11714±500

DMI, dry matter intake; DMD, dry matter digestibility; DE, digestible energy

Table 4: Nutritional adequacy of diet (on DM basis) fed to lions in different zoo

	Fat (%)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
National Zoological Park, New Delhi							
Male	36.7±0.9	58.1±0.9	1.23±0.3	0.91±0.2	82.8±1.2	181.0± 5.0	8.8±0.1
Sakkarbaugh Zoo, Junagarh							
Male	32.4±0.2	58.3±0.7	2.2±0.7	1.82±0.1	85.3±0.2	123.4±5.0	5.3±0.2
Female	32.4±0.1	58.6±0.2	1.97±0.2	1.80±0.1	85.3±0.1	125.0±1.0	5.3±0.3
Nehru Zoological Park, Hyderabad							
Male	34.3±0.1	62.3±0.1	1.0±0.1	1.2±0.1	88.0±0.1	135.0±0.1	8.0±0.1

CP, crude protein ; ppm, parts per million

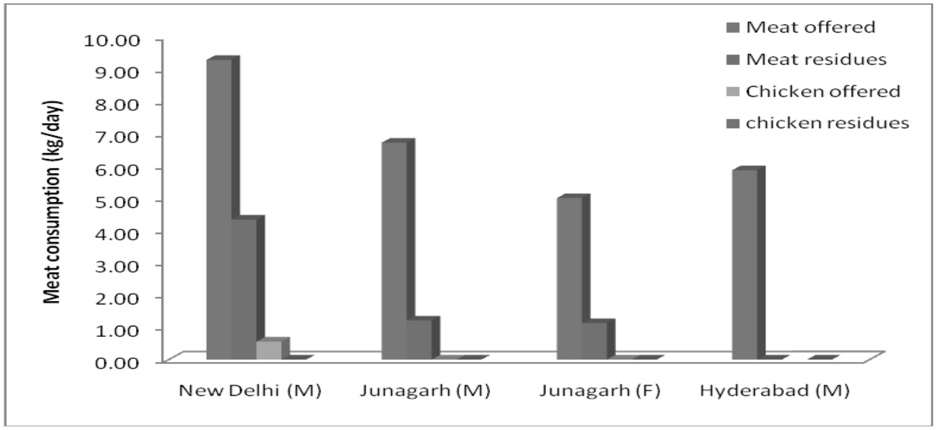

Figure 1: Actual consumption of meat by lions at different zoos

Dry matter intake was 1983, 2217 and 2311 g/d in male animals of Delhi, Junagarh and Hyderabad, respectively. The female animal consumed much less than male animals. However, these differences were only due to size. As a proportion of body weight dry matter intake was 1.10, 1.23 and 1.28% in males of Delhi, Junagarh and Hyderabad zoo, respectively. Dry matter consumption in lioness in Junagarh was 1.29% of body weight. Most striking finding was that when lions were fed more meat the percent refusal increased (Fig. 1). This is not only an economic loss, but also cause disposal and sanitary problem. Digestible energy intake was 10,278, 11,072 and 11,714 kcal/d in male animals of Delhi, Junagarh and Hyderabad, respectively. Lioness in Junagarh consumed 7,736 kcal DE/d. In carnivores, 90% of the digestible energy is utilized. Hence, we multiplied DE intake by a factor of 0.9 to derive metabolizable energy (ME). Further, the energy requirement of animal is a function of body size, rather than body weight. Hence, ME intake is expressed as $BW^{0.75}$. In the present experiment, ME intake was 179, 201 and 215 kcal/kg $W^{0.75}$ in male animals of Delhi, Hyderabad and Junagarh, respectively. ME intake in lioness was also very similar i.e. 193 kcal/kg $BW^{0.75}$. Even though lions in Delhi were fed maximum amount of meat, energy consumption was minimum in those lions. Maximum energy consumption by lions in Hyderabad zoo was obviously attributed to the boneless meat they were offered. Virtually, there was not a scrap left over in the enclosure.

Actual energy requirement of lions are not known. However, ME requirements are estimated to be between 155–260 kcal/kg $BW^{0.75}$ (NRC, 2006). Allen *et al*. (1995) reported that ME requirement for lions are lower in comparison to tiger and leopard. It was also indicated that body mass in lions could be maintained when energy is supplied @ 1.5 time interspecies basal metabolic rate (BMR). In this regard, all the animals received energy in excess of requirement. Nutrient requirements of lions are not known. To test the diet adequacy we compared the value of nutrient supply of the consumed diet with the requirement of cat (NRC, 2006).

According to that lion diet must supply 24% CP, 0.8% Ca, 0.6% P, 80 ppm Zn and 5 ppm Cu. All the diets provided all these nutrients in adequate amount. The boneless meat diet of Hyderabad also provided adequate amount of Ca, but was unable to maintain a proper Ca: P ratio.

Suggested Guidelines for feeding

Based upon the results of our experiments and comparison with the similar studies conducted in this and other species of felids, we suggest that a diet containing 6.75 kg of buffalo meat for an average sized adult lion and 5 kg of buffalo meat for an adult lioness of average body weight would be adequate.

1. If boneless meat is fed, each kg of meat should be supplemented with 10 g of $CaCO_3$ and 2 tsp of multivitamin supplement.
2. Behavioural enrichment could be provided by hanging up the meat in gunny bags, hiding it inside enclosure or by applying many other innovative ideas.
3. It is preferable to freeze the meat and then thaw it before feeding. This freezing and thawing will significantly reduce parasitic and microbial load.
4. During summer meat offered should be reduced by 500 g.
5. Body condition should be monitored regularly and adjust the amount of meat accordingly.
6. A diet chart should be maintained for each individual in the collection.
7. Lactating animals should be fed *ad lib*. They may be fed their daily ad-lib ration distributed over 2-3 equal meals.
8. Feeding time should be set so as to minimize exposure of meat to high ambient temperature. Regular record of actual food consumption must be kept.

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3.37 Leopard

Order	:	Carnivora
Family	:	Felidae
Genus	:	*Panthera*
Species	:	*P. purdus*

Leopard is the most widely distributed cat in the genus *Panthera*. It is found in all over the country with the exception of deserts, mangrove forest and thickly populated urban areas. The pelage colour varies from pale yellow to dark gold with black rosettes. Throat, chest, belly and inner side of the limbs are white in colour. Body weight of average male ranges from 50–70 kg and female body weight varies from 29–54 kg (Nowell and Jackson, 1996). They are not seasonal breeder. Sexual maturity is attained at an age of 2.5 years. Gestation length is 90–112 days after which 2 -3 cubs are born. Young one weighs 400–700 g and opens eyes 7–9 days after birth. Average life span for wild leopard is 10-12 years, in captivity they can live upto 21-23 years (Hunt, 2011).

Leopards are opportunist feeder. They can feed on many different kinds of prey. Karanth *et al.* (1995) reported that chital was the main (83%) component in leopard diet. Mukherjee *et al.* (2004) also reported that chital is the main component of (65%) leopard diet followed by Sambar (20%) and Langur (15%). In other studies, leopards have been reported to predate chinkara, hare, sambar, four-horned antelope, rodents, hare and peafowl. In Sanjay Gandhi National Park which is very close to city, main diet of leopard was dog (Edgaonkar and Chellam, 2002).

Feeding in Captivity

The information available on captive feeding of leopard is scanty. The feeding schedules practiced in different Indian zoos are listed in Table 1.

Table 1 a : Diet chart of leopard in some Indian zoos

S. No.	Name of the Zoo	Diet schedule		
1.	MC Zoological Park, Chattbir	Buffalo meat	Milk	
		0.5 kg	0.5 kg	
2.	Himalayan Nature Park, Kufri	Goat meat	Buffalo meat	
		2 kg	0.25 kg	
3.	Patna Zoo	Beef	Chicken	Fish
		1.8 kg	500 g	250 g
4.	Thiruvananthapuram Zoo	Beef	Milk	Egg
		3 kg	600 ml	150g
5.	Nandankanan Biological Park	Age of animal	Buffalo meat	
		Juvenile (6 Months – 1 year)	1 kg	
		Sub-adult (1 -1 ½ year)	3 kg	
		Above 1 ½ year	4 kg	

Table 1 b : Diet chart of leopard in some other Indian zoos

S. No.	Name of the Zoo	Diet schedule		
1.	Sephaijala Biological Park	Age of animal Adult Sub-adult	Beef/Goat Meat 3 kg 1.5 kg	
2.	Dr. Shivaram Karanth, Pilikula Biological Park, Manglore	Beef (with Bones) 1.00 kg	Beef (boneless) 0.75 kg	Chicken 1.25 kg
3.	Nehru Zoological Park, Hyderabad		Beef 3 kg	Liver 125 g
4.	Bhagwan Birsa Zoological Garden	Beef with bone 3 kg	Beef (bone less) 2.5 kg	
5.	Jaipur Zoo	Beef 3.5 kg	Milk 0.5 l	Egg one
6.	Rajiv Gandhi Zoological Park	Beef (bone) 3-4 kg	Chicken 3-4 kg ((Sunday)	
7.	Lucknow Zoo	Buffalo calf Meat 3-4 kg		
8.	V.J.B Udyaan Mumbai	Beef 3 kg	Eggs 1 number	
9.	Alipore Zoo	Buffalo meat (bone) 3.00kg (Summer) 5.00kg (Winter)	Buffalo meat Boneless 2.5 kg (Summer) 4.00 kg (Winter)	

It is evident that there is large variation in amount of meat being fed to captive leopards in different zoos. In most of the Western zoos, they are being fed with commercial feline diet. In San Diego zoo, leopards are fed 1.6 kg of commercial diet daily with supplemental minerals and vitamins. Barbiers *et al.* (1982) reported that crude protein digestibility was 83– 90%, whereas, ether extract digestibility was 94–99% in leopard. Leopards were able to maintain body mass when DE intake ranged from 162 – 185 Kcal/kg $BW^{0.75}$.

Materials and Methods

We conducted feeding trial on 27 leopards kept in different zoos. Zoo wise break up of leopard was 6 (3M, 3F) in Hyderabad, 3 in Delhi (3M), 12 (7M, 5F) in Bhopal and 6 (3M, 3F) in Banerghatta. All the animals were fed their respective diet 6 days a week. Leopards in Nehru Zoological Park, Hyderabad were fed boneless meat supplemented with calcium. All other zoos fed raw beef or buffalo meat. During the period of experimentation, all the animals were offered measured amount of food. The refusal and faeces voided by the animals were collected in full and suitable sample were taken for laboratory analysis.

Results and Interpretation

Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in table 2-4 and also presented in Figure 1.

The meat offered at Bhopal contained significantly higher amount of fat. Boneless meat of Hyderabad contained less calcium than the diet of other zoos. Total dry matter intake among male animals was minimum in leopards of Lucknow, followed by those in Delhi, Bhopal, Hyderabad and Banerghatta National Park.

Table 2: Nutrient composition of leopard diet in different zoos

Meat		On Dry matter basis							
	DM (%)	GE (kcal/kg DM)	CP (%)	Fat (%)	Ca (%)	P (%)	Fe ppm	Zn ppm	Cu ppm
Vanvihar National Park, Bhopal									
Offered	42.7	5510	39.4	49.1	3.44	1.76	88	135	6
Residues	49.1	4730	29.2	53	8.11	3.98	80	120	5
National Zoological Park, New Delhi									
Offered	39.5	5206	32.4	57.2	3.12	1.87	80	180	9
Residues	41.5	4660	26.4	57.7	4.22	2.88	75	170	9
Lucknow Zoo									
Offered	41.7	5210	32.2	57.4	3.04	2.01	95	145	8
Residues	47.1	4470	22.8	60	8.14	4.03	85	130	7
Nehru Zoological Park, Hyderabad									
Offered	39.4	5440	34.3	62.3	1.04	1.17	88	135	8
Residues	42.2	5330	28.4	70.3	0.99	1.23	74	115	7
Banerghatta National Park									
Offered	39.4	5420	36.2	54.1	2.84	1.84	95	8	45
Residues	42.5	4760	28	56.2	7.01	4	84	7	38

DM, dry matter; CP, crude protein; ppm, parts per million; GE, gross energy (kcal/kg DM)

Table 3: Intake and digestibility of meat by leopard in different zoos

	Offered	Left	DMI	DMD	DEI	Fat (%)	CP (%)
Vanvihar National Park, Bhopal							
Male	3.0	0.5	1016	92.3	5424	41.8	48.2
	±0.1	±0.1	±63	±0.6	±322	±0.3	±0.3
Female	2.8	0.5	967	93.4	5236	42.0	48.1
	±0.2	±0.1	±97	±0.7	±511	±0.7	±0.2
National Zoological Park, New Delhi							
Male	5.6	3.2	881	92.0	5064	41.5	56.5
	±o.3	±0.1	±90	±3.2	±573	±0.4	±0.1
Lucknow Zoo							
Male	2.5	0.5	851	88.9	3945	35.3	±0.7
	±0.1	±0.2	±56	±1.5	±140	56.6	±0.2
Female	2.5	0.4	86.3	±149	4101	34.6	56.8
	±0.1	±0.3	834	±6.3	±596	±1.5	±0.5
Nehru Zoological Park, Hyderabad							
Male	3.5	0.0	1398	92.4	7068	34.3	62.3
	±0.2		±65	±0.7	±344	±0.1	±0.1
Female	3.1	0.0	1225	93.3	6242	34.3	62.3
	±0.1		±6	±0.5	±32	±0.1	±0.1
Banerghatta National Park							
Male	4.6	0.8	1514	87.0	7653	38.1	53.6
	±0.3	±0.10	±17	±0.0	±821	±0.6	±0.1
Female	4.0	0.8	1257	87.0	6359	38.3	53.6
	±0.1	±0.1	±2.1	±0.1	±60	±0.1	±0.1

DMI, dry matter intake; DMD, dry matter digestibility (%); DEI, digestible energy intake (kcal/ day),

Table 4: Mineral composition of diet fed to leopard in different zoos

	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
		Van Vihar National Park, Bhopal			
Male	2.4±0.15	1.3±0.07	89.8±0.26	138.4±0.49	6.2±0.03
Female	2.3±0.27	1.2±0.13	90.0±0.46	138.8±0.86	6.3±0.06
		National Zoological Park, New Delhi			
Male	1.5±0.14	0.5±0.13	87.7±0.8	195±1.7	9.02±0.02
		Lucknow Zoo			
Male	1.4±0.38	1.3±0.15	98.3±0.75	149.9±1.13	8.3±0.08
Female	1.7±1.00	1.5±0.40	97.6±1.97	148.9±2.95	8.3±0.20
		Nehru Zoological Park , Hyderabad			
Male	1.0±0.00	1.2±0.00	88.0±0.00	135.0±0.00	8.0±0.00
Female	1.0±0.00	1.2±0.00	88.0±0.00	135.0±0.00	8.0±0.00
		Banerghatta National Park			
Male	1.9±0.25	1.3±0.13	97.5±0.65	46.6±0.41	8.2±0.06
Female	1.8±0.01	1.3±0.00	97.8±0.02	46.8±0.01	8.3±0.00

ppm: parts per million

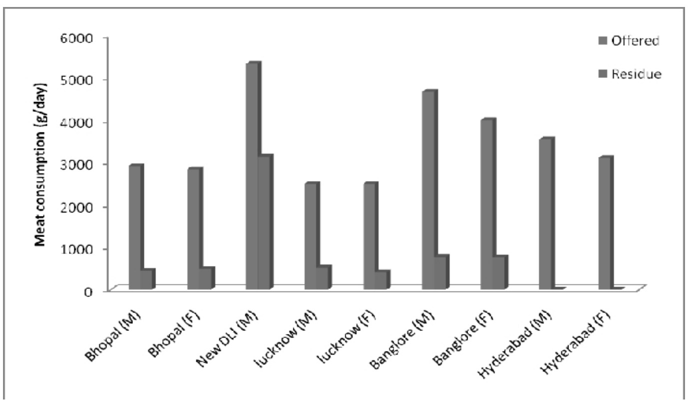

Figure 1: Meat offered and refusals in leopard at different zoos

Average DMI expressed as % of body weight was 1.69, 1.66, 1.54, 2.53 and 2.52% of body weight in male leopards of Bhopal, Delhi, Lucknow, Hyderabad and Banerghatta zoo, respectively. Dry matter consumption in female leopard was 2.01, 1.85, 2.72 and 2.79% of body weight in Bhopal, Lucknow, Hyderabad and Banerghatta, respectively. Female leopards are smaller than males. That is the reason why dry matter intake as proportionate to body weight was higher in females in comparison to male. It could also imply that if restricted feeding is not adopted female leopards will be more prone to obesity than males. In the present experiment, digestibility of dry matter ranged from 87 to 94 %. Digestibility was similar in males and female. Lower digestibility observed in Lucknow Zoo and Banerghatta National Park could not be attributed to any specific reason. However, the values were within the range reported for various species of big cats (Vester *et al.*, 2008). DE intake was 5424, 5064, 3945, 7068, and 7653 kcal/ day in male leopards of Bhopal, Delhi, Lucknow, Hyderabad and Banerghatta, respectively. DE intake was 5424, 5064, 3945, 7068, and 7653 kcal/ day in male leopards of Bhopal, Delhi, Lucknow, Hyderabad and Banerghatta, respectively. Similarly, DE intake was 5236, 4101, 6242 and 6359 kcal/day in female leopards of Bhopal, Lucknow, Hyderabad and Banerghatta, respectively. All these animals were fed 6 days a week. So the calorie requirement for the seventh day is to be met from the energy consumed during the previous 6 days of the week. Taking this point into account, weighted weekly average daily DE intake was calculated to be 230, 215,167,361 and 442 kcal / kg $BW^{0.75}$ in males of Delhi, Bhopal, Lucknow, Hyderabad, and Banerghatta, respectively. Barbiers *et al.* (1982) reported that leopard can maintain body mass when 165-182 kcal/ $kgw^{0.75}$ of DE was provided. The diet of male leopard in Lucknow zoo provided similar amount of DE. It is evident that the diet practiced in Lucknow zoo provided adequate calories to meet requirements without any potential threat of obesity. The diet schedule followed in other zoos provided energy in excess of requirement. All the females including those in Lucknow received more energy than requirement. We suggest that the diet schedule may be reassessed. As in the other big cats, nutrient requirement of leopards are not clearly understood. Hence, to test diet the diet adequacy we compared the value obtained in our experiment with those recommended for cats (NRC, 2006). It is suggested that the felid diet should contain 0.8 % Ca, 0.6 % P, 80 ppm Fe, 50 ppm Zn and 5 ppm Cu. All the diets tested were found to be adequate in all these regards. However, boneless meat diet was imbalanced in Ca: P ratio

Suggested guidelines for feeding

1. All the animals should be fed according to the body size. An average male should be fed 2.5 kg of meat, whereas, 2 kg of meat should be fed to an average sized female. Regular monitoring of body condition is of utmost importance. Amount of food can be adjusted according to the body condition.
2. When boneless meat is fed, meat should be supplemented with 7-10 g of $CaCO_3$/kg of fresh meat.
3. During cold winter, amount of meat may be increased by 20%.
4. Growing and lactating animals may be fed *ad lib* without any off-day.
5. Chicken may be given to bring variety in the diet on once or twice a week without increasing the total amount of food.
6. Provide 1500 IU of vitamin A and 150 IU of vitamin D in every kg of meat. If liver is fed as a part of diet this supplement may not be necessary. However, it is preferable to use vitamin supplement than liver.
7. As discussed for other felids, highest standard of general hygiene should be maintained throughout

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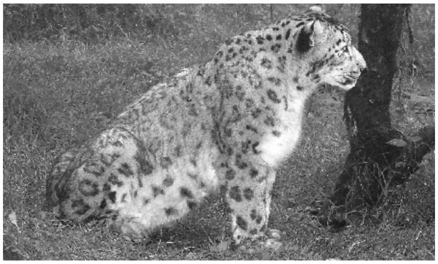
3.38 Snow Leopard

Order	:	Carnivora
Family	:	Felidae
Genus	:	*Uncia*
Species	:	*U. uncia*



Snow leopards are found in rocky and mountainous terrain of Central and South Asia at an attitude of 3000-5500 m above sea levels. They are medium sized cat. Body length ranges from 75 to 130 cm, with the tail adding an additional 75 to 90 % to that length. The height is about 60 cm and body weight ranges from 25 to 55 kg (McCarthy and Chapron, 2003).

The fur colour varies from grey to yellowish, with rosette of dark black colour. Eyes are pale green or gray in colour. Thick fur, small rounded ear and stocky body help to conserve heat. The long bushy tail aids in keeping body balance while moving on uneven terrain. The paws are wide and have hairs underside, which helps them move easily on snow and also conserve heat. Adaptation for rocky terrain includes well developed chest, short forelimb with larger paw for moving on snow, long hind limbs for leaping and long flexible tail for balancing. Adaptations for cold climate include enlarged nasal cavity, long fur with wooly undergrowth, thick furry tail for wrapping around face and body (McCarthy and Chapron, 2003). Snow leopard can not roar. They have got certain amount of ossification of hyoid bones. However, of late it is believed that big cats can roar only with specialized feature of larynx, which snow leopard lacks. Lifespan is about 18 years

The breeding usually takes place during late winter. Gestation length is 90 - 100 days (Toriella, 2002). In free range, they feed on bharals, ibex, gorals and other animals. They also predate on sheep and goat flock, causing a lot of man-animal conflict (Sunquist and Sunquist, 2002).

Feeding in Captivity

In most of the American and Central Asian zoos, they are fed on fresh horse meat, alternating with beef (Marama, 1968). They are each given 3 kg daily. In addition each leopard is given 20 g of oat shoot, 10 g of fish oil (or 3 drops of vitamin A) daily for 4 days of each week and 10 g of yeast. Three times a week they are given a live rabbit, duck or chicken.

In the 1940's, a snow leopard kept in Bronx zoos was fed 1.8 kg of horse meat five or six times a week which was supplemented twice a week with bone meal and cod liver oil. Fowls or pigeons were also offered two or 3 times each week (Crandall, 1964). At St. Louis zoo, a pregnant or lactating animal was fed freshly killed rabbits, pigeons and chicken in addition to horse meat (Frueh, 1968). In North America, most zoos now feed a commercial feline diet which consists of ground beef or horse meat and mineral and vitamin supplement (Wharton and Mainka, 1997). Bones are provided to promote healthy teeth and gums. At Bronx zoo, each week commercial canine or feline diet is fed for 5 days and chicken neck or beef knuckle is fed for 2 days. Mineral vitamin supplements are not necessary for properly balanced commercial ration. However, kitten up to 6 months of age are given 200 ml of kitten milk replacer and 5 g of calcium daily. In Philadelphia zoo, to each 2.2 kg of solid horse meat, 5 g of mineral mixture (9 parts oyster shell powder, I parts skimmed milk and 1 part iodized salt) is added (Rosenthal and Ott-Joslin, 1988). In most of the Indian zoos they are fed fresh meat 6 times a week (Table 1).

Table 1: Feeding schedule of Snow leopard in different Indian zoos

Name of the zoo	Type of food	Quantity	Feeding freequency
PNHZP, Darjeeling	Mutton/ beef	2.5-3.5 kg	6 times a week
Gangtok Zoo	Beef	3 kg	6 times a week
HNP, Kufri	Mutton	2 kg	6 times a week
Nainital Zoo	Mutton	3 kg	6 times a week

Materials and Method

We conducted feeding trials on 11 snow leopards in Darjeeling, 1 animal each in Kufri and Gangtok and 2 animals in Nainital zoo. During the trial period, measured amount of food was given to each animal. Residue and faeces were also collected in full. Faecal samples were collected by both direct measure and also by using markers. Nutrient composition of food offered, residues and faecal samples were analyzed by using standard laboratory analysis.

Results and Interpretation

Data pertaining to nutrient composition of meat offered and refusal are presented in Table 2.

Table 2: Chemical composition of meat fed to snow leopard in different Zoos

Meat		On Dry matter basis							
	DM (%)	GE (Kcal/kg DM)	CP (%)	Fat (%)	Ca (%)	P (%)	Fe ppm	Zn ppm	Cu ppm
				PNHZP, Darjeeling					
Beef									
Offered	42.11	5140	67.5	27.14	3.22	1.94	78	178	15
Residue	64.33	4170	75.0	13.14	7.94	3.89	98	225	16
Mutton									
Offered	31.03	4790	75.0	20.14	3.57	1.98	81	182	14
Residue	58.38	3980	73.2	12.18	10.4	5.11	112	230	14
				Gangtok Zoo					
Beef									
Offered	39.84	5020	69.2	25.14	3.24	1.94	84	210	17
Residue	65.44	4180	73.4	14.57	8.04	4.15	95	220	17
				Himalayan Nature Park, Kufri					
Mutton									
Offered	36.14	5120	65.7	28.41	3.74	1.91	94	105	16
Residue	52.16	4170	75.0	13.14	7.75	3.97	85	185	18
				Pt. GB Pant High Altitude Zoo, Nainital					
Mutton									
Offered	37.21	4720	73.0	21.43	4.11	1.88	94	158	17
Residue	60.42	4320	72.1	15.79	7.31	3.24	80	140	16

CP, crude protein; GE, Gross energy (kcal/ kg dry matter); ppm, parts per million

In most of the Western Zoos, snow leopards are fed on the basis of Nutrient requirements of domestic cat (NRC, 1986) which states that feline diet should contain 25% crude protein, 0.8% Ca, 0.6% P, 80 ppm Fe, 5 ppm Cu and 50 ppm Zn. The diet must supply 5 kcal GE/g diet DM. In their study, Allen *et al*. (1995) reported that crude protein content varied from 38 to 41%, whereas, fat content varied from 36 to 40% in snow leopard diets used in different US zoos. It seems that horse meat based feline diet used in American Zoos contain more fat and less protein than the raw meat diet fed in Indian zoos.

Table 3: Feed consumption, diet digestibility and nutritional adequacy of snow leopard diet in different zoos

	Name of the zoo			
Parameters	**Darjeeling**	**Gangtok**	**Nainital**	**Kufri**
Dry matter intake (g/ day)	614±44.41	733.25±6.91	656±13	492±19.1
Dry matter digestibility (%)	88.39±0.53	92.48±1.14	94.1±0.65	92.7±0.58
Diet adequacy				
CP (%)	65.69±0.63	67.41	73.6±0.07	61.0±0.78
Fat (%)	31.59±0.64	29.61	25.8± 0.21	36.12±1.37
Ca (%)	1.39±0.15	1.21	1.33±0.13	1.74±0.35
P (%)	1.163±0.64	1.01	0.80±0.05	0.88±0.19
Fe (ppm)	70.36±0.62	79.35	105.2±0.55	98.5±0.76
Zn (ppm)	160.27±1.42	205.77	173±0.50	214.9±1.82
Cu (ppm)	14.52±0.06	17	25.8±0.40	14.8±0.15
DEI (kcal/kg $W^{.075}$)	209±7.7	225	201±6.4	164±4.7

CP, crude protein; DEI, digestible energy intake; ppm, parts per million

Data pertaining to feed consumption diet digestibility and nutritional adequacies of the diets are presented in Table 2. From the perusals of the data, it is evident that the average DMI in all the 4 zoos was satisfactory. Overall DMI was 1.44, 1.53, 1.73 and 1.23% of body weight in Darjeeling, Gangtok, Nainital and Kufri, respectively. Similarly, Edwards *et al.* (1995) reported diet dry matter intake of 1.43 to 1.63 of body weight in small felids.

In this experiemtn, all the diets supplied adequate amount of Ca, P, protein and fat. Digestible energy intake was 209, 225, 201 and 164 kcal/kg $BW^{0.75}$ in Darjeeling, Gangtok, Nainital and Kufri Zoo, respectively. The values are higher than that recommended for cat (NRC, 1986). However, considerable variation in energy requirement between different species of felids has been reported (Allen et. al., 1995). These differences are not solely due to variation in body size, but could be due to species specific variation in metabolic strategies. DE intakes relative to metabolic body size in snow leopard was similar to those reported for adult leopards (*Panthera purdus*) by Barbiers *et al*. (1982). A leopard (53.8 kg BW) had 182 kcal/ $kgW^{0.75}$ DE intake and maintained body mass without any threat of obesity. Similar DE requirement have been reported also for cheetah (Allen *et al*. 1995). Snow leopards being acclimatized for cold climate may require higher amount of energy. During the present investigation, we have noted that snow leopards fed mutton received less calorie and more calcium in comparison to those fed beef. It seems to be a good practice and may be continued.

Suggested guidelines of feeding

1. For an average sized male 2.5 kg of meat and for an average sized female 2 kg of meat will be adequate.
2. Mutton would be a better source of nutrients than beef.
3. Food should be offered in the latest hour of the afternoon as would be practicable for the management. One time feeding is sufficient except for nursing mothers whose total ration may be divided into 2 -3 equal meals.
4. If excessive amount of bone is left over than precaution might be taken. In such case, Calcium carbonate may be supplemented @ 7g/kg meat.
5. A few drops of vitamin A concentrate may be supplemented. Most important is regular monitoring of body condition. Diets could be modified accordingly with response to the change in body weight.
6. Water should be made available at all times.

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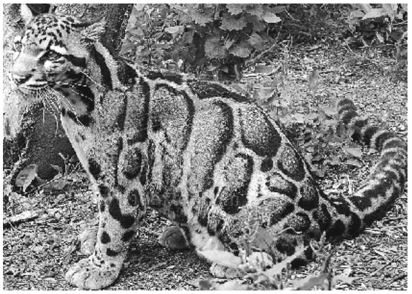
3.39 Clouded Leopard

Order	:	Carnivora
Family	:	Felidae
Genus	:	*Neofelis*
Species	:	*N. nebulosa*



Clouded leopard is a medium sized cat found in forested areas of North-East India and South-East Asian countries. In India, they are found in Northern Bengal and all the North-Eastern states (Chaudhury, 2003). It has tawny colour pelage and distinctive large irregular shaped eclipses on it which resembles a cloud pattern (Pocock, 1941). The species is protected under Schedule I of Wildlife Protect Act (1972) of India, and the IUCN Red Data Book lists it as vulnerable. Clouded leopards were believed to be highly arboreal. However, recent evidences suggest that they can spend considerable time on ground. It can hang upside down from branches by hind feet, can climb horizontal branches with it's back pointed toward the ground and can run head-first down (Holmes, 2009). Most preferred habitat type is primary evergreen tropical rainforest. They can also thrive in dry tropical forest, mangrove swamps, grassland and scrubland. In the Himalayas, they have been sighted upto an elevation of 2500 m (Nowell and Jackson, 1996).

Like all other felids, they are obligatory carnivore. One distinctive feature of clouded leopard is the very long upper canine teeth. The canine teeth are 3.8-4.5 cm long (Sunquist, 2002). They have got the longest canine (proportionate to body size) among wild carnivores. They are nocturnal. Main diet comprises of primates, birds, barking deer and wild pigs. Body length including tail ranges from 1.3-2 m and body weight ranges from 11-20 kg. They have ossified hyoid which allow them to purr, but can not roar. Clouded leopards are sexually mature at an age of 2 years. Mating can takes place during any time of the year. In captivity, maximum mating occurs during October-March. Gestation length varies from 85–109 days, after which 1-5 cubs are born. Average lifespan is 11 years in wild; in captivity they may live up to 17 years (Srivasatav and Nigam, 2009).

Feeding in Captivity

In captivity, clouded leopards are fed on various type of meat based diet. Most captive facilities in USA use horse-meat based diet. Some feed chunk meat supplemented with live prey. They are generally fed 500 g-1 kg of meat per day for 4-6 days a week. In most of the Indian zoos they are fed fresh chicken 6 times a week (Table 1).

Table 1: Feeding schedule of Clouded leopard in different Indian zoos

Name of the zoo	Type of food	Quantity	Feeding freequency
Sepahijala Biological Park			
Adult	Dressed chicken	1.0-1.5 kg	6 times a week
Sub-adult	Dressed chicken	0.5-0.75kg	6 times a week
Assam State Zoo	Dressed chicken	1.75 kg	6 times a week
Itanagar Zoo	Mutton	2.50 kg	6 times a week

Materials and Methods

During the present investigation, we conducted feeding trial on 7 clouded leopards kept in Sepahijala Biological Park. Two animals (both male) were kept individually. Two animals were kept as a male-female pair. Two other animals were kept as female-female pair. During the period of experimentation, they were fed 1288 to 1500 g of dressed chicken. The animals which were in pairs were considered as one singular animal unit. However, it was possible to workout the individual animal's intake by application of marker which we used during the present experiment. Feeding trial was continued for 5 days, during which measured amount of food was offered and residues left and faeces voided were collected in full amount. Representative samples of chicken, refusal and faeces were analyzed for nutrient content using standard laboratory procedures.

Results and Interpretation

Data pertaining to nutritional composition of chicken fed to clouded leopards are presented in Table 2.

Table 2: Nutrient composition of chicken fed to clouded leopards

Meat		**On Dry matter basis**				
	DM (%)	**GE (Kcal/kg DM)**	**CP (%)**	**Fat (%)**	**Ca (%)**	**P (%)**
Chicken offered	27.41	78.14	12.32	3.11	1.58	4210
Chicken residue	31.27	81.28	9.87	3.55	1.37	4060

DM, dry matter; CP, crude protein; GE, gross energy

Data pertaining to feed consumption, diet digestibility and nutritional adequacy of the diets are presented in Tables 3 and 4.

Table 3:Feed consumption, diet digestibility and nutritional adequacy of clouded leopard diet

Fresh basis		**On dry matter basis**			
Chicken offered (g)	Chicken residue (g)	DMI (g)	DMD (%)	DEI (kcal/d)	DEI (kcal/kgBW$^{0.75}$)
1344±39.6	225±52.4	297.8±9.5	87.7±1.5	1133±44	133±1.04

DMI, dry matter intake; DMD, dry matter digestibility; DE, digestible energy intake

Table 4: Nutritional adequacy of clouded leopard diet

ME (kcal/g)	CP (%)	Fat (%)	Ca (%)	P (%)
3.42±0.03	77.4±0.19	12.72±0.17	2.99±0.02	1.62±0.01

ME, metabolizable energy; CP, crude protein

Average dry matter digestibility observed in clouded leopard in this study was similar to that reported earlier in captive felids (Vester *et al.*, 2008). Allen *et al*. (1995) reported that digestibility of dry matter was lower in clouded leopard in comparison to other felids. Digestible energy intake was also lower in clouded leopards in comparison to other felids. Allen *et al.* (1995) reported that clouded leopard could maintain body mass, when DE supply ranged from 100-120 kcal/kg $BW^{0.75}$. It seems that clouded leopard has adopted a metabolic strategy to conserve energy. NRC (2006) recommends that feline diet should contain 9% fat, 0.8% Ca and 0.6% P. Feeding of 1.3 to 1.5 kg of dressed chicken was found to be adequate in all these regards. The results of the present investigation indicate that the current feeding schedule practiced at Sepahijala Biological Park is adequate.

Suggested guidelines for feeding

1. For variety, goat meat can be fed occasionally. However, the total amount of meat to be fed should remain the same.
2. The aspect of behavioural enrichment has already been discussed in case of other cats. Same principle will also be applicable here. Clouded leopard being arboreal means there is more scope of behavioural enrichment. Basic idea is to stimulate their instinctive behaviour.
3. Suggestion regarding food hygiene and other general nutrition had already been dealt with and should be applicable here as well.

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3.40 Leopard Cat

Order	:	Carnivora
Family	:	Felidae
Species	:	*Prionailurus.*
Species	:	*P. bengalensis*

Leopard cat is the most widely distributed Asian small cats. Their size is similar to that of a domestic cat. Average body length is 38-66 cm and body weight ranges from 0.55 to 3.8 kg. They have two prominent stripes on their forehead and well defined webs between the toes. There is no seasonal pattern in breeding. Gestation length is 60-70 days, after which 2-4 kittens are born. They may live upto 13 years (Sunquist and Sunquist, 2002). They are strict carnivore. Their main diet comprised of rodents. They also prey on lizards, amphibians and insects. They supplement their diet with eggs, poultry and aquatic prey (Sunquist and Sunquist, 2002).

Feeding in Captivity

In Indian zoos, raw meat is the main component of leopard cat diet. Feeding schedule practiced at different zoos is listed in Table 1.

Table 1: Diet schedule of leopard cat in some Indian Zoos.

Name of Zoo	Type of diet
Nehru Zoological Park, Hyderabad	Beef, 200 g; chick, 100g
MC Zoological park, Chattbir	Buffalo meat, 500 g; milk, 500 ml
National Zoological Park, Delhi	Chicken, 500g
Sepahijala Biological Park	Meat, 500g

Small felids are fed with commercial carnivore diet in most of the US zoos. The benefit of such diet is that they resemble vertebrate prey in chemical composition. However, prolonged use of canned food may cause dental and optic problem. It was indicated that canned food did not contain adequate amount of taurine. Other disadvantages included spoilage of food, rapid microbial growth and lack of behavioural stimulation.

Materials and Methods

During the present investigation we conducted digestion trial on 4 leopard cats (2M, 2F) in Gangtok zoo. All the animals were housed individually. They were fed 200- 250g of meat. During the trial measured amount of food was provided to each of the animals. The meat refusals and faeces voided by the animals were collected in full. Representative samples of meat, refusal and faeces were subjected to laboratory analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of meat fed to leopard cat are presented in Table 2. The meat fed to the cats was having 25% fat, which was satisfactory.

Ideally small felid diet should not contain more than 30% protein. In this regard, chicken will be a preferable alternative to beef. The sample contained less Ca than whole carcass of vertebrates. This happened because keepers selectively avoided long bony piece to leopard cats. However, keepers were wise to selectively feed softer piece which still had bone attach on it. Overall diet provided sufficient Ca. Data pertaining to feed consumption, diet digestibility and nutritional adequacy are presented in Table 3.

Table 2: Chemical composition of meat fed to leopard cat

Food	DM	On Dry matter basis				
	(%)	GE	CP (%)	EE (%)	Ca (%)	P (%)
Meat offered	39.84	5030	64.47	27.20	1.74	1.18
Meat residue	44.14	4930	66.82	25.12	1.88	1.01

DM, dry matter: GE, gross energy (kcal/kg DM); CP, crude protein: EE, ether extracts

Table 3: Meat consumption and nutritional adequacy of leopard cat diet

Meat offered (g/d)	Meat left (g/d)	DMi (g/d)	DMD (%)	DEI	Ca(%)	P(%)
233±8	23±11	83±5	89±2	376±31	1.7±0.01	1.2±0.01

DMI, dry matter intake: DMD, dry matter digestibility: DEI, digestible energy intake

According to the NRC (2003), a domestic cat weighing 4 kg will require 280-320 kcal of metabolizable energy daily. In this experiment digestible energy intake was 376 kcal. If we assume that 92% of digestible energy is utilized, then ME intake in the present experiment would be 338 kcal of ME/day, which is very similar to that recommended for cats. The results of the present investigation indicate that nutrient requirement guidelines for domestic cat will be also applicable to leopard cat. NRC (2006) recommends that feline diet should contain atleast 0.8% Ca and o.6% P. The diet schedule followed at Gangtok zoo was able to supply all these nutrients in adequate amount to fulfill requirements of leopard cats. It was concluded that feeding of 250 g of meat to leopard cat is adequate.

Suggested guidelines for feeding

1. If meats with bone are fed, there is no need to use any supplement. Supplementation of calcium and fat soluble vitamins is must if boneless meat is fed.
2. Chicken resembles more to it's natural diet. Chicken may be preferred over beef, buffalo meat, or mutton.
3. Variation could be brought by offering meat/chicken on alternate day.
4. There is no need of fasting in this and other small felids.
5. General principles of nutrition and food hygiene discussed for other cats may also be followed.

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3.41 Himalayan Black Bear

Order	: Carnivora
Family	: Ursidae
Genus	: *Ursus*
Species	*: U. thibetanus*

Asiatic black bear is widely distributed in better parts of the Asian continent. It could be found in Siberia, Japan, Taiwan, Vietnam and in all the countries of South Asia. However, its habitat is highly fragmented and population is declining. Taking this into account IUCN Red Data Book has listed this species as vulnerable. Himalayan black bear is a sub-species found in the Himalayan region of India at an altitude of 1200-3000 m (Sathyakumar, 2001). The other sub-species, Tibetan black bear is found in Assam and other North-Eastern states of India and other South Asian countries. Body weight of adult female varies from 65-91 kg, whereas, male body weight ranges from 110-150 kg. Pelage colour is glossy black with a large white or yellow V-shaped patch of hair on their chests like sloth bear (Goodness, 2004). First cub is born when the female is about 3-4 years of age. Gestation period is 200-240 days. In the North, breeding season begins in early summer; young are usually born in the mothers' winter dens. Cubs will remain with their mother for 24-26 months. Lifespan is 25 years in nature and 33 years in captivity (Goodness, 2004).

Bears have a typical carnivorous digestive system, with simple stomach, a short intestinal tract, and no caecum. Himalayan black bears are omnivores (Sathyakumar and Vishwanath, 2003). They will eat fruits and leaves and also animal tissues. Bears are omnivores; initially they prefer sugar rich fruit, but switch to fat rich fruit just before hibernation (Manjrekar, 1989). The amount and type of food required varies with the size of the bear; males are generally larger than females and need more food. It is important to remember that zoo bears may easily become obese.

Feeding in Captivity

In Denver zoo, they are fed on omnivore chow with fruits and vegetables alongwith occassional fish. In Philadelphia zoo, they are offered bear biscuit with variety of fruits and vegetables. Himalayan bears in Indian zoos are mainly fed fruit and vegetables which are supplemented with bread, concentrate foods and vitamin/ mineral supplements (Table 1). From the Perusals of the data it is evident that there is large variation in types and amount of feed being offerred to Himalayan black bear. It is true that the bears are opportunistic feeder, but it is to be remebered that commercial produces are very rich in soluble sugar content as compared to wild fruit and vegetations. If continued to feed for longer period on such food they may develop obesity and dental problem.

Table 1: Diet chart of Himalayan black bear in different zoos

Himalayan Nature Park, Kufri

Groundnut	Potatoes	Carrot	Vegetables/Leaves	Gur	Roti
0.25 kg	0.3 kg	0.3 kg	0.5 kg	1 kg	2.25 kg

MC Zoological Park, Chattbir

Milk	Roti (Maize)	Khichri	Brinjal	Bananas	Papaya
0.5 kg	0.25 kg	2.0 kg	0.5 kg	3 Nos	0.3kg
Bread	Apple	Apple + turnip	Guava + apple	carrots	Melon
0.2 kg	0.3 kg	0.150 kg	0.15kg	0.1 kg	0.3 kg

National Zoological Park, Delhi

Banana	Milk	cucumber/ carrot	Patoto/ Sweet Potato	Bel fruit	Water melon	Bhutta
7nos.	0.5 kg	0.25 kg	0.25 kg	0.25 kg (Apr- June)	0.5 kg (Apr- June)	1 kg (July – Sep.)
Guava	Singhara	Chickoo	Beri	Beet Root	Melon	Pears
0.5 kg (Oct.-Jan.)	0.25 kg (Oct.-Nov.)	0.5 kg (Feb – Apr)	0.25 kg (Jan-June)	0.25 kg (Feb-Mar)	0.5 kg Apr- June)	0.5 kg (June-Sep.)
Roti	2.25 kg					

Sanjay Gandhi Biological Park, Patna

Sweet Potato	Apple/guava/ cucumber	Banana	Jaggery	Bengal gram	Milk	Peanuts
4 kg	2.5 kg	8.5 kg	1.0 kg	750 g	3 l	500 g
Tomato	Roti					
1 kg	3 kg					

Thiruvananthapuram Zoo

Bread	Greens	Grapes	Honey	Mango/Apple	Milk	Orange
6 kg	800 g	500 g	200 g	400 g	4 l	400 g

Nandankanan Zoological Park, Bhubaneswar

Brinjal	Honey	Milk	Rice	Pumpkin	Banana	S. potato	Carrot	Bhutta
0.1kg	30 g	0.1 kg	1 kg	0.35 kg S=sweet	0.3 kg	0.25 kg (Oct-March)	0.25 kg (Oct-(Mar)	0.2 kg Sept.-Oct)

Sepahijala Biological Park, Tripura

Banana	Apple	Veg.	Wheat	Milk	Grapes	Egg	Fisah	Bird
6 Pcs	250g	1 kg	0.5 kg	0.5 L	100 g	1 no.	300 g	1-1.5 kg

Nehru Zoological Park, Hyderabad

Bread	Banana	Milk	Tomato	Carrot	Fish
3 kg	2 no.	1 l	250 g	250 g	500 g

Zoological Garden, Alipore

Boiled rice	Molasses	Red potato	Nuts
1.00 kg	80 g	150g	100 g

Shillong Zoo, Meghalaya

Sweet potato	Gur	Rice	Milk
100 g	150 g	900 g	800 ml

Lucknow Zoo

Barley flour Gram	Milk	Rice	Jaggery	Fruits and vegetables
300g	1 l	200 g	200g	1kg

Gandhi Zoological Garden, Gwalior

Roti	Vegetable	Fruit	Banana	Wheat	Gram	Ground nut
2 kg	6 kg	3 kg	4 number	100g	100 g	150 g

Materials and Methods

We conducted feeing trial on 5 black bears in Lucknow zoo. All the animals were housed individually. During the period of experimentation, they were fed their normal zoo diets. Cereals, pulses and jaggery were made into a blend. They were fed twice daily. Measured amount of feed was offered to all the animals. The food refusals and faeces voided were also collected for 5 consecutive days to determine intake and digestibility of nutrients. Samples of feed, faeces and refusals were analyzed for nutrient composition using standard laboratory procedures.

Results and Interpretation

Nutrient composition of different feed ingredients is presented in Table 2. Data pertaining to feed consumption, diet digestibility and nutritional adequacies of the diet are presented in Tables 3-4. Feed refusal was near to zero in all the animals. Dry matter digestibility was 84%. Bunnet and Hamilton (1983) reported that dry matter digestibility was 82% in grizzly bear, very similar to what we have observed in black bear in this experiment.

Table 2: Nutrient composition of feed ingredients fed to Himalayan black bear in Lucknow zoo

Food items	Nutrient composition (on dry matter basis)								
	DM (%)	GE	NDF%	CP(%)	Ca(%)	P(%)	Fe*	Zn*	Cu
Oat	89.4	4040	15.4	9.9	0.09	0.3 8	55	22	11
Rice	92.4	4120	12.8	8.4	0.08	0.32	68	18	9
Gram	91.8	3970	25.2	27.4	0.44	0.49	75	53	12
Gur	81.3	4040	-	-	0.28	0.41	81	35	14
Milk	14.2	6503	0	31.2	0.99	0.18	4	35	5
Palak	11.4	3540	23.4	14.2	0.89	0.22	220	29	8
Carrot	9.1	3720	20.5	11.1	0.52	0.21	960	36	11
Cucumber	5.7	3480	24.2	13.8	0.44	0.19	98	31	9
Brinjal	17.4	3340	22	18.8	0.26	0.18	55	26	8

DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; GE: gross energy (kcal/kgDM); * concentration in mg/kg DM

Table 3: Consumption of different food items (fresh basis) by Himalayan black bear in Lucknow zoo

Food items	Intake (g/day) ±S.E.
Oat	300±0
Rice	200±0
Gram	200±0
Gur	110±0
Milk	1000±0
Palak	220.25±14.35
Carrot	242.5±7.5
Cucumber	240±10
Brinjal	208.75±34.02

Similar digestibility was also observed in sloth bear during the same period as discussed in the next section. It seems that digestive efficiency of both the species are similar. Pritchard and Robbins (1990) found no significant interspecies differences in digestive or metabolic efficiencies between grizzly and Black bears. Metabolizable energy intake was 115 Kcal/kg BW $^{0.75}$. Polar bears were able to maintain body mass at such level of ME intake (Best, 1985). Our results indicate that the level of feeding is adequate, and there is no need to increase the amount of food. Both sloth and black bear diet contained similar amount of crude protein because same feed ingredients were fed to both the species. Nutrition Advisory Group recommends that polar bear diet should contain 0.6% Ca, 0.5% P, 80 ppm iron, 10 ppm Cu and 100 ppm Zn. The diet fed to Lucknow zoo was not able to meet the requirements of Ca and Zn. Further, Ca:P ratio was also improper. We suggest that the diet should be supplemented with balance mineral mixture.

Table 4: Feed consumption, diet digestibility and nutrient supply in Himalayan black bear in Lucknow zoo

Parameters	Mean ±S.E.
Dry matter Intake (g/day)	965.15±8.70
Digestible energy intake (kcal/d)	3581±32.34
Dry matter digestibility (%)	83.73±2.07
Diet adequacy	
NDF (%)	13.99±0.04
CP (%)	17.7±0.11
Ca (%)	0.35±0.01
P (%)	0.38±0.02
Fe (ppm)	90.15±0.96
Cu (ppm)	11.4±0.01
Zn (ppm)	34.7±0.21

CP, crude protein; NDF, Neutral detergent fibre; ppm, parts per million

Suggested guidelines for feeding

1. A diet containing 400 g cereals, 200 g pulses, 1200 g of high protein high calcium vegetables (spinach, beans, cabbage and small amount of seasonal fruits), 45 g jaggery, 1 kg of milk or yughart and 15 g honey may be fed. This should be supplemented with 30 g of balanced mineral mixture.
2. There is considerable variation in body weight. So individual member may be fed according to the body weight. The above recommendation are for an adult animal weighing 95 kg.
3. Bears are prone to obesity. Body condition should be monitored regularly and adjust the amount of food accordingly.
4. Soft food items should be fed first, followed by hard roughages. This will ensure cleaning of tooth and better dental health.
5. Behavioural enrichment could be provided by spreading the honey on utensil, suspending the food from the roof of the enclosure, by keeping the fruits

and vegetable in a gunny bag and any other innovative way that may suit the local condition.

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3.42 Sloth Bear

Order	:	Carnivora
Family	:	Ursidae
Genus	:	*Melursus*
Species	:	*M. ursinus*

Sloth bear is found at lower elevations of India and other South Asian countries. Their populations are estimated to be between 1000 and 7000. The IUCN (2003) Red Data Book lists the species as vulnerable. Body weight of adult male varies from 80-140 kg, whereas, female body weight ranges from 55-95 kg (Bies, 2002). Pelage colour is black with a large white or yellow V-shaped patch of hair on their chests. Morphological adaptation for insectivory includes a long muzzle with agile, protruding lips, and nostrils that can be closed when raiding the termite mounds. They have a hollowed-out bony palate and no front teeth so that they can suck ants and termites out of their nests. They have white, curved, blunt claws that are up to 7 cm long (Ward and Kynaston, 1995). Sloth bears reach sexual maturity at about 3 to 4 year of age. Breeding season is April-June in India. Average gestation period is 180-210 days (Bies, 2002). Birth occurs in a den, cave, or a shelter beneath boulders (Akhtar *et al*., 2007). Typically, two or three cubs are born in a litter. They are born blind. By one month of age cubs are able to travel through the forest with their parents. The cubs sometimes ride on their mothers' back by holding onto her coat. They stay with their mothers for 2 to 3 years (Ward and Kynston, 1995). Average lifespan in wild is 30 years and in captivity it is 40 years (Bies, 2002).

Sloth Bear is highly myrmecophagous (eating largely ants and termites). Sloth Bears are specifically adapted to feeding on ants and termites, but even in this species, the proportion of insects in the diet varies geographically as well as seasonally. In Royal Chitawan National Park, Nepeal, overall 83% of the scats contained insect remains. This proportion however, increased to 95% in the non-fruiting season, and during fruiting season it was decreased to 58%. The main insect prey was termites (65% of the diet in the non-fruiting season, 45% in the fruiting season), with fruits making up 35% of the diet in the fruiting season (Joshi *et al.,* 1997). By contrast, during the fruiting season in southern India, insects comprised less than 10% of the diet (Baskaran *et al*., 1997). In Central India, sloth bears diet comprised of 21 species of plants, termites, ants, and bees. Animal matter constituted 87% of the diet during monsoon and 82% during winter seasons, but dropped to 65% during summer. Fruits of Ficus species were reported to be important food resources to bears. They can also raid crops (Bargali *et al*., 2007). Sloth bears are known for their fondness of honey. All bears are opportunistic in seeking alternative foods when their primary foods are in short supply.

Feeding in Captivity

Bears have a typical carnivorous digestive system, with simple stomach, a short intestinal tract and no caecum. Sloth bears in zoos are mainly fed fruit and vegetables generally supplemented with bread, concentrate foods and vitamin/ mineral supplements (Table 1).

Table1: Diet chart of sloth bear in different zoos

MC Zoological Park, Chattbir

Roti /Maize	Milk	Khichri	Bread	Sweet	Orange	Apple	Guava	Banana
0.25kg	0.25 kg	1 kg	0.4 kg	0.1 kg	0.1 kg	0.3 kg	0.1 kg	3 nos.

National Zoological Park, Delhi

Banana	Milk	Cucumber /carrot	Potatos/sweet Potato	Bel fruit	Water melon
5 nos.	0.5 kg	0.25 kg	0.25 kg	0.25 kg (Apr- June)	0.5 kg (May- June)
Guava	Singhara	Chickoo	Beri	Beet root	Mask Melon
0.5 kg (Oct.-Jan.)	0.25 kg (Oct.-Nov.)	0.5 kg (Feb – Apr)	0.25 kg (Jan–Feb)	0.25 kg (Feb – Mar)	0.5 kg (Apr-June)
Bhutta	Pear				
1 kg (July-Sep)	0.5 kg (June-Sep)				

Patna Zoo

Sweet Potato	Apple /Kheera	Banana	Gur	Bengal gram	Milk	Roti	Tomato	Peanut
4 kg	2 kg	8 kg	1.5 kg	1 kg	1 l	3 kg	1 kg	600 g
Egg	2 nos.							

Thiruvananthapuram Zoo

Bread	Greens	Grapes	Honey	Mango/ apple	Milk	Orange
12.8 kg	1.6 kg	1.6 kg	400 g	800 g	8 lit	800 g
Pineapple	400 g					

Nandankanan Biological Park, Bhubaneswar

Brinjal	Honey	Milk	Rice (Boiled)	Pumpkin	Ripe Banana	Sweet potato	Bhutta (seasonal)
100 g	25 g	100 g	1 kg	300 kg	300 g	250 g	0.2 kg

Dr. Shivaram Karanth Pilikula Biological Park, Mangalore

Rice	Bread	Milk	Jaggery	Fruits	Egg	Honey
0.5 kg	1 kg	11	25 g	2 kg	one	200 g

Nehru Zoological Park, Hyderabad

Bread	Banana	Milk	Tomoto	Carrot	Meal worm	Sweet lime/ orange	Guava
2 kg	1 Nos	½ + ½ l	100 g	250 g	100 g	1 in number	100 g

Bhagwan Birsa Zoological Garden, Ranchi

Rice	Milk	Jaggery	Honey	Ber	Dalia
1.25 kg	1.5 l	500 g	25 g	50 g	1 kg

[Dalia = (Maize – 50% + Dal – 25% + Wheat – 25%) crushed]

Rajiv Gandhi Zoological Park and Wildlife Research Centre, Pune

Banana	Ragi	Khas	Mousambi	Papaya	Beet	Grape	Chiku	Honey
1.2 kg	1.0 kg	1.0 kg	1.0 kg	1.0 kg	1.6 kg	500 g	1.0 kg	150 g
Kaligad/	Bread	Milk	Egg	Jaggery	Dhoor	Tomato	Pine apple	
300 g	1.0 kg	2 l	150 g	250 g	250 g	0.5 kg	300 g	

Lucknow Zoo

Barley flour	Gram flour	Rice	Jaggeay	Fruits and vegetable
300 g	200 g	200 g	220 g	1.4 kg

Materials and Methods

We conducted feeing trial on 5 sloth bears in Lucknow zoo. All the animals were housed individually. During the period of experimentation, they were fed their normal zoo diet. Cereals, pulses and jaggery were made into a blend and were fed twice daily. Measured amount of feed was offered to all the animals. The food refusals and faeces voided were also collected for 5 consecutive days to determine intake and digestibility of nutrients. Samples of feed, faeces and refusals were analyzed for nutrient composition using standard laboratory procedure.

Results and Interpretation

Nutrient composition of different feed ingredients is presented in Table 2. Data pertaining to feed consumption, diet digestibility and nutritional adequacies of the diet are presented in Table 3-4.

Table 2: Nutrient composition of feed ingredients fed to Sloth bear in Lucknow zoo

Food items	Nutrient composition (on dry matter basis)								
	DM (%)	GE	NDF%	CP(%)	Ca(%)	P(%)	Fe*	Zn*	Cu
Oat	89.4	4040	15.4	9.9	0.09	0.3 8	55	22	11
Rice	92.4	4120	12.8	8.4	0.08	0.32	68	18	9
Gram	91.8	3970	25.2	27.4	0.44	0.49	75	53	12
Gur	81.3	4040	-	-	0.28	0.41	81	35	14
Milk	14.2	6503	0	31.2	0.99	0.18	4	35	5
Palak	11.4	3540	23.4	14.2	0.89	0.22	220	29	8
Carrot	9.1	3720	20.5	11.1	0.52	0.21	960	36	11
Cucumber	5.7	3480	24.2	13.8	0.44	0.19	98	31	9
Brinjal	17.4	3340	22	18.8	0.26	0.18	55	26	8

DM, Dry matter; CP, crude protein, NDF, Neutral detergent fiber; GE, gross energy Kcal/kgDM;

* mg/kg DM

Feed refusal was near to zero in all the animals Dry matter digestibility was 84%. Bunnet and Hamilton (1983) reported that dry matter digestibility was 82% in grizzly bear, very similar to what we have observed in sloth bear in this experiment. Pritchard and Robbins (1990) found no significant interspecies differences in digestive or metabolic efficiencies between grizzly and Black bears.

Table 3: Consumption of different food items (fresh basis) by Sloth bear in Lucknow zoo

Food items	Intake (gram/day)
Oat grain	300±0
Gram	200±0
Rice	200±0
Milk	1000
Gur	200±0
Spinach	311±7.5
Carrot	350±0
Cucumber	294.2±19.56
Brinjal	319.2±7.94

Table 4: Nutritional adequacy of Sloth bear diet in Lucknow zoo

Parameters	Mean±S.E.
Dry matter Intake(g/d)	1083.5±1.90
Digestible energy intake (kcal/d)	3834±18.85
Dry matter digestibility (%)	83.1±0.90
Diet adequacy	
NDF (%)	13..13 ±0.03
CP (%)	14.7±0.03
Ca (%)	0.35 ±0.02
P (%)	0.34±0.00
Fe (ppm)	97,99±0.10
Cu (ppm)	11.03±0.01
Zn (ppm)	33.7±0.02

CP, Crude protein; NDF, neutral detergent fiber; DE, digestible energy; ppm, parts per million

Dry matter and energy digestibility was inversely related to the dietary fiber content, whereas, digestible protein was directly correlated with dietary protein. In this experiment, the fibre content was very low, so higher digestibility was expected. Crude protein content of the diet seems to be lower for typical omnivorous carnivore. In the present experiment, cereal content of the diet was 52 %. They supply high levels of available energy, but contain very low levels of protein and other nutrients. The discrepancy between available energy and protein creates a physiological paradox for many animals consuming high-energy low- protein diets, as they will be protein deficient if they eat to meet their minimum energy requirement. In such situation, animal increase the feed consumption to meet protein requirement. In this process, it also consumes excess calorie. Felicetti *et al*. (2003) have reported that digestible energy intake at mass maintenance increased 2.1 times, and composition of the gain changed from primarily lean mass to entirely fat when the protein content of the diet decreased from 15.4% to 1.6%. Daily fat gain was up to three times higher in bears fed low-protein diets *ad lib*., compared with bears consuming the higher-protein diet and gaining mass at the same rate. Thus, bears eating fruit in nature or a high energy diet in captivity can either consume other foods to increase dietary protein or over eat high energy diets and use diet-induced thermogenesis and fat synthesis to deal with their skewed energy-to-protein ratio (Rode *et al., 2001*). However, in this study, protein content was near to 15 %. At similar level of proteins, captive bears were able to grow properly. Thus, we feel that higher level of protein recommended for dog which often is used as a model for carnivorous omnivore may not be necessary for sloth bear. From the results of the present experiment and review of literature it seems that 15% of protein in the diet of captive sloth bear would be adequate. Digestible energy intake was 126 kcal/kg $W^{0.75}$/ day. Polar bear were also able to maintain body mass when digestible energy intake ranged from 115-140 kcal/kgBW $^{0.75}$/ day (Best, 1985). Our results indicate that the level of feeding is adequate, and there is no need to increase the amount of food. Nutrition Advisory Group recommends that polar bear diet should contain 0.6% Ca, 0.5% P, 80 ppm iron 10 ppm Cu and 100 ppm Zn. The diet fed to Lucknow zoo was not able to meet the requirements of Ca and Zn. Further, Ca: P ratio was also improper. We suggest that the diet should be supplemented with a balance mineral mixture. This may be applicable to most of the zoos using similar kinds of food ingredients.

Suggested guidelines for feeding

Based upon the experiment conducted and review of the literature we suggest following guideline for feeding sloth bear in captivity

1. A diet containing 400 g cereals, 200 g pulses, 1200 g of high protein high calcium vegetables (spinach, beans, cabbage and small amount of seasonal fruits), and 45 g jaggery, one kg of milk / curd and 15 g honey is suggested. This should be supplemented with 30 g of balanced mineral mixture. This ration will supply adequate amount of nutrition for an adult weighing 95 kg.
2. Soft food items should be fed first, followed by hard roughages. This will ensure cleaning of tooth and better dental health.
3. Behavioural enrichment could be provided by spreading the honey on utesil, suspending the food from the roof of the enclosure by keeping the fruits and vegetable in a gunny bag and any other innovative way that may suit the local condition.

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3.43 Binturong

Order	:	Carnivora
Family	:	Viviridae
Genus	:	*Arctitis*
Species	:	*A. Binturong*

Binturong is a close relative of civets in the family of Viviridae. It is found in rain forest of Bangladesh, North-East India and South-East Asia (McPhee, 1999). It is listed as vulnerable in the IUCN Red Data Book. It has got a body like bear and face like cat. Most characteristic features include shaggy black hair, white whisker and long prehensile tail. Body length varies from 60-90 cm, tail length is also 60-90 cm. Body weight ranges from 13 to 20 kg (McPhee, 1999). They are not seasonal breeders; however, most of the births take place during February to April. Gestation length is 90-92 days (Nowak, 1991). Females attain sexual maturity at an age of 2.5 years. (Wemmer and Murtaugh, 198).The average lifespan is 18 years in wild and 23 years in captivity (McPhee, 1999).

It is an arboreal nocturnal animal, but can occasionally come down to the ground (Duckworth et al., 1997). They have been seen to be active even during day time (Datta, 1999). They have got a prehensile tail which support them in all arboreal activity (McPhee, 1999). Binturong is a predominantly frugivorous species, but can occassionally eat carion, small invertebrates, fish, birds, eggs and leaves (Nowak, 1991).

Feeding in Captivity

Feeding schedule of Binturong in Sepahijala and Itanagar Biological Park are presented below.

Food item	Sepahijala	Itanagar
Banana	5 in numbers	2 innumbers
Apple	200 g	-
Seasonal vegetable	700 g	200 g
Bengal gram	100 g	-
Grapes	100 g	-
Egg	1 number	-
Minced meat	-	250 g
Boiled rice	-	250 g
Milk powder	-	20g

In Arignar Anna Zoological Park, Vandalore, they are fed apple (3 in numbers), banana (12 in numbers), Orange (3 in numbers), tomato (150 g), carrot (250 g) and 25 g beef (Arivazhagan and Thiyagasan, 2001). At Liberec zoo, Binturong is fed 1 pound each of raw meat and fruits (Bulir, 1972). In National Zoological Park, Washington DC, each Binturong receives whole banana, one quarter apple, one quarter orange, one shredded carrot and 227 g of commercial feline diet (Xanten et al., 1974). In addition, 12 mice and one oxtail were supplemented twice weekly.

Materials and Methods

We conducted feeding trial on 7 Binturong kept in Sepahijala Biological Park, Tripura. Four females were kept in 2 enclosures as female-female pair. Two males were also kept as pair. Another female was housed individually. We conducted a digestion trial of 5 days duration, during which measured amount of feed was offered to the animals. Amount of faeces voided and refusals were also measure accurately to obtain intake and digestion. We also used internal and external marker to estimate nutrient utilization. Samples of feed, faeces and refusals were analyzed for nutrient content using standard laboratory methods.

Results and Interpretation

Data pertaining to chemical composition of food ingredients fed to Binturong is presented in Table 1. Actual consumption of food items are presented in Figure 1. Data pertaining to feed consumption, diet digestibility and nutritional adequacy of the diet are presented in Table 2.

Table 1: Nutrient composition of diet fed to Binturong

Food items	DM (%)	on DM basis kcal/kg GE	g/100 g CP	NDF	Ca	P	mg/kg Fe	Cu	Zn
Soaked gram	52.4	3990	26.47	32.5	0.48	0.23	52	11	68
Banana	25.1	4110	5.12	11.9	0.09	0.17	58	8	25
Apple	15.8	4040	4.99	11.3	0.11	0.16	108	9	34
Sweet lime	6.1	4010	5.04	13.8	0.19	0.22	28	11	25
Egg	26.4	6120	49.24	0	0.21	0.76	69	12	49
Bottle gourd	5.2	3250	4.11	36.4	0.39	0.21	88	12	32

DM, dry matter; CP, crude protein; GE, Gross energy (kcal/kg DM)

Table 2: Feed consumption, diet digestibility and nutritional adequacy of Binturong diet

DMI (g/d)	DMD (%)	DEI kcal /kg $BW^{0.75}$	Diet adequacy CP (%)	NDF (%)	Ca (%)	P (%)
251	59	8.9	16.9	24.6	0.300	0.21
±12	±4.0	±3.6	±0.71	±1.57	±.001	±0.001

DMI, dry matter intake; DMD, dry matter digestibility; CP, crude protein; DEI, digestible energy intake; NDF, neutral detergent fibre

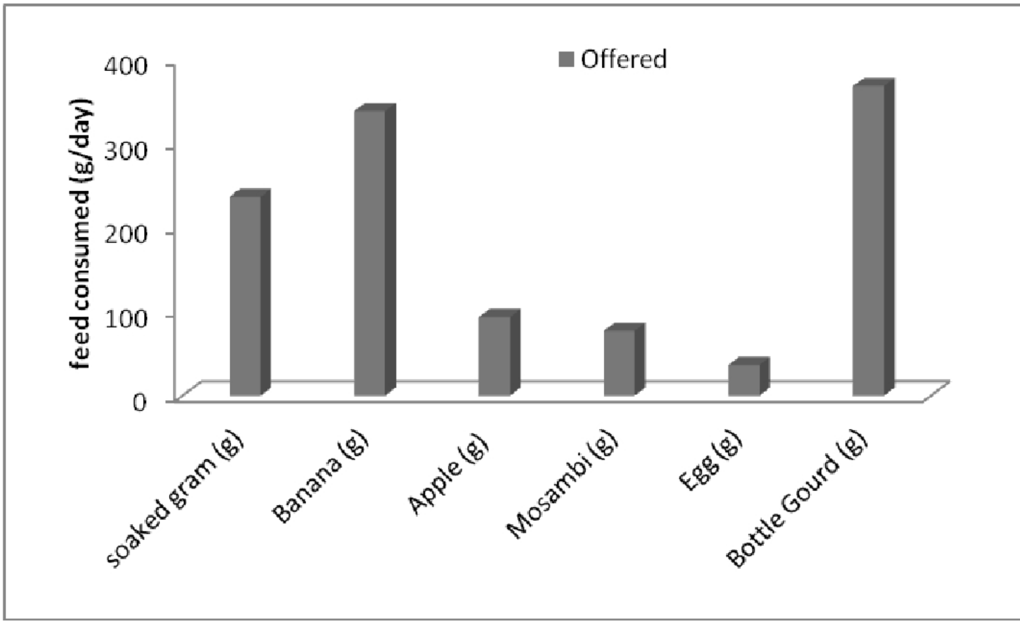

Figure 1: Consumption of different food items by Binturong

On an average, dry matter intake was 1.5 ±0.007% of body mass. Dierrenfeld (2003) reported that dry matter consumption is 1.1% of body weight in Binturong. Higher dry matter intake observed in our study could be due to the difference in food items used. In our study, only natural food items were used, whereas, in the Bronx study, canned and dried primate food (60%) was the main component of the diet. Dry matter digestibility of Binturong in Bronx (46%) and Sepahijala was also different. Digestibility was higher in Binturong at Sepahijala Biological Park. The digestible energy intake was 89 Kcal/kg $BW^{0.75}$ which is just 1.25 times higher than the inter-species basal metabolic rate of 70kcal/kg $BW^{0.75}$. This would indicate that Binturong has adopted a metabolic strategy of conserving energy. The diet supplied 17% crude protein which would be adequate for most of omnivorous carnivores studied and reported. This species should not be an exception. One significant observation was low calcium in the diet. Whether Binturong has different calcium metabolism and requirement than most other mammals is not known. Hence, it would be desirable to follow omnivore standard. A typical fruit eater monkey diet should contain 0.56% of calcium. The Binturong diet supplied not even half of it. From the results of the experiment, we suggest that the present feeding schedule is adequate in terms of calorie and protein, but deficient in calcium.

Suggested Guidelines for feeding

1. A diet containing 250 g soaked gram, 350 g banana, 100 g apple, 75 g orange, 35 g egg and 400 g of bottle gourd will be adequate
2. Supplementation of calcium is suggested. Add 1.5 g of calcium carbonate

to small amount of milk. This should be fed before the main feeding so that animal consumes it.

3. Take maximum hygienic measures when such food items are tried.

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3.44 Common Palm Civet

Order	:	Carnivora
Family	:	Viverridae
Genus	:	*Paradoxurus*
Species	:	*P. hermaphroditus*

Palm civet is a small viverrid well distributed in South and South-East Asia. Average body mass is 3.1 kg. The body colour is black to grayish. They have a white mask on their face. They are nocturnal animal and solitary by nature. They are very fond of palm sap, (Shiroff, 2002). Sexual maturity is attained at 341 days of age. Average gestation length is 60 days, litter size is 3.4 and average birth mass is 89 g. Average lifespan is 22 years ((Shiroff, 2002). They eat on various different types of berries pulpy fruits, insects and smaller preys. Joshi *et al.* (1995) reported that natural diet of palm civet contains 23% meat, 9% invertebrates and 68% fruits. The digestive system of viverrids is very similar to that of cat (Stevens and Hume, 1995), but the caecum is rudimentary and even absent in binturong (Crapo *et al*., 2002).

Precise nutrient requirement for viverrids are not known. The target nutrient levels are based on those of well studied carnivores like dog, cat and mink (AZA, 2010). Energy requirement of viverrids like other mammals depend on body mass, food habit, climatic condition and activity level. Munoz-Garcia and Williams (2005) reported that basal metabolic rate is dependent on the size of the home range. Species that are more carnivorous in nature have larger home range and have more BMR than those which are more frugivorous in nature. Rabinwitz (1991) reported that average home range size of palm civet is 3.2 sq km.

Feeding in Captivity

Table 1: Diet schedule of Indian palm civet in different zoos

Hyderabad zoo	Beef	Bread	Milk	Day old chicks	
	200 g	5 slices	200 ml	(twice a week)	
Assam State Zoo, Guwahati		Beef	Banana		
		600 g	2 in numbers		
NZP,Delhi	Buffalo meat	Bread	Milk		
	200 g	100 g	100 ml		
	Banana	Papaya	Chiku		
	1	200 g	100 g		
Nandankanan Biological Park		Goat meat	Milk	Fish	Banana
		50 g	5 g	100 g	200 g
MCZP, Chattbir	Buffalo meat	Banana	Egg	Papaya or sweet melon	
	500 g	1 in number	1 in number	100 g	
Mumbai Zoo	Beef	Seasonal fruit	Banana/ carrot	Boiled egg	
	200 g	150 g	100 g	1 in number	

Materials and Methods

We conducted feeding trial on 16 Palm civets kept in Assam State Zoo, Guwahati. In one closures, a group of 3 animals were housed, 8 animals were kept in pairs and 5 animals were kept individually. The animals kept in group or as pairs were considered 1 singular unit for a particular group or pair. During the trial period, the animals were fed measured amount of feed. Faeces voided and residues left over were also measured accurately to estimate intake and digestibility of nutrients. Samples of feed, faeces and left over were analyzed for nutrient content using standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of feedstuff fed to India palm civet are presented in Table 2. Amount of meat and banana and their refusal by Indian palm civet is presented in Figure 1. Dry matter consumption, diet digestibility and nutritional adequacies are presented in Table 3.

Table 2: Nutrient composition of diet fed to civet cat

Food items		On Dry Matter basis				
	DM(%)	GE (kcal/kg)	CP (%)	Fat (%)	Ca(%)	P (%)
Banana offerred	23.88	4010	5.12	1.09	0.07	0.15
Goat meat	33.84	4790	68.01	23.25	2.08	1.78
Meat residues	39.17	4260	66.77	17.68	2.39	1.52

DM, dry matter; CP, crude protein; GE, Gross energy

Table 3: Feed consumption, diet digestibility and nutritional adequacy of civet diet

DMI	DMD (%)	DEI (kcal/d)	CP (%)	Fat (%)	Ca (%)	P (%)
129.5	91.4	570.4	51.5	19.4	1.45	1.56
±5.62	±1.08	±23.2	±1.29	±0.31	±0.07	±0.06

DMI, dry matter intake, DMD, dry matter digestibility, DEI, Digestible energy intake, CP: Crude protein

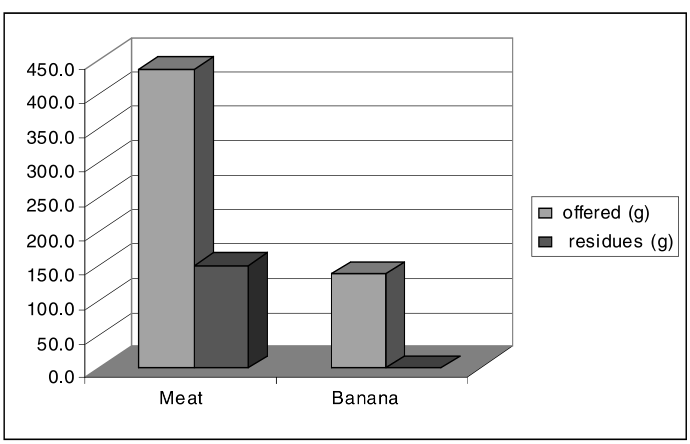

Figure 1: Banana and meat consumption (g/day) by civets on fresh basis

From the data pertaining to nutrient composition of meat and bananas fed to palm civets (Table 2) and actual consumption of meat and banana (Fig 1), it is evident that the civets preferred banana as there was no residue of banana left. It has already been mentioned that the natural diet of palm civet contains 68% of fruits (Joshi *et al*., 1995). Precise nutrient requirements of these species are not known. So, to test the dietary adequacy, we compared the achieved nutrition status with that of target nutrient level recommended for omnivorous carnivores (AZA, 2010). Nagy *et al.*, (1998) proposed the following model to calculate the energy requirement of omnivorous viverrids: DE (kj/d) = 6.03 $BW^{0.678}$, where BW is the body mass of the animal in gram.

Assuming an average body mass of 3500 g, an adult palm civet will require 1525 kJ or 364 kcal of DE for maintenance of body mass. The palm civets in Guwahati zoo received 570 kcal of DE, which is 56% higher than the requirement. In another study, Munoz-Garcia and Williams (2005) reported that a palm civet weighing 3160 g will have basal metabolic rate of 366 KJ or 87 kcal/ kg $BW^{0.75}$. Generally, basal metabolic rate is multiplied by a factor of 1.5 to derive maintenance energy requirement, which will translate into 130 kcal of ME or 144 kcal of DE. The current feeding schedule of Assam State Zoo provided 223 kcal of DE/kg $BW^{0.75}$, which was again 55% higher than the targeted energy level. We suggest that the level of meat should be restricted to 100 g/d. The diet of omnivorous carnivore should contain 17.5-26% crude protein, 0.3-1.2% Ca and 0.3-1.0% P (AZA, 2010). The diet evaluated at Guwahati zoo contained 2 times higher protein than the recommended level which may cause stress to kidney and liver and may also contribute to urolithiasis. As meat with bone was fed, the diet supplied adequate amount of Ca. But the main concern was skewed Ca:P ratio. This happened because both meat and banana are poor source of Ca.

Suggested Guidelines for Feeding

1. Diet should comprise of 30% meat and 70% fruits and vegetables.
2. When animals are group housed, provide food in different location to avoid overfeeding by dominant animals.
3. It is better to scatter the food inside the feeding cubicles which will stimulate foraging instinct. Feeding should be done at night hours.
4. Fruits are notorious in Ca:P. Supplement the meat with $CaCO_3$ @7-10 g/kg of meat. Feeding of milk is not encouraged. Milk is provided to increase Ca content of the diet. It is better to supplement Ca directly.
5. A diet comprising of 100 g of meat and 200 g of banana could provide adequate calorie and protein. However, such diet would require Ca supplementation as had already been discussed.
6. Body weight should be monitored regularly. Any animal heavier than its wild counterpart should be suspected for obesity. Amount of food to be offered can then be decided accordingly. Any eventual change in diet should be made gradually.

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3.45 Eurasian Otter

Order	:	Carnivora
Family	:	Mustelidae
Sub-Family	:	Lutrinae
Genus	:	*Lutra*
Species	:	*L. lutra*

In India, 3 species of otters namely - Eurasian Otter (*Lutra lutra*), smooth-coated otter *(Lutra perspicillata*) and small-clawed otter (*Aonyx cinereus*) are found. Eurasian otter is widely distributed from the Arctic Circle to Africa and from Ireland to Indonesia (MacDonald, 1994). They can thrive on different types of aquatic habitats (Sivasothi *et al*., 1994). In most of their distribution range, otters are sympatric with gharial (*Gavialis gangeticus*), crocodile (*Crocodylus palustris*), Ganges river dolphin (*Platanista gangetica*), and several species of turtles.

Habitat preference is determined by availability of food, fresh water and bank side vegetation. They require rocks, earth pile, tree roots and wood debris to rest, groom and to build "Holt". Average body size ranges from 57 to 95 cm, tail length varies from 35-45 cm and average body mass ranges from 7-12 kg (Krunk, 2007). They have numerous strong whiskers which they use to locate prey. All the four paws are webbed and claws are well developed. Their main diet is fish. However, they can eat frogs, cray fish and water birds. An adult may consume about 1 kg of fish daily (Heggberget and Moseid, 1994). They are not seasonal breeders, females attain sexual maturity at 18-24 months of age, however, average age of breeding is 2.5 years. Gestation length is 60-64 days after which 1-4 pups are born (Hauer *et al*., 2002). Average lifespan in captivity is 22 years (Kennedy, 2003).

Feeding in Captivity

The precise nutritional requirements of otters are not known. Hence, they are fed on the basis of NRC (2006) requirements for carnivorous animals. Recommendation of American Feed Control Official (AAFCO, 1994) and Waltham Centre for Pet Nutrition (Earle and Smith, 1993) are also considered while formulating ration for otter by most of American zoos. Based upon these, commercial complex feline diets are fed to otters which are supplemented with various different food items like fish, live cray fish, bone, oxtail and multi-mineral-vitamin supplement. In most of the Indian zoos, however, only fish diet is used (Table 1).

Table 1: Diet schedule of Eurasian otter in some Indian Zoos

Name of Zoo	Type and amount of food
Assam State Zoo, Guwahati	1 kg of fish
Nehru Zoological Park, Hyderabad	One boiled egg, 2 slices of bread and 1 kg of fish
National Zoological Park, Delhi	1.5 kg of fish (6-9 inches)
M.C. Zoological Park, Chattbir	Small fish, 1 kg
Lucknow Zoo	Live fish, 1 kg

Materials and Methods

We conducted feeding trials on 4 otters in Ahmedabad zoo. Two animals were housed individually, whereas, other 2 were housed as a pair whom we consider as one experimental unit. However, it was made possible by the keeper to feed them separately and individually. In Lucknow, all the three animals were housed together. To obtain requisite number of replicates to permit statistical analysis, we repeated the measurements for 3 times on separate periods, each period consisting of a feeding trial of at least 3 days duration. During the trial, measured amount of food was offered, residues were also (only 1 animal refused its entire ration) accurately measured. Considering the natural behaviour of the animal, it was not possible to collect all the faeces. So we used indigestibility marker to determine the volume of faeces voided. Samples of fish, refusal and faeces were analyzed for nutrient content using standard laboratory methods.

Results and Interpretation

Table 2: Nutritional composition of fish fed to otters in Lucknow and Ahmedabad Zoos

Name of the Zoo	DM (%)	on dry matter basis				
		CP (%)	Fat (%)	Ca (%)	P (%)	GE (kcal/kg DM)
Ahmedabad	23.81	74.14	14.30	1.83	0.76	4270
Lucknow	23.45	74.13	13.27	1.9	1.20	4130

CP, Crude protein; GE, Gross energy (Kcal/ kg DM)

Table 3: Feed consumption, diet digestibility and nutritional adequacy of otters diet in Lucknow and Ahmedabad zoo

Name of the Zoo	Fish consumed (g/day)	Dry matter consumed (g/day)	DE intake (kcal/kgW$^{0.75}$)	DMD (%)
Ahmedabad	1742±52.5	358±42	279.9±13.7	73.9±2.2
Lucknow	1240±66.0	289±15	192.8±17.3	75.7±0.8

DE, digestible energy; DMD, dry matter digestibility

Data pertaining to nutrient composition of fish are presented in Table 2. The fish fed to otter in both the zoos were similar in nutrient content. Fish used in Ahmedabad zoo contained 14.3% fat, whereas, fish fed to otters in Lucknow zoo contained 13.27% fat. Reid and Smith (1994) have recommended that fish containing 15-30% of fat are most suitable for feeding of otters in captivity. Dry matter intake was 5.27 and 3.61% of body weight in otters of Ahmedabad and Lucknow zoo, respectively. Average dry matter digestibility was 73.88 and 75.7% in Ahmedabad and Lucknow, respectively (Table 3). Ruff (2007) reported that dry matter digestibility varied from 68-85% depending upon the nature of the diet. It was also observed that digestible energy intake for adult maintenance was 172 kcal/kg BW$^{0.75}$. However, in this experiment we observed higher DE intake which was 195 and 279 kcal/kg BW$^{0.75}$, in Lucknow and Ahmedabad zoo, respectively. It seems that feeding of 1.25 kg of fresh fish was able to supply DE in excess of requirement for adult maintenance. Ruff (2007) reported that digestible energy requirement of otter is higher than other carnivores. It was stated that DE requirement for adult maintenance is 172 kcal/kg BW$^{0.75}$ (Ruff, 2007). The diet of Lucknow provided 11% more energy than this recommended value. Mean DE intake was 61% higher in Ahmedabad zoo.

Suggested guidelines for feeding

1. Always feed fresh fish. Freezing and thawing process will increase the thiaminase activity and will also cause nutrient loss.
2. Do not feed fish having excessive fat. Excessive intake of fat will increase the requirement of Vitamin E. If Vitamin E is not supplemented while feeding high fat containing fish, it may cause fatal diseases (Merck, 1986) due to damage of cell membrane.
3. Live fish may increase the behavioural stimulation; however, prior permission of competent authority may be obtained.
4. Pesticide residue is one of the major contributors to destruction of natural habitat of otter. While it may not be possible to eliminate the pesticide residues (if already present in fish) completely, washing will certainly help in reducing the amount of some of the residues.
5. Always procure fish from a reliable vendor.
6. Feeding of 1.0-1.25 kg of fresh fish would be adequate for adult maintenance. However, lactating animal will require more energy. Increase the amount of fish by 25% for lactating animals.

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3.46 Red Panda

Order	:	Carnivora
Family	:	Ailuridae
Genus	:	*Ailurus*
Species	:	*A. fulgens*
Common name	:	Lesser Panda

Red Panda is a unique taxonomic species that is in danger of extinction (Glatston, 1991). The species is protected under Schedule I of Wildlife Protection Act of India. The IUCN lists the species as endangered. Red Panda is found in Nepal, NE India, Northern Myanmar, Bhutan and South-West China (Yonzon and Hunter, 1989; Wei et. al., 1999). The distribution is restricted in temperate forests at an attitude of 1500 to 4800 m above msl (Glatston, 1991). However, Pradhan *et al*. (2001) found pandas at an attitude between 2800–3000 m above msl.

The fur on the upper part of the body is reddish brown in colour, fur on the lower parts are blackish in colour. They have tear–marks on the face. An adult red panda could be 56-63 cm long, with 37 to 47 cm tall tail. Average weight of male varies from 3.7 to 6.2 kg, female body weight range from 4.2 to 6.0 kg (Heath and Platnick, 2008). The bushy tails have six ochre rings which help them to camouflage. Like giant panda, the radial sesamoid bone is elongated. The muscles normally attached to the first digit are attached to the radial sesamoid in the pandas making the bones highly flexible giving them forceps like grasp. This manus specialization allows red panda to be highly selective feeder. They first grasp the bamboo culm with the forepaw, insert it into mouth by sideways and then pull out the culm, twisting the head, stripping the leaves.

Red pandas are solitary, only except during mating. They usually attain puberty at 18 months of age. However, they are totally sexually mature at 2-3 years of age. Gestation length is 112-158 days. Mating takes place from mid-January to early March. Female gives birth to cubs (1-4) in mid June to late July. Nests are formed in rock crevice or on trees with brushwood, twigs, grasses and leaves. Weaning takes place at 6-8 m of age. The average lifespan is 10-12 years (Glatston, 1991).

The red panda is a unique carnivore that has adapted as a specialist bamboo eater. The tooth structure is very similar to that of an omnivore, whereas, the ratio of body length to gut length is very similar to that of a small carnivore (Bleijenberg and Nijboaer, 1989). Even though their diet comprises mostly of fibrous material, red pandas do not have any adaptation for degradation of fibrous material by harbouring fibrolytic bacteria in the gut. They have got a simple stomach, no caecum and short and straight non-complex colon. The digestive strategy adopted by red panda is to derive maximum nutrients within a shortest possible time. Thus, they have to consume a lot of food to fulfill their requirements (Plumb, 2004). Kock *et al*. (1989) studied red panda diet in different UK zoos. Based upon their and other work, Red Panda Husbandry

Manual recommends that red panda diet should be low in fat (5%), and contain at least 18% crude protein, 0.5% Ca, 0.4%, P with Ca:P ratio ranging from 1:1 to 2:1.

Feeding in Captivity

Feeding schedule of Red Panda in Indian zoos has undergone quite a lot of transformation over the years. Some of these transformations have been presented in Table 1.a and the current feeding schedules in PNHZP, Darjeeling and Gangtok zoo are presented in Table 1.b

Table 1a: Changes made in captive Red Panda diet over the years

Food item	Conventional zoo diet	Improved diet (since 1995)	Further improved diet (since 1999)
Suji	75 g	75 g	-
Sugar	50 g	50 g	20 g
Egg	one	two	two
Condensed milk	300g (diluted to 1.5 l)	300g (diluted to 1.5 l)	1 l
Bamboo leaves	3 kg	3 kg	2 kg
Carrot	-	-	200 g
Papaya	-	-	200 g
Protemax	-	-	10 g
Apple	-	-	400 g
Banana	-	-	Three
Bread	-	-	150 g

Table 1b: Diet schedules of captive Red Panda in Darjeeling and Gangtok zoo

Food item	PNHZP, Darjeeling	Gangtok Zoo
Bread	50 g	30 g
Banana	250 g	275 g
Apple	350 g	150 g
Milk	250 ml	-
Sugar	20 g	-
Papaya	-	50 g
Carrot	-	150 g
Bamboo leaves	3 kg	3 kg

Many a captive red panda diet contains significant proportion of fruits. Too much feeding of soft fruits can lead to dental problems like periodontitis and may also contribute to obesity (Preece, 2002). Other nutrition related disorders were enteritis, lipidosis and fatty degeneration, heart problems, pneumonia and pulmonary oedema (Preece, 2002). Hair loss is also a commonly reported veterinary problem that may have nutritional links such as low protein levels or excessive fat in the diet (Beijuidenhou, 2004; Batchelder, 2003). Further, a link has been suggested between improper nutirition and low reproductive success of red panda in captivity (Glatston, 1991).

Materials and Methods

We conducted feeding trial on red pandas in Darjeeling and Gangtok zoo. In Darjeeling, 10 animals were kept as pairs, 1 group of 3 animals and a solitary animal. In Gangtok, four animals were kept in pairs and one animal was fed individually. We conducted a digestion trial of 5 days duration in each location. During that period measured amount of food was offered and their refusals were measured accurately, faeces voided by the animal were collected manually and also by using markers. Samples of feed and faeces were analyzed for nutrient using standard methods.

Results and Interpretation

Different food items fed to red panda in both the zoos during the period of investigation and their nutrient composition are presented in Table 2.

Table 2: Chemical composition of diet fed to captive Red Panda

		On DM basis							
	Dry matter (%)	GE (kcal/Kg DM)	CP (%)	NDF (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
				PNHZP, Darjeeling					
Bread	58.22	4210	12.34	9.4	0.12	0.41	67	21	9
Banana	24.11	4100	5.37	11.8	0.11	0.15	23	27	9
Apple	15.23	3980	6.01	8.1	0.1	0.08	33	24	7
Milk	12.28	5480	26.4	0	1.04	0.98	4	35	5
Sugar	-	4000	0	0	-	-	-	-	-
Bamboo offered	41.31	4080	7.2	74.87	0.74	0.32	182	29	12
Bamboo residue	46.72	3880	5.5	78.15	0.64	0.21	152	21	9
				Gangtok Zoo					
Bread	55.97	4200	11.94	10.2	0.11	0.39	64	23	8
Banana	23.77	4040	5.62	12.3	0.09	0.22	21	22	9
Apple	15.14	3910	5.42	16.9	0.12	0.09	35	23	9
Papaya	10.74	3810	5.92	14.4	0.27	0.08	0	33	12
Carrot	8.94	4040	11.24	24.7	0.33	0.36	64	32	10
Milk	12.78	5440	26.2	0	1.14	0.86	5	37	5
Bamboo offered	40.81	4052	8.3	74.64	0.81	0.41	185	35	13
Bamboo residue	44.34	3890	5.9	79.1	0.66	0.35	161	28	11

CP, crude protein; DM, dry matter; GE, gross energy; NDF, neutral detergent fibre; ppm, parts per million

It is evident from the data that there was very large variation in nutritional make up of bamboo offered and it's refusal., which indicate that red panda is very selective and consume only the nutritious leafy part of the bamboo plant Data pertaining to feed consumption, diet digestibility and nutritional adequacies are presented in Table 3. Daily feed intake was more or less similar in red pandas in both the zoos. The non-bamboo portion of the diet was readily consumed by the red pandas in both the zoos. However, proportion of non-bamboo food item was significantly higher in red panda of Darjeeling zoo. Bamboo leaves comprised of 59 and 69% of total diet (on DM basis) in Darjeeling and Gangtok Zoo, respectively. Overall, dry matter intake was 7.27 and 7.7% of their body weight. These values seem to be higher than value of 5.9% reported in Giant panda (Dierrenfild *et al*. 1982).

Bamboo leaves consumption was 4.2 and 5.3% of body weight in Red pandas of Darjeeling and Gangtok Zoos, very similar to 4.2% reported in Giant panda in National Zoological Park, Washington, DC. As the proportion of non-bamboo food items was higher in Darjeeling zoo, digestibility of dry matter was also higher in that zoo. In this experiment, dry matter digestibility was 45 and 36% in Darjeeling and Gangtok Zoo.

Digestive efficacy has been reported to vary from 38 to 55% in giant panda. Because the previous study was limited only to 2 animals and no direct comparison between the 2 species were made it could not be conclusively said if the digestive efficiency of red panda is even lower than giant panda.

Table 3:Feed consumption, diet digestibility and nutritional adequacy of red panda diet in different zoos

Parameters	Darjeeling	Gangtok
Dry matter intake (g/ day)		
From non-bamboo food	165.3±7.9	119±12.2
From bamboo	234.7±12.3	266.7±27.7
Total	400 ±16.1	385.67±39
Dry matter digestibility (%)	36.08±0.22	45.32±0.99
Digestible energy intake (kcal/kg $BW^{0.75}$)	259.1±10.8	222.8±10.1
Diet adequacy		
NDF content (%)	37.9±1.67	41.1±2.76
Crude protein content (%)	13.68±0.52	16.47±1.18
Ca (%)	0.83±0.03	1.12±0.07
P (%)	0.62±0.03	0.57±0.03
Fe (ppm)	205.0±9.36	213±12.9
Zn (ppm)	49.7±2.40	54.2±3.7
Cu (ppm)	18.6±0.92	17.9±1.12

However, the comparison certainly indicates towards that digestible energy intake was 259 and 223 kcal/kg $BW^{0.75}$ in red panda of Darjeeling and Gangtok zoo respectively. Digestible energy intake in male and female giant panda was reportedly 323 and 219 kcal/kg$W^{0.75}$ (Dierrenfeld *et al*. 1982). We were not able to segregate the effect of sex because many of our red pandas were reared and fed in pair and the values reported herein are mean of a pair. Average weight of wild panda is reported to be 4.3 kg (Yonzan and Hunter, 1989). Many individuals in zoos weighed 8 kg indicating obesity (Plumb, 2004). The body weight of red pandas in Gangtok were very close (4.9 kg) to those observed in wild. So obesity is unlikely at that location.

However, the animals in PNHZP received energy higher than those received by animals in Gangtok. Thus, possibility of obesity could not be ruled out. During our observation, we found that animals in Darjeeling were heavier (5.5 to 6 kg) than those in Gangtok. We suggest restricting the non-bamboo portion of the diet to less than 25% on dry matter basis.

SSP for red panda suggests feeding guidelines as per the Nutrient Requirements of domestic canids (NRC, 1985). According to this, red panda diet should contain 0.59% Ca, 0.44% P, 2.9 ppm of Cu and 36 ppm of zinc. Compared to domestic canids requirement, red panda dietary intake level of all of the above minerals were higher in the present investigation. Mainka *et al*. (1991) reported that Giant panda diet contained 0.82% Ca, 0.62% P, 14.3 ppm Cu and 32 ppm zinc. Intake of Cu in this study was higher than Giant/Red pandas in free range, but was still well below the toxicity level for Cu in other non- ruminant species including rats and swine (Rechcigl, 1978). From the present investigation and from the review of literature it seems that red panda diet supplied adequate amount of minerals in both the zoos. SSP guidelines for feeding red panda recommend 18% crude protein in the diet. Diet of Darjeeling and Gangtok zoo contained 13.7 and 16.5% CP, respectively. Thus, both the diets were short in protein supply. However, diet of Giant panda in National Zoological Park, Washington DC contained 9.2% CP only (Dierrenfeld *et al*., 1982).

Suggested guidelines for feeding

SSP guidelines for feeding of red panda are followed worldwide. For the benefit of the readers the guidelines is reproduced.

1. SSP recommendation is mostly followed in Western Zoos, where, bamboos are not readily available. In this regards, both our zoos keeping red pandas are located in areas where bamboo is readily available. Nevertheless, we do use produces and concentrates. Moreover, the basic principle of SSP guidelines may be followed.
2. Feeding of milk is not recommended under normal circumstances. Milk/ sweetened gruel could be used for younger animals who refuse to take their normal diet. Milk/gruel can also be used for medication.
3. All ingredients should be fresh. Spoilage of food should be avoided. Feeds should be inaccessible to vermin. Feeding inside the feeding cubicle is appreciated. They should be provided at least 2 meals. Old food may be removed before offering fresh food.
4. Food consumption should be monitored closely. Wild panda weigh 4.3 kg, but in most of the captive facilities they weigh much higher. Red panda require more energy during winter and lactation. The feed left over should be at least 5% for those categories of animals.
5. When animals are housed in pair or in group several feeding stations should be provided in the feeding cubicles to avoid over/ underfeeding.
6. Use of fruits and produces should be restricted. They can be used for medication.
7. Drinking water should be always available. When water is deprived food intake will also decrease.

8. Young pandas at the time of weaning, at 5-7 months of age are susceptible to death due to starvation. Such cubs could be fed with sweetened gruel/ milk.

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3.47 Indian Pea Fowl

Order	:	Galliformes
Family	:	Phasianidae
Genus	:	*Pavo*
Species	:	*P. cristatus*
Common name	:	Peacock

Peafowl is the national bird of India. The male (peacock) has blue-green or green coloured plumage. The female (peahen) is brown in colour. Peafow's are native of India, Male body weight ranges from 4-6 kg, whereas, female body weight ranges from 2.75 to 6 kg with an average of 4 kg. They can adapt themselves to several different kinds of habitats ranging from deciduous forests to cultivated lands and near villages (Jackson, 2006). Sexual maturity is attained at 3 years of age. Peafowls are polygamous. Breeding is influenced by onset of monsoon. Incubation period ranges from 27-29 days. Clutch size ranges from 3 to 12 with an average of 5. Lifespan is 20-24 years (Fowler, 2011). Indian peafowls are omnivorous. They consume grains, leaves, buds, insects, worms, lizards and small snakes (Jackson, 2006).

Birds share the same basic structure with other vertebrates for extraction of nutrients from food. The specialized feature of Galliformes is presence of crop, division of stomach into 2 parts (proventriculus and ventriculus) and presence of paired ceca. Recent evidences support that in some wild galliformes, microbial digestion of cellulose takes place in crop. VFA produced in the ceca may contribute from 8-30% of the energy requirements of bird. This is important because wild galliformes diet contain significant amount of fibre. These forage materials are also rich source of β carotene. This plays an important role in the biology and life cycle of peacock. The male with the brightest plumage colouration is supposed to be the strongest, have more immunity, more resistance to parasitic load and thus will be more likely to be preferentially selected by hens.

Very limited information is available on the feeding of wild Galliformes. Body temperature of birds is higher (41 to 42ºC). As a result metabolic rate is higher in avian species. In addition, birds excrete nitrogen as uric acid, a process that requires 3.95 times as much energy as for the excretion of equal amount of urea. The amount of food required to fulfill the energy requirement depends upon the energy density of the diet, digestibility of the diet, environmental condition, and physiological status and activity level (Koutsos *et al*., 2001; Harper and Turner, 2000). Birds will generally eat the amount that is required to satisfy their energy requirement when fed *ad lib* and the diet is balanced with respect to content of other nutrients. When a diet with low energy density is fed, birds will increase their intake.

Feeding in captivity

Feeding schedules followed in Different Zoos is given in Table 1.

Table 1: Diet schedule of Pea Fowl

MCZP, Chhatbir

Mixed grain	Green peas	Spinach/Cabbage	Garlic	Cucumber/Carrot	Papaya	Apple
100 g	50 g	50 g	5 g	10 g	10 g	10 g

NZP, Delhi

Leafy vegetables	Garlic	Mixed grain	Bread	Kima Besan
50 g	5 g	100 g	25 g	100 g

Thiruvananthapuram Zoo

Green Vegetables	Green Chilly	Green Gram	Poultry Feed	Rice	Wheat
30 g	20 g	20 g	30 g	20 g	30 g

Nandankanan Bioological Park, Bhubaneswar

Bengal gram	Ground nut	Garlic	Green vegetable	Onion	Poultry feed	Pulses and grains	Paddy
50 g	50 g	5 g	100 g	50 g	40 g	40 g	50g

Sepahijala Biological Park, Tripura

Paddy	Wheat	Banana	Apple	Bengal gram	Mustard
50 g	50 g	2 Nos	200 g	50 g	30 g

Bhagwan Birsa Zoological Garden, Ranchi

Poultry feed	Spinach	Mash	Broken rice	Bajra	Onion	Paddy
150 g	50 g	50 g	25 g	25 g	25 g	25 g

Zoological Garden, Alipore

Mixed grains	Crushed maize	Chopped vegetables	Meat mixed with powdered gram
75 g	25 g	25 g	50 g

Nehru Zoological Park, Hyderabad

Poultry feed	Green leaves	Meat/ worms
120 g	50 g	25 g

V.J.B. Udyaan, Mumbai

Mixed grain	Plantain/papaya	Mixed vegetables	Mash / Poultry feed
200 g	100 g	100 g	-

Materials and Methods

We conducted feeding trial on 17 peafowls kept in Kamla Nerhu Zoological Garden, Ahmedabad, 12 peafowl in Sanjay Gandhi Biological Park, Patna and 18 birds kept in Alipore zoo, Kolkata. In Ahmedabad, all the birds were group fed. Seven birds were kept in one enclosure, whereas, 5 birds each were kept in other 2 enclosures. They were fed a ration comprising of commercial poultry mash, grains and mixed vegetables. In Kolkata, number of birds kept in an enclosure was 3, 1, 3, 6, 2 and 3, respectively. They were fed a ration of grains, bran, gram flour, egg and ant larva mixed thoroughly. In Patna, number of peafowl kept in an enclosure was 4, 1, 4 and 3, respectively. They were fed a ration comprising of grains, poultry mash, gram, egg, onion and garlic. The duration of trial was 6 days in each location. During this period, birds were given measured amount of food. The food left over and faecal samples were also measured accurately. Sample of feed, left over and faeces were analyzed for nutrient content using standard laboratory procedures.

Results and Interpretation

Nutrient composition of diet fed to peafowl in different zoos is given in Table 2. Data pertaining to feed consumption, nutrient utilization and diet adequacy are presented in Table 3.

Table 2: Nutrient composition of diet fed to peafowl in different zoos

Food items	DM (%)	On Dry Matter basis						
		GE (kcal/g DM)	CP (%)	Ca (%)	P (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)
Green vegetables	11.24	3.68	16.83	0.78	0.32	88	8	31
Poultry mash	90.12	4.14	22.87	2.34	0.79	61	12	49
Jowar-bajra mixture	91.42	4.04	11.43	0.14	0.54	28	11	32
Ant larva	43.9	6.18	33.01	0.03	0.49	49	8	88

DM, dry matter; CP, crude protein; GE, gross energy (kcal/kg DM)

Table 3: Feed consumption, diet digestibility and nutritional adequacy of peafowl in different zoos

Name of the zoo	Vegetables	Mash	Grains	DMI (g/d)	qm	CP (%)	Ca (%)	P (%)
Ahmedabad	103±4	59±4	138±8	199.5 ±2.6	78.1 ±2.6	15.3	1.29 ±0.02	0.61 ±0.01
Kolkata	Mixture of grains, bran, gram flour egg and ant larva mixed thoroughly 276±16			147.9 ±8.5	83.82 ±1.1	27.1	0.22	0.41
Patna Zoo	Mixture of grains , poultry mash, gram, egg, onion and garlic 263.2±11			153.8 ±6.3	82.34 ±0.86	15.8 5	0.64	0.58

DMI, dry matter intake; qm, dry matter metabolizability

Perusals of data revealed that dry matter consumption was 4.4, 3.7 and 4.5% of body weight in Ahmedabad, Alipore and Patna zoo, respectively. The diet of the three respective zoos supplied 629, 560 and 482 kcal of ME/d. The diet metabolizability was 78, 84 and 82%, in the 3 respective zoos. Metabolizable energy content of the three respective diets was 3148, 3783 and 3127 kcal/kg DM. The higher ME content of the Alipore zoo diet could be attributed to higher fat and calorie content of ant larva. The diet currently being used in Ahmedabad zoo would be adequate for adult maintenance and most of the other life stages of pea fowl. To test the diet adequacy we used the model of Nagy *et al.* (1989)

ME requirement (kj/d) = 0.851* (body mass in g) $^{0.959}$.

According to this estimate, ME requirement of peafowl in the 3 respective zoos would be would 643, 579 and 509 kcal/day. From the perusals of the data, it is evident that all the 3 diets supplied adequate amount of energy to fulfill requirement. According to Leeson and Summer (1993), 15 % crude protein would be adequate for pheasants. All the diets supplied adequate amount of protein to fulfill the requirement. However, the ant larva based diet of Kolkata zoo contained very high amount of protein which could be most suitable for chick rearing. Such high protein diet is not required for adult maintenance and may cause stress to the birds. The diet of Ahmedabad, Alipore and Patna zoo contained 1.29, 0.67 and 0.22% of Ca. The diets of Alipore and Patna were inadequate in calcium content. The diet of Ahmedabad zoo was able to supply adequate amount of Ca for adult maintenance. However, during breeding this should be increased. From the results of the present experiment, we conclude that the diet fed to peafowl in Ahmedabad zoo would be adequate to supply requisite nutrients. However, following suggestions may be followed for betterment.

Suggested guidelines for feeding

1. All newly hatched chicks should be given access to clean, cool water 1-2 hours prior to their introduction to feed.
2. Young chicks generally have a higher requirement for protein than adult birds; a 28-30 percent protein turkey starter feed will usually provide well balanced nutrition for newly hatched chicks.
3. During the first five to ten weeks of life, peafowl chicks should be fed only the high protein starter feed. Grain, high quality fresh grass and legumes may be introduced gradually at eight to ten weeks of age.
4. Nutritional requirements for peafowl change at breeding time. For good hatchability and fertility, a high quality breeder ration should be fed. Breeder ration should be introduced at least one month before the breeding season is expected to start.
5. Do not offer feed on ground or onto the litter. This could lead to eating litter which can have disastrous results. Keep the height of the feeders at about the level of the birds back. When changing feeder and watering equipment, do so gradually: otherwise the birds may not recognized new equipment and starve to death.

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3.48 Rosy Pelican

Order	: Pelecaniformes
Family	: Pelecanidae
Genus	: *Pelecanus*
Species	: *P. onocrotalus*

White Pelican *or* rosy pelican is widely distributed in Europe, Asia and African countries. Large population of the bird migrates across continents. They have been considered as least concern species in the IUCN Red List of Threatened Species (Bird Life International, 2009). They are well adapted in almost all regions of the world from tropical to warm temperate zones. They forage in open waters; both fresh and saltwater (like brackish, alkaline or saline lakes, lagoons, marshes, broad rivers, deltas, estuaries and coasts of land locked sea). White pelicans are fully migratory and fly over the land to seek suitable feeding locations. The breeding season is normally in spring in the temperate zone, all over the year in African countries and from February to April in India (Mullamy *et al*., 1994). Great White Pelicans are large birds with body mass of 10-11 kg (Mullamy *et al*., 1994). An adult bird is 1.45-1.75 m long with a wingspan of 2.45-2.75 m (Mullamy *et al*., 1994). Among all other species of pelicans, Brown Pelican (*P. occidentalis*) is the smallest weighing just 2.75 kg with a 106 cm long body and can have wingspan of 1.83 m. Dalmatian Pelican (*P. crispus*) is the largest among the pelicans, which is 183 cm long, with a maximum wingspan of 3 meters and weigh up to 15 kg (Mullamy *et al*., 1994).

P. onocrotalus is found in all over North India from Punjab to Assam and occasionally visits South India. It is white or rose tinged with a tuft of yellow feathers on the breast, has a slight crest and the feathers of the forehead end in a point above the bill. Females are somewhat smaller than males. Sexual maturity is attained at 3 years of age (Marchant *et al*., 1990). The nesting material are collected by the males, female gives them a shape. The nest may be a pile of sticks and vegetation on ground (Nelson *et al.,* 2003). The ground-nesting (Rosy pelicans) species have a complex communal courtship involving a group of males chasing a single female in the air, on land, or in the water while panting, gaping, and thrusting their bills at each other. They can finish the process in a day. In all species copulation begins shortly after pairing and continues for 3 to 10 days before egg-laying. The female then heaps the nesting material in upward direction to form a simple structure. Clutch size is normally 1-3, rarely it may go upto 6. Both male and female take part in incubation. Incubation period is 30-35 days (Marchant *et al*., 1990). The major component of the diets of free-living pelicans is fish, but they also eat amphibians, crustaceans and on some occasions, smaller birds (Sibley, 2000). They prefer fish in the weight category of 400-1500 g. They often catch fish by expanding the throat pouch. Then they must drain the pouch above the surface before they can swallow.

Feeding in Captivity

Table 1: Diet schedules of captive pelican in some Indian zoos

Name of the zoo	Type and amount of fish
Jaipur Zoo	1.25 kg fish daily
Thiruvananthapuram Zoo	500 g fish daily
Assam State Zoo, Guwahati	2 kg of small fish daily
Lucknow Zoo	1 kg of large fish daily
MC Zoological Park, Chattbir	2 kg of small fish daily
National Zoological Park, Delhi	2 kg of fish (6-9 inches in size)
Nandankanan Biological Park, Bhubaneswar	1 kg of gadisha fish

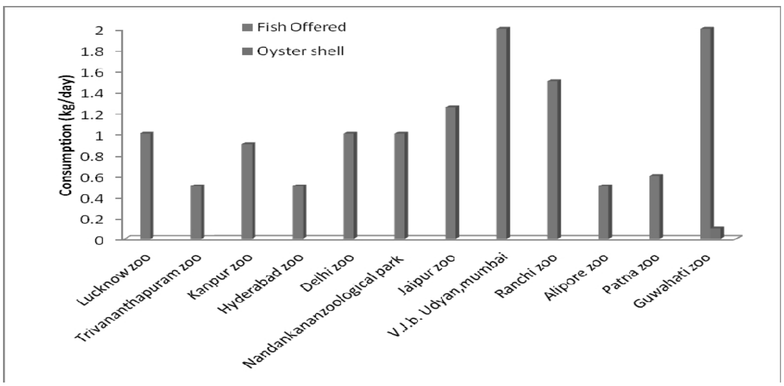

Figure 1: Amount of fish being fed to pelican in different Indian zoos

Pelican are great attraction in zoos across the world. The main aim of keeping the species in zoo is conservation breeding and education. Proper nutrition is important for better reproduction, health, and animal welfare. Majority of zoos in Europe and US rely entirely on thawed, frozen fish for growth, maintenance, and breeding. In most of the Indian zoos, however, frashly captured fish is fed to the birds (Figure 1 and Table 1).

Carbohydrate consumption (<2% of the total diet), of this piscivorous birds have the lowest among birds. As a result, pelicans have adapted to increase the rates of amino acid catabolism and the use of the carbon skeleton for gluconeogenesis (Klasing, 1998). The specific requirement of crude protein and amino acids are not known, but it is estimated between 20-30% of the total diet on dry matter basis. Whole fish contains between 33-77% proteins, on DM basis. Thus, protein and amino acid deficiency is rarely expected, except due to mismanagement. Shmueli *et al.* (2000) calculated the roosting metabolism of captive great white pelicans as 2.478 kcal/kg/h. Energy requirement for exercise and production was found to be 2.6 times of the basal metabolic rate (BMR). Fish generally contain 1.0 and 1.8 kcal/g on fresh basis (Shmueli *et al.*, 2000). Dietary fat provides energy, fat-soluble vitamin and essential fatty acids. For reproductive success, the presence of ω-3 and ω-6 polyunsaturated fatty acids in the diets of pelicans is considered vital

(Surai *et al.* 2001). Inadequate supply of important fatty acid leads to late embryonic mortality, low sperm production, and low post-hatch survivability.

Vitamins A, D, K, riboflavin, pyridoxine, pantothenic acid, and B_{12} are present abundantly in fish (Reiter and Crissey, 1991). The dietary requirement for vitamin E has not been specifically established for many captive exotic birds, but was extrapolated from domestic poultry models (NRC, 1994). The presently accepted supplementation dose of vitamin E in captivity is 0.1 IU/g fish/day (0.4 IU/g DM) (Reiter and Crissey, 1991). Vitamin A deficiency in pelicans may not be of concern when feeding whole fish. If birds are fed eviscerated fish in captivity, they could become susceptible to vitamin A deficiency (Robbins, 1993). Pelicans have good tolerance of excess vitamin A. Thus, chances of hypervitaminosis are meager. However, feeding of vitamin-A at higher concentration for longer period may lead to toxicity. The recommended minimum concentration of dietary vitamin A is 3.5 IU/g/day DM. Thiamin is a coenzyme in carbohydrate metabolism and aids in synthesis of fatty acids. It may also play a role in nerve impulse transmission. Deficiency of thiamine causes ataxia and awkward-backward flexion "star gazing", impaired digestion, diarrhea, seizures and neurological disorders (Robbins, 1993). Diets supplemented with 25-30 mg of thiamin/kg fish/day (100-120 mg/kg DM) will prevent thiamin deficiency (Geraci, 1986).

The ash component of the common fish species fed to captive pelicans ranges from 4.8-24.5% DM (Bernard and Allen, 1997). Manganese and iron tend to be limiting nutrients in most fish species and therefore supplementation may be required. However, analyses should be performed before deciding to supplement minerals. Bone deformation and/or reduced egg production and egg hatchability, are associated with manganese deficiency. Iron deficiency causes anaemia and loss of plumage colouration (NRC, 1994).

Materials and Methods

During the present investigation, feeding trial was conducted on 7 and 38 white pelicans in Patna and Ahmedabad zoo, respectively. The birds in Ahmedabad were housed in a group of 28 and 10 in two separate enclosures and were group fed. The birds in Patna zoo were kept in one enclosure. However, it was possible to feed them individually. Trial period was of 6 days in each location, during this period the birds were fed their respective zoo diet. Accurately measured amount of fish was offered to each of the birds in Patna and it was ensured that each bird consumed its respective quota. There was no left over by any of the seven birds during the period of experimentation. In Ahmedabad, however, there were some residues which were not consumed by the birds. Mean fish consumption of the 2 groups was measured over two trial periods to obtain 4 replicates of measurement. Fish samples were collected from both the zoos and were analyzed for nutrient content using standard laboratory procedures.

Results and Interpretation

Nutritional composition of the fish fed to the pelicans is presented the Table 2. Data pertaining to feed consumption and nutritional adequacies are presented in Table 3.

Table 2: Nutrient composition of fish fed to pelicans

Fish	DM	On dry matter basis				
	(%)	CP (%)	Fat (%)	Ca (%)	P (%)	GE (kcal/kg DM)
Ahmedabad	23.81	74.14	14.3	1.83	0.76	4270
Patna	24.28	75.62	16.4	1.64	0.71	4490

DM, dry matter; CP, crude protein; GE, gross energy

It was found that fish intake was 7.79 and 6.56% of body weight in Ahmedabad and Patna zoo, respectively. In free range, pelicans consume fish at the tune of 8% of body weight (Guillet and Furness, 1985). Dry matter intake was 186 and 159 g/d/bird in 2 respective zoos. Shmueli *et al.* (2000) calculated the roosting metabolism of captive great white pelicans as 2.478 kcal/kg/h or 595 kcal/day. The diet of Ahmedabad and Patna zoo provided 793 and 715 kcal of GE/day, respectively.

Table 3: Feed consumption, diet digestibility and nutritional adequacy of diet fed to pelicans

Parameter	Ahmedabad zoo	Patna zoo
Fish intake	779±48.7	656±23.4
DMI (g)	186±11.6	159±5.6
GE kcal/d	793±49.6	715±25.6
Diet adequacy		
CP (%)	74.14	75.62
Fat (%)	14.30	16.4
Ca (%)	1.83	1.64
P (%)	0.76	0.71

Kg/d, kilogram per day; DMI, dry matter intake; GE, gross energy (kilo calorie per day); CP, crude protein

Considering the digestibility of energy to be 85%, the DE supply would be 674 and 608 kcal DE/bird/day in 2 respective zoos. From the perusals of the data, it is evident that both the diets supplied adequate amount of energy for maintenance. Crude protein intake (CPI) in Ahmedabad and Patna zoo was 138 and 120 g/day which are adequate to fulfill requirement (NRC, 1994). Ca and P were also adequate in the diet of both the zoos and were in proper ratio.

Suggested guidelines for feeding

1. Feeding of 750 g of good quality fish containing 4500 kcal GE/kg DM is adequate to fulfill nutrient requirements of a pelican weighing 5 kg. A big pelican weighing 10 kg of body weight would require 1-1.5 kg of fish depending upon fat content of the fish.
2. Live fish can be fed sometimes as behavioural enrichment, subject to approval of Competent Authority.
3. Very small and very large fish should be avoided. Cutting the large fish to smaller piece will not solve the problem. The size of the fish should not exceed 285 mm.

4. Feeding should be monitored to ensure that all birds get their quota.
5. In normal feeding situation, no supplement would be required. Supplementation of vitamin E source @ of 100 IU/kg fresh fish will be helpful in combating the environmental stresses.
6. Accept the fish only after through examination. Fresh fish has bright red gill, clear eyes and firm pliable body. Stale fish will have darker gill, cloudy eyes and soft body on which finger impression would be easily made and the impression remains.
7. If by any reason frozen fish is to be used, please ensure that it is thawed before feeding.

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3.49 Parakeets

Order	:	Psittacoformes
Family	:	Psittacidae
Genus	:	Psittacula
Species	:	*P. krameri*
		P.roseate
		P.eupatria

Parakeet is a general term which includes large number of small to medium sized birds. Rose-ringed Parakeet (*Psittacula krameri*) has an extremely large range and adapted well to survive in degraded habitat. The average length of this parakeet is 40 cm and can weigh around 120 g (Ali and Ripley 1998). Males bear a distinctive red colour ring on their neck which female and chicks either do not have, or display dark grey neck ring. In the wild, Rose-ringed parakeets usually feed on buds and fruits. Blossom headed parakeet (*P. roseata*) is a bird of open forest. It nests in holes in trees; this is a 30 cm long green colour bird. Head of the male is pink in colour; there is a narrow black neck collar and a black chin stripe. The female has a pale grey head and lacks the black neck collar and chin stripe. Alexandrine parakeet (*Psittacula eupatria*) is a large parakeet species measuring 58 cm in length and weighing 200-300 g (Ali, 1998). It is mainly green with a blue-grey sheen on its cheeks and nape, particularly in males. The species is dimorphic in adulthood (3 years and older). The immature birds are monomorphic and are similar but duller in appearance to that of the adult females. Adult males always show pitch-black neck rings and large pink bands on their napes (commonly called nape bands). Breeding season is from November to April in their natural distribution range. Average clutch size is 2-4 eggs measuring 34.0x 26.9 mm (1 x 1.3 in). The average incubation period is 28 days (Ali, 1998).

Psittacine digestive tracts begin at the beak, followed by a toothless mouth, tongue, pharynx, esophagus, crop, proventriculus, gizzard, intestine, rectum, cloaca, and vent (Klasing, 1998). Accessory organs include the biliary and salivary systems, pancreas, intestinal lymphoreticular tissue, and bursa. Each portion of the digestive tract performs function for acquiring, digesting and absorbing nutrients or for immunocompetence. Acquisition of food is enabled by the beak, tongue, and oral cavity. Beak shape and size are often adapted to accommodate food habit. For example, granivorous birds often have defined ridges on the edges of their beaks that are used for seed cracking. An articulation of the maxillary beak to the skull permits increased gape diameter which acts as shock absorber while cracking the hull of seeds. Touch receptors, which confer strong tactile sense, are found on the tongue, oral cavity, and beak. In contrast, taste buds are found in much lower numbers than those in mammals. Parrots have been reported to have 350 taste receptors, compared with 9000 in human. Once food leaves the oral cavity, it enters the oesophagus, which is expandable to allow large volume of food items to be swallowed. The oesophagus widens into the crop, which consists of a thick, cornified epithelium that protects the bird from damage resulting from swallowing whole foods. Softening of food takes place in this region to enable more efficient digestion of feedstuffs, as well as regurgitation of softened food to chicks. Crop capacity has been shown to change seasonally. The proventriculus and gizzard of psittacine birds are variable in their functional anatomy. The proventriculus contains gastric glands that produce HCl and pepsin, which begin to break down and emulsify foods. The gizzard of granivorous species is large and muscular, with a thick interior koilin lining. Once food particles are broken down and partially emulsified, the digesta moves into the small intestine. The primary functions of the small intestine are enzymatic digestion and nutrient absorption. Pancreatic enzymes hydrolyze most starches, proteins, and nucleic acids in foods, but the proportion of enzymes released during a meal varies with species. Nutrient absorption occurs across the intestinal villli into the enterocytes. By enhancing surface area, the villi facilitate nutrient absorption in this region.

The ceca of birds in the order Psittaciformes are absent or vestigial, resulting in little or no hindgut fermentation of poorly digestible carbohydrates. Therefore, the small intestine terminates at the rectum, which empties into the cloaca. The cloaca serves as a storage site for urine and faeces. In many avian species, retrograde movement of urine from the cloaca to the rectum allows for resorption of protein, salts, and water; this phenomenon likely occurs in psittacine birds as well. The average length of time that food is retained in the GI tract (mean retention time) depends upon food characteristics, feeding strategy, digestive anatomy, and body size. In general, larger birds have longer GI tracts and retention times. The rate of passage of digesta in psittacine birds has not been well studied. However, in granivores retention times are approximately 40-100 minutes, and in frugivores retention times are approximately 15-60 minutes. Complete evacuation of a single meal from the crop of a budgerigar takes 11.75 hours, whereas complete evacuation of the entire tract takes 26 hours (Klasing, 1998).

Feeding in Captivity

The natural diet of parakeets consists of seeds, nuts, fruits, berries, buds, flowers and nectars. They cause considerable damage to crop of maize, rice and other crops. The natural diet is difficult to duplicate in captive facilities. A mixture of vegetables, fruits, seeds, grains and nuts generally represent the typical basic diet. In general, seeds from cultivated plants are more concentrated in energy and lower in protein and many other essential nutrients than seeds available in the wild. Likewise, cultivated fruits and vegetables are higher in energy and water, but lower in other essential nutrients compared with relatives in the wild.

Ullrey *et al.* (1991) compared the nutrient content of seeds commonly used in commercial avian diets with estimated requirements of psittacine birds and concluded that they were typically deficient in amino acids, calcium, available phosphorus, sodium, manganese, zinc, iron, vitamins A, D, K, and B_{12}, riboflavin, pantothenic acid, choline, and available niacin.

McNab and Salisbury (1995) analyzed available data and concluded that the BMR of psittacine birds is dependent upon the thermal climate of the species' origin but is unrelated to food habits or water availability. Species originating from tropical climates have BMR similar to those of other nonpasserines. The amount of food required to fulfill the energy requirement is dependent upon the density of metabolizable energy in that food and its digestibility. There appears to be a divergence in the digestive capacity of birds in the order Psittaciformes depending upon their dietary specialization. Granivorous and omnivorous species are comparatively more efficient at obtaining energy from foods than nectarivores (Koutosos *et al*., 2001).

Table 1: Diet schedule of parakeets at different zoos in India

MC Zoological Park, Chhatbir

Apple/ guava	Green peas	Cabbage	Cucumber /carrot	Ground Nut	Paddy
10 g	10g	10g	10kg	20g	10.kg

Nandankanan Biological Park, Bhubaneswar

Bengal grams	Ground Nut	Green Sag	Maize	Banana	Papaya(Dec. – March)	Green guava (Aug–Sept)
10 g	10 g	20 g	10 g	15 g	25 g	25 g

Maize cob (Sep – Oct)	Water Melon (Apr – May)	Green pea (Dec.-Feb)
25 g	25 g	10 g

Nehru Zoological Park, Hyderabad

Fruits	(Banana/apples)	S. lime
100g + 100gms= 200 g		= Sunflower

Lucknow Zoo

Gram	Groundnut	Singhara	Carrot	Papaya
10 g	10 g	20 g	10 g	10 g

Across granivorous avian species, the protein requirement increases with increased body size. Therefore, higher levels of protein may be required by macaws and other larger psittacine birds in comparison to smaller ones. Experiment with African gray parrots (*Psittacus erithacus erithacus*) suggests a requirement of between 10 and 15% protein for maintenance (Murphy, 1994). Protein and amino acid requirements for reproduction are dependent on the number of eggs laid per clutch, the frequency of egg laying and the protein composition of the eggs. The amino acid composition of budgerigar eggs is similar to those of chickens and other avian species (Massey *et al*., 1960). So, there is no reason to expect that the dietary amino acids requirement for laying hens should differ markedly among species. However, rates of egg production usually differ between species. Amino acid and protein requirements are increased most in avian species that lay on a daily basis and have larger clutches, whereas, the requirements for species that lay a single egg or lay on an intermittent cycle are often increased only slightly above maintenance requirements (Koutosos *et al.*, 2001). Calcium is required in greater quantities than any other mineral and is used for bone mineralization, metabolic homeostasis, and eggshell calcification. In general, the maintenance requirement for calcium is quite small. Although this requirement has not been determined in psittacine birds, the calcium requirement for maintenance in chickens is less than 0.1% of the diet (Rowland *et al*., 1973). Most seeds commonly fed to captive birds have less than 0.1% calcium, and grains are especially low with less than 0.03% calcium. Clinical evidence (Arnold *et al.*, 1967: Wallach, 1973) supports the contention that diets based exclusively on seeds result in calcium deficiency and that the calcium requirement psittacines is above 0.05%.

Materials and Methods

We conducted feeding trial on 7 rose ringed, 3 blossom headed and 10 Alexandrine parakeet kept in Lucknow zoo. All the birds were group fed. They were fed a ration comprising of fruits, nuts and pulses. The duration of trial was 6 days. During this period, they were given measured amount of food. The food left over was also measured accurately. Sample of feed, left over and faeces were analyzed for nutrient content using standard laboratory procedures.

Results and Interpretation

Table 2: Nutrient composition of feed ingredients fed to parakeets

Food items	Nutrient composition (on dry matter basis)							
	DM (%)	GE	CP (%)	Ca (%)	P (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)
Banana	24.12	4.10	5.13	0.09	0.19	23	28	9
Soaked gram	49.27	3.90	8.43	0.39	0.21	65	58	14
Ground nut	88.14	6.41	29.44	0.42	0.24	72	69	12
Singada	8.49	3.44	8.14	0.18	0.14	68	34	9
Carrot	8.24	3.64	8.27	0.16	0.21	114	32	10
Papaya	9.99	3.87	7.43	0.18	0.14	20	22	8
Green chilly	10.14	3.84	18.4	0.20	0.41	65	25	5
Ber	10.14	3.53	11.97	0.28	0.19	38	27	7

DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; GE, gross energy (kcal/kg DM); ppm, parts per million

On perusal of data, it was found that dry matter intake as proportion of body weight was 7.31, 10.73 and 8.15% in Alexandrine, Blossom headed and Rose-ringed parakeet, respectively. Higher dry matter intake in blossom headed parakeet could be attributed to the body size. Smaller animals generally consume more feed in proportion to their body size. Among the 3 species, blossom headed was the smallest one.

ME requirement of parakeets kept in outdoor aviary ranged from s 154 to 229 kcal/kg $BW^{0.75}$. In Lucknow zoo parakeets were kept in an indoor aviary. Thus, the diet of all the 3 species supplied adequate or more energy than the requirement indicated for captive psitticines. Interspecies variation indicate that ME consumption and probably requirement was maximum among the smallest species i.e. blossom headed parakeet. Crude protein content of the diet was 14.5, 14.7 and 12.6% for Alexandrine, blossom headed and rose ringed parakeet, respectively. Experiments conducted on African gray parrot suggest that CP requirement varies from 10-15% in psitticines. Diet of all the 3 species received dietary protein within this range. Thus, protein deficiency is not likely.

Table 3: Species difference in feed consumption, diet utilization and nutrient supply in different species of parakeets

Food consumed (fresh basis gram)	Alexandrine	Blossom headed	Rose-ringed
Banana	23.3±3.53	10.8±0.35	12.7±0.63
Soaked gram	7.3±1.20	4.0±0.20	4.6±0.18
Ground nut	7.7±0.33	4.6±0.20	3.9±0.56
Singada	9.3±1.20	2.4±0.92	2.8±0.95
Carrot	6.3±3.19	4.2±0.34	5.1±0.18
Papaya	7.67±0.33	3.2±0.53	3.1±0.66
Green chilly	1.5±0.20	1.1±0.10	1.1±0
Beri	1.8±0.17	0.70±0.10	0.9±0.09
Total dry matter intake (g/d)	18.29±0.17	0.70±0.10	0.9±0.09
DMI (% BW)	7.31±0.60	10.73±0.16	8.15±0.80
Gross energy intake (kcal/d)	88.6±6.5	48.1±0.68	46.95±3.37
ME intake (kcal/d)	70.1±3.9	38.0±0.88	35.4±3.1
Diet adequacy			
CP%	14.5±0.39	14.7±0.46	12.62±0.91
Ca(%)	0.20±0.001	0.20±0.01	0.17±0.01
P(%)	0.17±0.01	0.20±0.01	0.17±0.01

DMI, dry matter intake; ME, metabolizable energy, CP, crude protein

The Ca content of the diets seems to be very low. Calcium requirement for psitticines are not known. However, calcium requirement for adult maintenance is estimated to be less than 0.1% of the diet (Rowland *et al*., 1973). However, growing chicks (1%) and laying hens (3.3%) would require much higher amount of calcium in their diet. The fruit and seed diets of captive parakeets are notoriously low in Ca content. African gray parrots are frequently diagnosed with hypocalcemia (Rosskopf *et al*., 1985). Yet cockatiel diet containing as little as 0.35% Ca supported normal calcification of shell (Roudybush, 1996). These contrasts could not be explained on the basis of present day knowledge. More experimentation is warranted. If the zoo is interested in breeding and raising chicks, then it would be desirable to raise the Ca percent in the breeder ration to 3 and in chick starter ration to 1% of diet on DM basis.

Suggested guidelines for feeding

1. Alexandrine parakeet is almost 3 times bigger than a blossom headed parakeet. Yet, their diet chat is similar or same in most zoos.
2. Nuts are very high in calorie content. Peanuts could be easily replaced with grains. Millets are closest to the wild grains and may be preferred over other grains. Grains and produces should be fed in separate feeder.
3. If intended breeding, add supplementary Ca to increase its content to 3% of diet. Add 4 g limestone and 1 g of dicalcium phosphate to each 100 g of grain mixture. If the birds are selectively not consuming the limestone part, then apply liquid calcium preparation on the fruit mixture like a salad dressing so as to achieve the desired level of calcium.
4. If chicks are being raised, increase the Ca content of the diet to 1% by adding 2.2 g of dicalcium phosphate and 1.1 g of limestone for each 100g of feed.

5. Ten g of cereal grains, 5 g of pulse seeds, 30 g of fruits like banana and another 30 g of other fruits and vegetables should be sufficient for Alexandrine parakeet. For blossom headed and Ring-necked, the amount should be just 50 and 60% of that being fed to Alexandrine parakeet.

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3.50 Hornbill

Order	: Coraciformes
Family	: Bucerotidae
Genus	: *Anthracoceros*
Species	: *A. coronatus* (Indian pied hornbill)
Genus	: *Buceros*
Species	: *B. bicornis*

Hornbills are are known for their chactristic bill and casque. Predominant plumage colouration is black except in throat, belly and edges of wings, where it is white. They have loud calls, characteristically large bills and casque (Kemp, 1995). All hornbills are cavity nesters. The most unique feature of hornbills is that the female is sealed in the nest (usually made on a tree hole) made by mud and saliva. During the period of nesting, male feeds the female and her chick through a narrow slit made into the nest. During this period of nesting, the female molts and subsequently re-grow her blight feathers (Datta, 2001).

The great hornbill is found in North-East and Southern India. The wreathed, rufous necked and brown hornbills are found in India, Sri Lanka and Borneo (Datta, 2001). The great hornbill is a large sized bird. Body length of this bird ranges from 95-105 cm and body weight may reach up to 3400 g. Males are generally heavier and larger than females (Kinnaird and O'Brien, 2007). The most important morphological feature of the birds is the presence of yellow to yellowish black colour casque on top of the bills. The casque is a hollow structure which the bird uses for aerial casque butting (Raman, 1998).

The Indian pied hornbills (*Anthracoceros Coronatus*) are found as three distinct population in the Indian sub-continents. They prefer ever-green forests. They are medium sized hornbills. Body length ranges from 55-65 cm and body weight ranges from 600-1050 g (Kinnaird and O'Brien, 2007).

Females of *Buceros* species attain sexual maturely at an age of 3-4 years of age, clutch size is 2-4, incubation period is 37-46 days and nesting period (from hatching till leaving the nest) is 72-96 days The period in nest for females of *Buceros* sp is 86-134 days and for *Anthracoceros* sp the period is 48 days or more (Glama *et al.*, 2002).

Both *Anthrococeros coronatus* and *Buceros bicornis* are highly arboreal (++++), which may sometimes show terrestrial activity (++). They are predominantly frugivorous (++++) and may also eat carnivorous diet (++), particularly during chick rearing period (Kemp, 1995). Both these species are particularly fig specialist.

Feeding in Captivity

Diet schedule of captive hornbills followed by different Indian zoos is presented in Table 1. From the perusals of the data in Table 1 it is evident that fruits are the main component of captive hornbill diets in Indian zoos. Figs, the main component is wild hornbills diet contain higher amounts of Ca than commercial fruits fed to hornbills in Indian zoos. Commercial fruits contain more soluble sugar and considerably less Ca and fibre in comparison to figs and other wild fruits (French *et al*., 1999). In nature, hornbills consume whole fruits and regurgitate the seed. While making zoo diet, these points should be kept in mind. Further, they prefer smooth skinned fruits over rough skinned fruits and consume the fruit without peeling it. They also show preference to brightly coloured fruits. Such preferences could be due to presence of carotenoids and flavonoids in brightly colored fruits (Galama *et al*. 2002).

Table 1: Feeding schedule of hornbill in some of the Indian zoos

Name of the zoo	Indian pied hornbills	Great hornbill
Sepahijala Biological Park	Banana, 3 numbers; apple, 50 g; grape, 50 g; boiled rice, 50 g; earthworm, 50 g.	
Biological Park, Itanager	-	Silk worm, 100 g; apple, 250 g; boiled egg/mutton, 150 g; mixed fruits, 250 g.
National Zoological Park, Delhi	-	Kima besan, 300 g; egg, 1 number; banana, 10 numbers; tomato,250g; papaya, 250g.
Assam State Zoo	Papaya, 10 g; Apple, 10 g; Banana, 3 numbers; maize, 10 g; grapes, 10 g; mutton 25 g.	Papaya, 100 g; banana, 10 numbers; rice, 10 g; gram powdered, 100 g; soya flakes, 25 g, mutton/ liver, 100 g; oyster shell,2 g.

A diet containing 10.8% CP and 4.0 kcal GE/g was able to maintain body mass of hornbills (Foeken and De Vries 2001). However, protein requirement increases during chick rearing period. In free range, they consume a lot of animal matter during this period. Invertebrate prey is preferred over vertebrate prey. It may seem irrational because invertebrate prey contain less Ca and other micronutrients than vertebrate prey. But the benefit is that invertebrate prey contains considerably less Fe (30-50 ppm) in comparison to vertebrate prey (50-250 ppm) (Dierrenfeld and Shepperd, 2000). Thus, it is a strategy adopted to reduce the risk of iron storage diseases.

Iron storage diseases are of concern in hornbills. Hemochromatosis is a clinical condition in which excessive iron is accumulated in hepatocytes and Kupffer's cells in liver. Iron may also get accumulated in other organs. Common symptoms of the disease include swelling of abdomen, ascitis, labored breathing and weight loss. Hemosiderosis is the less harmful form of the disease in which excess iron accumulates in the tissue and circulates freely in the blood. Genetic factor could contribute to development and progression of iron storage diseases. Dietary factors which contribute to development of iron storage diseases include absence of natural chelator in diet, excessive content of Fe, vitamin C and heavy metal in the captive diet (Lowenstein, 1986) Treatment includes phlebotomy, incorporation of low Fe-low vitamin C diet and introduction of natural chelator. Vets usually start with letdown of 1% blood per week. The best treatment is administration of deferoxamine meselate. A low iron diet (50 ppm) should be fed. The diet should contain fewer amounts of vitamin-C rich fruits like berries, tomatoes and citrus fruits. The maximum tolerable limit of vitamin C in the diet is 100 ppm.

In free range, Hornbills shift to lipid rich fruits during pre-breeding period. Fruits from the family Luaracae are particularly preferred by *Buceros bicornis* (Kannan and James, 1998). They also increase the protein content of the diet during this period by increasing the consumption of animal matter (Ponswad *et al*., 1983). The increase in dietary protein and lipid has stimulatory effects on captive hornbills. The dietary concentration of protein and lipid may be increased a month prior to expected date of mating. This will also help the pair to get accustomed to the unfamiliar diet which would eventually become part of the chick rearing diet (Galama *et al.* 2002).

Materials and Methods

During the present investigation, we conducted feeding trial on 4 Indian pied hornbills each in Sanjay Gandhi Biological Park, Patna and Sepahijala Biological Park, Tripura. We also conducted feeding trial on two Great hornbills in Itanagar Biological Park and one great hornbill in Assam State Zoo. During the period of experimentation, all the birds were offered measure amount of food. All food refusals and excreta were also collected for consecutive 3 days. Representative samples of food, refusals and excreta were analyzed for nutrient content using standard laboratory methods.

Results and Interpretation

Data pertaining to nutrient composition of different food item being fed to hornbill in Indian zoos are presented in Table 2. Data pertaining to feed consumption and diet digestibility are presented in Table 3.

Table 2: Nutrient Composition of feed ingredients fed to hornbills

Food item	DM (%)	Nutrient content (%DM basis)			
		CP (%)	GE	Ca (%)	P (%)
Grape	5.9	4.8	4.1	0.08	0.14
Banana	26.25	5.1	4.1	0.07	0.21
Apple	15.75	6.2	3.9	0.09	0.11
Sattu	62.58	32.45	3.9	0.38	0.27
Liver	32.58	68.45	4.7	0.04	0.76
Rice	51.23	8.2	4.2	0.09	0.28

DM, dry matter; CP, crude protein; GE, gross energy (kcal/g)

Table 3: Feed consumption, diet digestibility and CP content of hornbill diets

Species	*Buceros bicornis*		*Anthracoceros coronatus*	
Name of the Zoo	Guwahati	Itanagar	Guwahati	Itanagar
Dry matter intake (g/d)	107.6±6.2	123.3±17.5	122.0±10.2	102.5±5.3
Dry matter metabolizability (%)	92.9±1.0	93.3±1.0	92.4±0.8	94.4±0.8
CP content of diet (%)	32.2±1.4	7.0±0.1	18.2±2.2	7.2±0.1

Ponswad *et al*. (1998) reported that on an overage, an oriental pied hornbill consumed 57.5 g of fig, 82.7 g of non-fig fruit and 36.8 g of animal matter with a total food consumption of 177g. The average moisture content of fruits could vary largely, but for convenience, we would amuse that dry matter content of fig, non-fig fruit and animal matter was 20, 20 and 30%, respectively. An approximation of this figure will give us a value of average daily dry matter intake of 40 g. If we give an allowance of 20% for food refusals, then supply of 50 g of dry matter would be sufficient for an adult oriental pied hornbill. The perusals of the data indicate that amount of food currently being fed to oriental pied hornbill in both the facilities are higher. There was large variation in the crude protein content of the diet of Patna zoo and Sepahijala Biological Park. A diet containing 10.8% CP would be adequate for maintenance of hornbills. In this regard, the diet of the Patna zoo supplied more protein than requirement. The diet of Sepahijala Biological Park would be deficient in protein, if this standard is followed. The natural diet of hornbill contains almost 4-5 times more Ca than commercial fruits. From the Ca content of the feed ingredients it can be deduced that the diets currently being fed to hornbills in different captive facilities in India are suspected to be deficient in Ca content. A Ca:P ratio of 2:1 to 1:1 would be desirable. So it would be desirable to include supplementary Ca in the diet of captive hornbill.

Great hornbills are about 3 times larger than the Indian pied hornbills. In this scale, an average daily DMI of 120-150 g would be sufficient for maintenance. In this regard, both the diets of Itanagar and Guwahati zoo were marginally lower than the desired level of intake. The diet of Guwahati zoo contained less CP; where as, the diet of Itanagar zoo contained more CP. The high protein diet could be fed during breeding and chick rearing period.

Suggested Guidelines for Feeding

1. Depending upon the results and review of literature, we suggest that an Indian pied hornbill weighing 1 kg could be fed with following food items:

   Banana, 50 g: apple/pear/plum/seasonal fruits (having about 15% DM), 100g; rice or roti, 20g; Sattu/ besan (grounded Bengal gram flour blended with water) ball, 20 g. This diet would supply 10.8% CP which would be adequate for maintenance However, the diet would not supply adequate amount of Ca. Hence, it should be supplemented with 0.5 g $CaCO_3$ which could be mixed thoroughly with rice or sattu ball. This diet should be adequate for maintenance. However; the diet should be changed one month prior to expected date of mating. During mating and chick rearing period we would suggest the following high protein diet:

   Banana, 50 g; apple/pear/plum/seasonal fruits 100 g and minced meat/ insects 60 g. The amount of $CaCO_3$ may also be increased to 1 g.

For great hornbill

   Maintenance diet: A diet containing 150 g banana, 300 g apple/pear/ plum/seasonal fruit, 60 g cooked rice/ roti, 60 g sattu ball supplemented with 1.5 g of $CaCO_3$ would be adequate.

   Breeding and chick rearing diet: A diet containing 150 g banana, 300 g seasonal fruits, 300 g minced meat/insects/animal matter supplemented with 4-5 g of $CaCO_3$ would be adequate. During this period, the male should be fed on demand without any restriction to food.

2. Hand feeding should be avoided. If such practice is continued, the male may develop stronger bond with the keeper than with the female bird.
3. The feed tray should be placed 1.5 cm above the ground.
4. A perch should be made near to the feeding station so that the birds can feed each other.

5. A wide surface (on ground) around the feed tray should be provided to reduce feed spoilage and to restrict entry of the vermin into the enclosure. However, such surface should not be composed of iron sheet, as hornbills are highly susceptible to iron toxicity.
6. Non-breeding birds should be fed at least twice a day, whereas, breeding birds should be fed at least thrice a day. During chick rearing period, males should be fed on demand.

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3.51 Star Tortoise

Order	:	Testudines
Family	:	Testudinidae
Genus	:	*Geochelone*
Species	:	*G. elegans*

Star tortoise is a terrestrial chelonian of India, Sri Lanka and Pakistan. They inhabit both semi-arid and arid forests. The main identification mark is cream yellow carapace (outer hard dorsal shell part) with dark star shaped pattern that helps them to camouflage in the surroundings vegetation (Das, 1995). The carapace protects them from the predators and eventual external injuries which may be inflicted during foraging. The carapace of females is more curved and they also have comparatively longer limbs which aids in nest building. Star tortoises are mostly solitary. The average body length ranges from 15-20 cm in male and 25-30 cm in female (Das, 1995), while body weight ranges from 1.0-2.4 kg. Walking speed is 0.3-0.5 km/h. The mating season of Indian star tortoise begins with the onset of the monsoon, so the exact time is dependent on the area in which the individual lives. In the wild, females attain sexual maturity at an age of 8-12 years, whereas, males attain it at 6-8 years. Females may lay as many as 9 clutches of 1-10 eggs in a year. Eggs are usually elliptical and sometimes spherical. Average length of the egg ranges from 35-52 mm. Incubation period ranges from 47-180 days. Sex is mostly determined by incubation temperature. Males are produced when incubation temperature is 28-30ºC, whereas, predominantly female hatchlings are produced when incubation temperature is 31-32ºC. Hatchlings are of 25-45 g in body mass (Bouchard, 2009). Typical lifespan in wild is 35-80 years; in captivity average lifespan is 25 years (Slovens and Slovens, 1999). They are mostly herbivores and selectively browse on grasses, fallen fruits, flowers and leaves of succulent plants. The Indian star tortoise prefers to browse during the rainy and winter season when forages are abundantly available. Food preference shift to fallen fruits and flowers during the spring season. During summer there is sharp reduction in the frequency of feeding. This way they conserve energy through aestivation process.

The digestive strategy of tortoise comprises of a capacious but simple digestive tract which provide them greatest flexibility to survive on variety of forage materials in unreliable habitat. The digestive system of tortoise comprises of enzymatic digestion in foregut and microbial fermentation in hindgut (Stevens and Hume, 1995). Oesophageal epithelium of tortoise is cornified. There is presence of numerous mucus glands along the digestive tract. Gastric contents were acidic, whereas, hindgut digesta were near neutral pH. The colon was the primary site of fermentation. The proportion of acetate ranged from 69–84%, whereas, propionate and butyrate ranged from 10-15 and 1–12%, respectively. The short chain fatty acids produced in the hind gut supplies energy. About 2 kcal of ME is supplied by each gram of fibre on dry matter basis (Donoghue, 1998). Tortoises are quite efficient in fibre utilization and contribution of dietary fibre to total digestible energy intake ranged from 22–64%. Mean retention times of digesta ranged from 14.2–14.8 days (Barboza, 1995a).

Tortoises are ectothermic. Their body temperature can vary with the ambient temperature. Ambient temperature influences activities including food consumption and energy utilization. Metabolic activity of tortoises is only ¼ of that in mammals. Donoghue (1998) suggested following model to calculate daily ME requirement in herbivorous reptiles:

ME (kcal/day) = 32 $W^{0.77}$, where W is the body weight in kg

It was also suggested that diet should contain 25% crude protein on dry matter basis. Oftedal and Allen (1996) demonstrated that tortoises selectively avoid food items that are rich in K. When a singular food was offered, food intake was inversely correlated with K concentration of the diet. It was also reported that they prefer diets rich in N and poor in K content. Thus, leguminous fodder could be a good option for feeding tortoises in captivity.

When considering the calcium nutrition of star tortoise, the ratio of calcium to phosphorus is more important than the total amount of calcium in the diet. Ideal Ca: P ratio for most animals range from 1.5:1- 2.0:1 (Scott, 1996). However, natural diets of wild tortoises typically contain calcium: phosphorus ratio of at least 4:1 (Highfield, 1994) and it is hypothesized that chelonia have a higher dietary calcium requirement than some other reptiles. The forage of choice must contain calcium: phosphorus ratio of at least 1: 1. Such forage based diet may be regularly supplemented with calcium carbonate. Vegetables like cabbage, turnip leaves, mustard leaves, lettuce, and spinach contain calcium: phosphorus ratio of at least 1: 1 (Innis, 1994). However, green vegetables like spinach, cabbage and beet leaves contain considerable amount of oxalates which may bind calcium and reduce its absorption of Ca in the small intestine. However, Innis (1994) suggested that tortoises can tolerate high levels of oxalates. If oxalate containing greens are fed sparingly, and the type of greens is varied regularly, then oxalate content of the green vegetables may not be a serious practical problem. It would be desirable to offer different variety of green forages every day. Indian star tortoises are fond of basking under sunlight. Natural sunlight provides UV rays which is essential for internal synthesis of vitamin-D_3, required for better utilization of calcium. Vitamin D_3 increase the Ca absorption in the intestinal wall by releasing calcium binding protein, increases the 1, 25-dihydroxy cholecalciferol concentration and inhibits the calcium loss through the kidney. Thus, basking helps tortoises to utilize calcium more efficiently for the egg shell formation in females and carapace development in juveniles. In rainy season, the tortoise drinks water from any sources available to them (river, canals, ditches etc.). Grasses, fruits and wild flowers are the main source of water during spring season and they frequently urinate at this time. During warmer season they store water, urea and nitrogenous wastes in gall bladder and give off waste material as a thick whitish paste rather than watery urine. The most important excretory product is uric acid (Donoghue, 1998).

Feeding in Captivity

Wild herbivorous tortoises feed on a wide range of vegetations, which are high in fibre and calcium, and low in fat, protein and phosphorus content. Captive tortoises will do best, if fed on similar vegetation such as weeds, flowers and grasses. Most of the Indian zoos feed mixed vegetables, banana, tomato, potato, grams and leafy vegetables to their star tortoises (Table 1). In comparison to natural forage commercial produces are generally higher in protein, lower in fibre and in many instances have skewed Ca:P. Most commonly observed nutritional diseases in tortoises include metabolic bone diseases, hypovitaminosis, thiamin deficiency, and cachexia (Donoghue, 1998: Fladelius *et al*., 2005).

Table 1: Feeding schedule of tortoise in different Indian zoos

National Zoological	Green leafy	Banana	Tomato	Potato/Sweet potato	Beef Keema			
Park, Delhi	25 g	One	25 g	25 g	25 g			
Assam State		Bread	Wheat	Soya flakes				
Zoo, Guwahati		slice	Bran					
	> 10 kg weight	50 g	25 g	25 g				
	< 10 kg weight	25 g	12.5 g	12.5 g				
Pilikula	Mixed vegetables	Grass	-		-			
Biological Park	20 g	10 g	-		-			
Nehru	Species	Gram	Carrot	Potato	Sweet Potato	Insect	Lucerne	Spinach
Zoological	Giant	100 g	50 g	50 g	50 g	50 g	1 kg	200 g
Park, Hyderabad	Star	10 g	-	-	-	50 g	50 g	-
Kanpur Zoo	Soaked grams	Moth	Greens	-				
	20-30 g	40 g	100 g	-				

Materials and Methods

We conducted feeding trial on 13 star tortoises in Jodhpur zoo and 4 star tortoises in Alipore zoo. Three feeding trials of 3 day duration were conducted at each location. During the period of experimentation measured amount of food was offered to each of the animals. The residues left over and excreta voided were also accurately measured. Tortoises voided large faecal pellets that were separate and distinguishable from their uric acid containing urinary excreta. To validate feed consumption and diet digestibility external and internal markers were also used. Samples of feed, refusals, and faecal samples were analyzed for nutrient content using standard laboratory procedures.

Results and Interpretation

Data pertaining to nutrient content, feed consumption and dietary adequacies are presented through Tables 2 and 3. The feed ingredient used in Jodhpur zoo seems not to be part of natural diet of tortoises. Yet, star tortoises readily consumed the rice-milk pudding offered to them. It has been reported earlier that tortoises prefer sugar containing food (Donoghne, 1998). Due to low fiber content and high carbohydrate content, the consumption of dry matter was 10 fold higher in tortoises of Jodhpur zoo than those in Alipore zoo.

Table 2: Nutrient composition of diet fed to star tortoises

Food items	DM (%)	On dry matter basis			
		GE (kcal/kg)	CP (%)	Ca (%)	P (%)
Lettuce	5.81	3810	25.90	1.07	0.58
Cucumber	6.92	3740	12.37	0.38	0.27
Beans	15.13	3780	23.24	0.57	0.34
Amaranthus	14.45	3880	21.45	1.21	0.44
Cabbage	11.02	3940	24.37	0.72	0.38
Spinach	10.11	3830	20.20	0.83	0.18
Rice-milk pudding	31.72	5340	18.89	0.52	0.63

DM, dry matter; CP, crude protein; GE, gross energy

Dry matter digestibility was also significantly higher in tortoises of Jodhpur in comparison to tortoise in Alipore zoo. Dry matter digestibility in tortoises of Alipore zoo was similar to that observed earlier in desert tortoises fed grass based diet (Barboza, 1995b). The higher digestibility observed in Jodhpur zoo could be due to lower fibre and higher starch and sugar content of the diet. It seems that digestibility of diet is influenced by type of diet like herbivorous mammals. However, the impact of such highly digestible diet on colonic health and obesity needs detailed investigation. The tortoises in Jodhpur were heavier than those in Alipore zoo.

Table 3: Feed consumption, diet digestibility and nutritional adequacies of star tortoise diets in two different zoos

Parameter	Name of the zoo	
	Jodhpur	Alipore
Dry matter intake (g/d)	34.53±3.56	6.51±0.53
Dry matter digestibility (%)	88.78±0.85	67.43±0.34
GE intake (kcal/d)	180.94±19.24	22.33±1.96
DE intake (kcal/d)	166.34±18.51	14.19±0.99
ME intake (kcal/d)	149.7±16.65	12.77±0.89
ME intake (kcal/Kg $BW^{0.75}$)	86.03±9.57	8.34±0.58
Diet adequacy		
CP (%)	19.2±0.27	22.23±1.01
Ca (%)	0.53±0.003	0.86±0.02
P (%)	0.61±0.002	0.39±0.01

GE, gross energy; DE, digestible energy; ME metabolizable energy; CP, crude protein

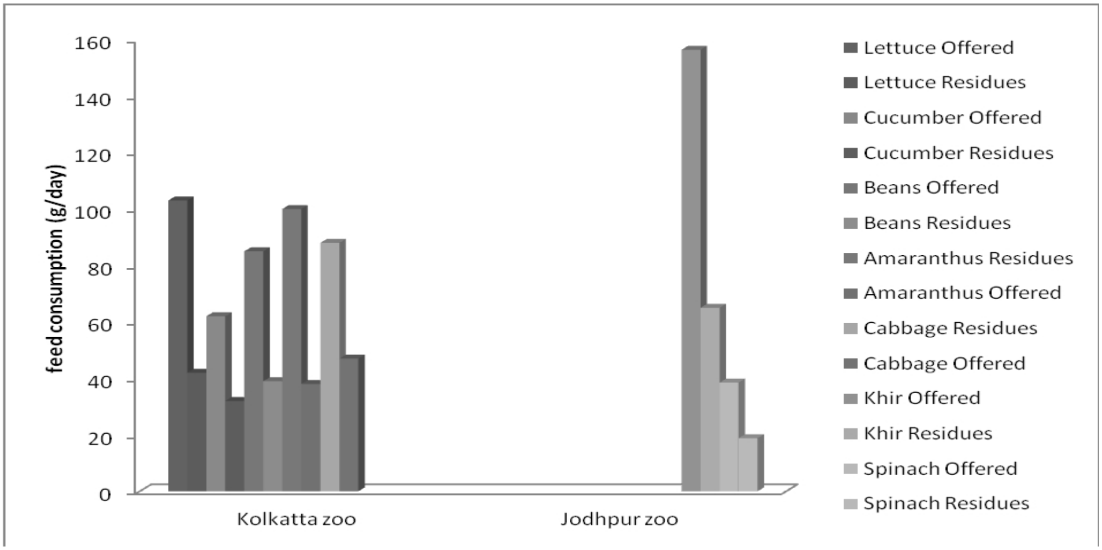

Figure1: Actual consumption of different food items by star tortoises

Consequent to higher intake and digestibility, metabolizable energy intake was also 11 times higher in tortoises of Jodhpur than those in Alipore zoo. Yet the tortoises in Alipore zoo received adequate amount of energy to fulfill their requirement. Barboza (1995b) reported that maintenance requirement for a desert tortoise is lower than other reptilian herbivores. The maintenance energy requirement was only 4.8 kcal ME/ kg $BW^{0.75}$ (Barboza, 1995b). Thus, the diet of Alipore zoo would be adequate to fulfill this requirement. N requirement for desert tortoise was estimated to be 56 mg-N/kg BW/day. According to this, daily CP requirement of star tortoises of Alipore and Jodhpur zoo would be 616 mg and 735 mg head/day, respectively. Average daily CP intake by star tortoises was 1.45 and 6.54 g in the 2 respective zoos. Thus, it seems that the diet of the Alipore zoo was able to provide adequate amount of protein. Calcium requirement of tortoises is not known. However it is supposed to be within the range of 0.5-0.7% Ca and 0.3-0.4% P (Allen and Oftedal, 2003). Both the diets provided adequate amount of Ca to support this minimum requirement. However, tortoises are suspected for higher calcium requirement and metabolic bone diseases are quite prevalent in captive tortoises (Fladelius *et al*. 2003). Further, growing animal and adult females will require much higher amount of calcium. Till such time that these requirements are precisely set, it would be desirable to supplement Ca in the form $CaCO_3$ on regular basis. The Ca:P ratio in Jodhpur zoo is skewed which is a major concern. We discourage feeding of rice and sugar on account of a) higher concentration of readily available energy which may adversely affect hindgut microflora and may cause gastro-intestinal disorder; b) Such food items are not part of the natural diet of tortoises; c). Very high energy supplied by this diet may cause stress and damage to kidney and liver; d). Skewed Ca:P ratio may impair carapace development, mobility and reproduction.

Suggested guidelines for feeding

1. No food of animal origin should be fed to star tortoise
2. A typical diet should comprise of green leafy vegetables, 95%, and fruits (5%). A typical diet should contain 20% protein, 75% carbohydrates and 5% fat. Diet containing more than 12% fat is contra-indicated.
3. Green vegetables like mustard, radish, cabbage, turnip, spinach, leguminous fodder and cut grasses can be fed to star tortoises. It is to be remembered that cruciferous vegetable contain goitrogenic substances, whereas, spinach, cabbage and beet leaves also contain considerable amount of oxalates. So, an array of variety of vegetables should be fed. Vegetables of choice may be changed on daily basis. The key to chelonian nutrition is variety. Never allow your tortoise to feed selectively on a few preferred food items
4. Flowers of China rose, carnations and rose may also be fed to tortoises.
5. Star tortoises like sugar rich food items like fruits. But, the amount of fruit should not exceed 5% of the total diet.
6. Cuttle fish bone may be kept inside the tortoise enclosures.
7. At least 6.4 g of $CaCO_3$ or 2.6 g of Ca may be added per kg of fresh food.

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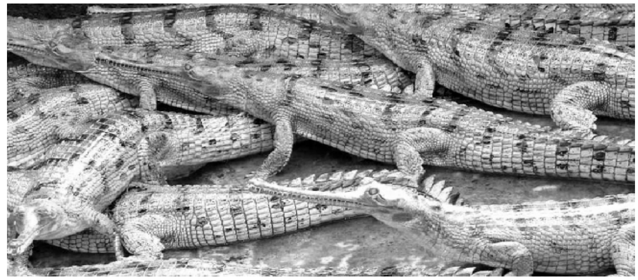
3.52 Gharial

Order	:	Crocodylia
Family	:	Ghavialidae
Genus	:	*Ghavialis*
Species	:	*G. gangeticus*



Gharial is a critically endangered species of reptile found in National Chambal Wildlife Sanctuary, Katarniaghat Wildlife Sanctuary and Mahanadi Biome of India and in a few protected areas of Nepal (Chaudhury *et al.*, 2007). They are now found in only 2% of their former range. They prefer free flowing rivers with deep pool and high sand bank (Whittaker and Basu, 1983). The most important morphological feature of the species is a very long snout, at the end of which mature male bears a bulbous, "ghara" (earthen pot) like structure. This "ghara" is used for making resonance sound, visible and acoustic courtship behavior (Anonymous, 2009). Indian gharials are one of the largest species of crocodilians. The average length of adult males varies from 3-5 m, whereas, average length of female ranges from 2.75 to 3.75 m. Average body mass of the species ranges from 159 to 250 kg (Whittaker and Basu, 1983). Their musculatures do not permit them to walk on the ground, but they can push the body forward across the ground. The outer toes are two third webbed and inner toes are 1/3 webbed. With the long tail, webbed toes and long snout they can swim very fast underwater, reaching up to 40 km per hour (Walter and Johnson, 2011). They have long snout with 106-110 sharp teeth which are specifically useful for catching fish (Bouchard, 2009).

Sexual maturity is attained at 8 and 15 years of age in females and males, respectively (Bouchard, 2009). Gharials are seasonal breeder. Mating season ranges from November to February and nesting occurs through March to May. Between 30 and 50 eggs are deposited in the nest that the females make on sand bank. An average egg is 8.6 cm long, 5.5 cm wide and weighs 100-156 g. Incubation period varies from 60-80 days during which the female are very territorial and guards the nest (Bouchard, 2009).

Young gharials will feed on insects and smaller vertebrates. Adult animals will exclusively feed on fish. Their long bills and sharp teeth on them are specially suited for capturing fish. They also use their strong tail to corner fish against the bank where they can easily catch them (Piper, 2007).

Feeding in Captivity

Diet schedule of gharials in different Indian zoos is presented in Table1.

Table 1: Diet schedule of captive gharials in Indian zoos

Name of the Zoo	Diet Schedule	
	Type and amount of feed	Feeding frequency
National Zoological Park, Delhi	1.5 kg fish	Daily
Nandankan Biological Park, Bhubaneswar	1.5 kg fish	6 days a week
Pillikula Biological Park	1 kg fish	Thrice a week
Itanagar Biological Park	0.5 -1 kg of fish	Daily
Ranchi Zoo	750 g fish	Daily
Lucknow Zoo	1 kg fish	Daily
MCZP, Chattbir	2 kg fish	Daily
Mumbai Zoo	3 kg fish	Thrice a week

Fish could be considered as a complete package of nutrition for gharials. Bones would provide Ca, P and Mg; liver and kidney would provide trace minerals and vitamins, thyroid will provide iodine and pancreas would provide zinc. If good quality fish are fed any supplement may not be necessary. However, if excessively fatty fish are fed, nutrient density (amount of nutrient per unit calorie intake) would decrease and there is a chance of obesity. Some frozen fish have anti-thiaminase activity. If such fish are fed, supplementation of thiamin would be necessary. Excessive PUFA content of the diet may also necessitate supplementation of tocopherol (discussed in detail in Otter and other piscivores).

Materials and Methods

During the period of investigation, we observed the daily feeding pattern of 7 gharials kept in Gwalior zoo. They were fed 1 kg of fresh fish/animal/d. The animals were fed individually and they consumed their respective quota of fish. Representative samples of fish were collected and subjected to nutritional analysis following standard laboratory methods.

Results and Interpretation

Data pertaining to chemical composition of fish are presented in Table 2.

Table 2: Chemical composition of fish fed to gharials in Gwalior zoo

DM	% DM Basis				
(%)	CP (%)	EE (%)	GE (kcal/kg DM)	Ca (%)	P (%)
24.05	68.10	21.45	4620	2.04	0.98

DM, dry matter; EE, ether extract; CP, crude protein; GE, gross energy

Gharials, like other crocodilians continue to grow throughout their life. However, growth rate may depress with the advancement of age (Huchzermeyer, 2003). Like other reptiles, gharials are also exothermic. Their body temperature varies with the ambient temperature. Further, these animals are also heterothermic exhibiting a wide range of body temperature in line with ambient temperature (Donoghue, 1998). Thus, the gharial's core body temperature, activity, food preference and energy needs are controlled by environmental temperature. Metabolic rate and daily energy requirement of animals are calculated using standard equation (Schmidt-Nielson, 1990). Like mammals and birds, metabolic rates of reptile also depend on the body size. Larger the animal, smaller will be the metabolic rate per unit of body mass. Energy requirement increases during reproduction, protein synthesis, muscular exercise and after eating. However, metabolic rate in reptile is only about a quarter of that in mammals and birds. Donoghue (1998) estimated that standard metabolic rate in reptile is 32 $BW^{0.77}$ kcal/d, where BW is body weight in kg. Gharials are exclusive fish eater. Most of their calorie demands are fulfilled by fat and protein. Intake of carbohydrates including fiber is minimal, because they utilize amino acids for production of energy; the rate of gluconeogenesis is relatively higher (Donoghue and Langenberg, 1996). Intake of protein (30 to 60% of calories) and fat (40-70% of calorie) is higher in gharials. Their digestive system is relatively short and simple and fermentation activity is minimum (Stevens and Hume, 1985). Stomach can be divided into 2 parts; proximal part comprise of strong musculature like gizzard in bird. The distal portion is secretory and most acidic in nature in which almost all biological matter including scales and bones can be digested (Huchzermeyer, 2003). Gharials consume stone and gastrolith which aid them in processing of unchewed prey that they consume (Davenport *et al*, 1990)

Davenport *et al*. (1990) reported that juvenile crocodile would consume upto 9-10% of body mass on fresh food basis. The appetite returns at an interval of 40 h, the complete clearance of a meal from the gut require 4-5 d. Assimilation rate for dry matter was 78%, for energy it was 85% and for protein it was 97%. Only 7% of the total consumed calorie is utilized for maintenance (Garmett *et al*., 1988). Thus, it is evident that maintenance energy requirement for crocodilians is less in comparison to mammals and birds. At 28^0C, an American alligator weighing 70 kg would require 72 kcal ME for maintenance. At 32^0C the requirement could be double, but it was still only a quarter of that required for a similar sized man.

Basal metabolic rate in crocodilian species is five to ten times lower than the mammals of similar size (Garmett, 2009). Thus, in gharials ME requirement (average of 140 kcal/kg $BW^{0.75}$ in most mammals) would range from 14 to 28 kcal ME/kg $BW^{0.75}$. If we consider the mean value, ME requirement would be 21 kcal ME/kg $BW^{0.75}$. Thus, a gharial weighing 100 kg would require $21x100^{0.75}$ kcal ME/day= 21x31.6=664 kcal ME/day. If the fish contain 4.6 kcal/gDM then 144 g fish DM would be required. If we assumed that digestibility (Davenport *et al*., 1990) is 80% than 180g of fish DM would be required to fulfill the requirement. As the DM content of fish was 24%, a diet of 750 g fish (on fresh basis) will be adequate for maintenance of a gharial weighing 100 kg. Similarly, amount of fish required for a gharial weighing 150 and 200 kg would be 1019 (say 1 kg) and 1265g/d (say 1250g), respectively. As food is retained for considerable time in digestive tract of gharials, it would be desirable to feed them only thrice a week. If this schedule is to be followed the amount of fish to be fed during each feeding would be 1750 g, 2300 g and 2951 g per feeding for a gharial weighing 100, 150 and 200 kg, respectively. Similarly, false gharials (~200kg BW) was fed 2-3 kg of fish thrice week (Mathew, 2012). As the fish is a complete package of nutrition for gharials, all other nutrient demand can be fulfilled by following above mentioned guideline.

Suggested guidelines for feeding:

1. Body condition measurement should be monitored regularly.
2. Gharials weighing 100, 150 and 200 kg body weigh need 750, 1000 and 1250 g of fish daily, respectively.

3. Frozen fish should not be fed.
4. Live fish can be fed sometimes as behavioural stimulation.
5. If compelled to feed frozen fish, then add 25-30 mg thiamin and 1000 IU of vitamin E to each kg of feed.

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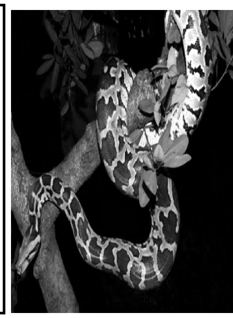
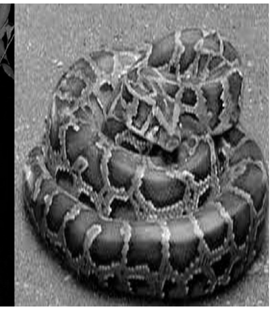
3.53 Indian Rock Python

Order	:	Squamata
Family	:	Poythonidac
Genus	:	*Python*
Species	:	*P.molurus*
Other common name	:	Indian-Python, blackmailed python





Indian rock python is a large non-venomous species of snake found in South-East Asia. There are 2 recognized subspecies P*ython molurus molurus* (Indian python) and P*ython molorus bivittatus* (Burmese python). Burmese python is larger than Indian python. The geographic distribution of both the species is also distinct; Indian python is found in India, Pakistan and Bangladesh, whereas, Burmese python is distributed from Burma through eastward to China (Murphy and Handerson, 1997). They are well adapted to different types of habitat ranging from evergreen forest, woodland, scrubland, rocky terrains and grassy marshes. They prefer damp terrains and remain close to water source (Padgett, 2003). A Burmese python can weigh upto 137 kg and may measure 7.6 m. Indian python is shorter at maximum length of 4.6 m and maximum body mass recorded was 52 kg (Minton, 1966). However, most pythons may not attain this much of huge size. Usually, Indian python measures about 3 m (Wall, 1912). The colour pattern is wheatish with blotched pattern varying from shade of tan to dark brown (Bhupathy, 1990). Indian pythons are dimorphic and females are larger and heavier (Coborn, 1991; Shine, 1994). In NZP, Washington DC, a male was 3 m long, whereas, female attained length of 4 m and exceeded 50 kg of body mass. Indian python reaches sexual maturity at 2-3 years of age. The male initiates dorsal anterior advances by pressing it's head to the females body. Both sexes scent mark during the breeding period (Walsh and Murphy, 2003). Males will erect their spurs perpendicular to the body wall and would vibrate them on the females dorsum, often female remain quiescent as the male place his vent region in apposition to females cloaca. Females would raise their tail and gape cloaca in response to male's copulatory attempt. A discernible muscular movement (immediately posterior to the trunk of the male) was observed after insertion of the hemipenis. Copulation ranged from 10 min to several hours (Walsh and Murphy, 2003), much shorter than 6 h 45 min recorded in *Python molurus bivittatus* (Gillingham and Chambers, 1982). The gravid would refuse any kind of food at least 1 month prior to oviposition. Clutches are laid 2 months after conception. Clutch sizes ranges from 8 to 100 in Northern India where eggs were laid between March and June. Maternal incubation in *Python molurus* ranged from 57 to 66 days (Pope, 1961). Vinegar (1973) reported that eggs incubated artificially, at lower (27^{0}C) temperature hatched later than those artificially incubated at higher (30.5^{0}C) temperature. Eggs incubated at 23^{0}C did not hatch. Female pythons remain tightly coiled around their eggs throughout the incubation period (Hutchinson *et al*., 1966). Female pythons maintain constant clutch temperature by constriction of muscle and non-shivering thermogenesis (Vinegar *et al.*, 1970). Egg mass ranged from 176.8 to 276.9 g and egg dimension ranged from 88x62 mm to 106x79 mm (Walsh and Murphy, 2003).

Pythons are carnivores. They prey on reptiles, birds and mammals. Pythons employ the sit-and-wait tactics of hunting (Greene, 1997). In free range, the meals are highly infrequent and pythons wait for weeks and sometimes months between meals (Wilson, 2007). Their prey list may range from a small lizard, to a ground dwelling bird to a prey as formidable as pangolin, deer or leopard (Murphy and Henderson, 1997). They use their sense of smell to locate a prey (Berttet and Wagner, 1997). Scent molecules from surrounding area are carried to mouth by tongue, from which it is transferred to "Jacobson's organ". Here the scent molecules are sorted as male/female, danger/harmless or prey/meaningless scent etc. They grasp the prey in the mouth and constrict it to death by throwing a loop over the prey or around it. Pythons can swallow prey larger than their diameter because they have an elastic ligament between lower jaws and multi-hinged jaw joint and the teeth are arranged in a reverse-saw like manner which prevent the prey from escaping. Once the prey is dead, python will swallow it starting from the head. Swallowing is aided by constriction of axial muscles that drives the prey into expandable oesophagus and stomach. Approximately 0.1-0.2% of the meals energy is spent in the swallowing process (Secor, 2008).

Extended lower oesophagus and stomach exerts pressure on lungs and blood vessels making it difficult for the python to breathe. Therefore, it is necessary for the snake to digest the meal as quickly as possible to relieve pressure (Secor, 2008). While the python is waiting for it's meal, it's gastrointestinal tract is down regulated in structure and function. In this state, acid production by stomach, secretion of gall bladder and pancreas has ceased, intestinal epithelial tissues are in atrophied state and intestinal microvilli are short (Cox and Secor, 2008). Activity of other organs like heart, liver pancreas and kidney is also reduced (Secor, 2008).

In response to a meal, oxynto-peptic cells of python's gastric mucosa starts secreting HCl and inactive pepsinogen into stomach. The pH of stomach drops to 2.0 within 24 h of swallowing the prey. Soft tissues and skeleton of the prey begins to dissolve. Inspite of the large buffering capacity of the prey itself, python continues to maintain luminal pH in the range of 1.5-2.0. By the third day of digestion only 25% of the ingested food remains in the stomach, which mostly comprise of trunk, vertebrae, tail, hind limb and hair. After 6 days nothing but a mat of hairs remained in the stomach (Cox and Secor, 2008). Upon entry into the small intestine, the pH of the chyme is rapidly neutralized from 1.5 to 6.0 presumably by the secretion of $HC0_3^-$. At the same time, bile from gall bladder and amylase, lipase and protease is secreted into the intestinal lumen. Gall bladder is decreased by 64% due to release of bile. Enzyme release in small intestine is associated with appearance of zymogens within pancreatic acinar cell and trypsin within the intestinal lumen (Secor and Diamond, 1995). Up-regulation of intestinal tissue's form and function begins even before the chyme has entered intestine. Within 6 h, microvillus length, amino acid uptake rate and amino-peptidase activity doubles (Secor, 2008). Within 24h after feeding, 17-27% of prey would enter the intestine by that time, intestinal tissue mass has increased by 70%. There was 4 fold increase in microvillus length and 5-10 fold increase in amino acid uptake (Secor and Diamond, 1995). Unabsorbed hairs starts entering large intestine after 48 h. At this point, large intestine traverses anteriorly to form a blind pouch, a caecum and continues posteriorly to the cloaca. As the days pass on more and more unabsorbed materials accumulate in large intestine and caecum, urates are accumulated in the distal end of the large intestine which has come from the kidney through the ureters. Burmese pythons often pass a bolus of urate 3-7 day after eating. A combined bolus of urate and faeces is passed out within 1-2 weeks of passing out the urate (Secor, 2008). As the last of the meal passes down to intestine, down regulation of the organs initiate. At 10 d after meal, the pH of stomach is 6.0, enzyme activity is reduced by 50%, intestinal mass decreased by 35%, and intestinal nutrient uptake activity is not different from those before feeding. During this time, other organs (heart, liver and kidney) also is down regulated in structure and function. Thus, both up and down regulation of structure and function of organs and tissues, in response to consumption of a meal and it's digestion is equally dramatic in pythons (Secor, 2008).

A Pythons coordinate feeding and fasting responses across the organs and tissues, which is reflected in the collective change in their mass and function. Pythons doubled the mass of pancreas, liver and kidney after consuming a meal which indicates that enzymatic, hepatic and renal functions are up-regulated with response to a meal (Secor and Diamond, 1995). There is 5 times increase in ventilation and cardiac output (Secor, 2008) and 50% increase in stroke volume. The increased stroke volume is due to 40% increase in heart mass (Anderson *et al.*, 2005). The up-regulation of organs and tissue during digestion entails substantial metabolic investment and co-ordinated interactions of different tissues. Total amount of energy spent on all postprandial activities involved in the digestion and assimilation of food is commonly referred to as specific dynamic action or SDA. SDA is particularly high in large carnivorous reptiles (Secor and Diamond, 1997). The SDA accounted for 25-30% of ingested energy in reptiles (Overgaard *et al*., 2002; Ott and Secor, 2007). Postprandial metabolic rate increased by 44 times which accounted for 37% of the meals energy (Secor, 2008). The magnitude of SDA is influenced by composition of meals and environmental temperature. Low temperature prolonged the metabolic responses (Secor and Diamond, 2000), whereas, high protein diet increased the SDA (Mc Cue *et al*., 2005). The SDA is not the only route through which energy is spent. Before being absorbed some energy is lost in faeces and after metabolism energy is also lost through urine. Apparent digestible energy (ADE) was 89-98 and 78 to 93.7% in Australian python (Bedford and Christian, 2000). For blood python , ADE was 93.3% and AAE was 88.7% of ingested energy. Cox and Secor (2007) recorded that ADE was more than 89.5% and AAE was 85% of ingested energy in Burmese Python. They further illustrated the energy budget of Burmese python fed @ 25% body mass. Proportion of ingested energy lost in faeces and urate was 13.3 and 7.0%, respectively. Energy spent as SDA, Standard metabolic rate (SMR), activity metabolic rate (AMR) and growth was 33, 10, 4 and 36%, respectively. Average daily gain (ADG) of captive juvenile blood python was 2.6 g/d (Vinegar *et al.*, 1970). Burmese python fed meal equivalent to 15 and 25% of body mass achieved ADG of 1.7 and 3.7 g/d, respectively (Cox and Secor, 2007). The ADG in reticulated python ranged from 3.5-7.0 g/d (Pope, 1961). Adult pythons kept in captivity may not require the energy spent in growth of juvenile snakes. So, their diet should be adjusted accordingly.

Up-regulation of structure and function in Python is an adaptive mechanism to conserve energy. Pythons encounter long bout of fasting. The benefit of down-regulation during this long bout of fasting is decreased energy expenditure. During the period of fasting energy expenditure is reduced by 70%. The standard metabolic rates (SMR) of sit and wait-foraging snakes are 47% less than foraging snakes (Secor and Diamond, 2000).

Feeding in Captivity

National Zoological Park, Washington, DC has successful breeding record of Indian python. They feed their python mostly with rats and rabbits. Feed were offered every other week. During breeding season (December-March) the snakes fed infrequently or stopped feeding completely. Chickens or other fowls were occasionally consumed during that period (Murphy and Walsh, 2003). Most of the Indian Zoos feed their pythons with chicken once every week (Table 1)

Table 1: Feeding schedule of Indian python in some of the Indian Zoos

Name of the Zoo	Food offered	Quantity	Frequency
National Zoological Park, Delhi	Live rabbit	One	Once a week
Nandankanan BIological Park, Bhubaneswar	Chicken	One	Once a week
Itanagar Biological Park	Live chicken	1-2 kg	Once a week
Bhagwan Birsa Biological Park	Live chicken	250-500 g	Once a week
Sepahijala Biological Park	Chicken	350-600 g	Once a week
Nehru Zoological Park, Hyderabad	Chicken	400-500 g	Once a week
Lucknow Zoo	Live Rabbit	1-3 Nos.	Every 15-25 days

Materials and Methods

During the present investigation we monitored the feeding schedule of 7, 3, 5, 4, 4 and 6 Indian pythons in Delhi, Bhubaneswar, Itanagar, Ranchi, Hyderabad and Lucknow Zoo, respectively. The prey items offered to the pythons were accurately weighed before offering them to the snakes. No refusal was found during the period of investigation as snakes usually consume whole prey. Energy consumption was calculated from the reference value available in the literature.

Results and Interpretation

Data pertaining to feed consumption and calculated energy intake (kcal) during a feeding cycle is presented in Table 3. From the perusals of the data it is evident that there was large variation among the zoos with respect to type, amount, and frequency of feeding.

Table 2: Wet mass, dry mass and energy density of food items fed to captive Indian python

Food item	Wet mass (g)	Dry mass (g)	Energy wet (kcal/g)	Energy density (kcal/g)	Reference
Rat	196	31.6	1.8	5.8	Cox and Secor, 2007
Chicken	-	32.5	-	5.9	Bird and Ho, 1976
Rabbit	+	28.9	-	5.06	Powers *et al*., 1989

+ Average body weight of rabbit at weaning 1 m, 2 m, 3 m, 4 m, 5 m and 6 m of age was 569, 1110, 1572, 1952, 2332 and 2586 g, respectively (Das *et al*., 2006).

Table 3: Feed consumptions and energy intake in captive Indian Pythons

Name of the Zoo	Prey consumed (kg/d)	DM consumed (g/d)	Duration of feeding cycle(d)	Energy consumed (kcal)
Delhi	2.2 ± 0.23	641± 39	7	3242 ± 198
Bhubaneswar	1.8 ± 0.18	596 ± 57	7	3518 ± 339
Itanagar	1.9 ± 0.14	624± 45	7	3683 ± 266
Ranchi	0.66 ± 0.08	216 ± 22	7	1272 ± 132
Hyderabad	0.68± 0.06	220± 17	7	1300 ± 103
Lucknow	3.2 ± 0.16	935± 45	25	4729 ± 229

Table 4: Energy budget in Python

Name of the Zoo	Energy consumed (kcal)	Fecal energy (kcal)	Urate energy (kcal)	SDA (kcal)	AMR (kcal)	SMR (kcal)
Delhi	3242	421	227	973	97	1524
Bhubaneswar	3518	457	246	1055	106	1654
Itanagar	3683	479	258	1105	110	1731
Ranchi	1272	165	89	382	38	598
Hyderabad	1300	169	91	390	39	611
Lucknow	4729	615	331	1419	15	2349

SDA, specific dynamic action; AMR, activity metabolic rate; SMR, standard metabolic rate

Energy requirement in pythons like other species of reptiles is related to metabolic body size. However, metabolic rate of pythons are very low. Cox and Secor (2007) reported that juvenile Burmese pythons fed at 10 d interval spent only 35.9 kcal/kg $BW^{0.75}$ for 10 days or 3.6 kcal/ kg $BW^{0.75}$/d. In this scale, a breedable python weighing 50 kg ($50xW^{0.75}$=18.8) would spent 474 kcal ME in 7 days as SMR. In this regard, all the 5 zoos which fed once a week supplied adequate energy to meet requirement. Similarly, for maintenance of python for 25 days 1692 kcal of energy would be spent as SMR. The diet of Lucknow zoo provided adequate energy to meet requirement. Minimum amount of food was offered in Ranchi and Hyderabad zoos. Energy supply was 26 and 29 % in excess of calculated SMR in Ranchi and Hyderabad zoo. However, if we have to consider that during breeding season (December to March) pythons do not consume any food. Brooding pythons also spent energy in form of non-shivering thermogenesis by which she can maintain clutch temperature above ambient temperature. Thus, conserved energy could be useful during those critical periods, but feeding of 2 kg of chicken every week would supply energy 27.3% in excess of calculated SMR, which may not be essential. Feeding schedule of Lucknow zoo supplied energy 39% in excess of calculated SMR. Considering the digestive physiology of pythons, adult pythons should be fed infrequently. They should be fed once in 2 or 3 weeks. If two week schedule is followed they may be fed chicken weighing 1.25-1.50 kg. If 3 weeks feeding schedule is followed chicken/rabbit weighing 2.0-2.25 kg may be fed.

Suggested guidelines for feeding:

1. Live animals that have been purchased for use as prey should be housed, fed and managed by maintaining highest ethical standards.
2. Sick animals cannot be fed to pythons. Prey animals should be thoroughly screened for parasitic diseases and other pathogens. It is not ethical to keep live prey in python cage beyond a reasonable time. Usually, if the python is hungry, it will grasp the prey within a few minutes.

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CHAPTER-4

Hand Rearing of Orphaned Neonates

4.0 Hand Rearing of Orphaned Neonates

Hand rearing of wild neonates is an extremely sensitive issue. Dam rearing is the best for the neonate. Mother's milk not only provides complete nutrition for proper development and growth, but also provides passive immunity which is very crucial for survival and for leading a healthy and long life. Besides, during the nursing process neonate develops strong bond with the mother that is crucial for learning ways of life without which the neonate may not reproduce successfully and even if reproduce may not be a good parent itself. Possible human imprint during the hand rearing process has devastating effects on normal physical, physiological and behavioual growth characteristics of a certain species. Yet, there are situations when hand rearing becomes only option to save the neonate. Serious illness or death of the dam, poor or no milk production by the dam and poor maternal instinct due to extreme stress forces the management to take decision for hand rearing. Extremely poor condition of the neonate, severe illness and congenital defects may also favour a decision towards hand rearing of the neonates. Number of individuals of some of the endangered species is extremely low. All our effort to save any possible offspring of such species should be made. Sometimes, a decision for hand rearing is taken on the ground where the enclosure is not fit for nursing. In such case, proper enclosure should be designed. Before separating the offspring from its dam, sufficient time should be provided to the mother to adjust. Offspring should not be separated just because the mother is not nursing during first few hours or even a day. Act of parturition is stressful to the dam. In no case, hand rearing should be practiced as a routine management tool.

Once a decision has been taken, following procedures may be followed:

1. Procurement: Items like utensils, bottles, nipples, beddings, linens, surrogate mother, toys, heating devices, formula, toiletry, serum/colostrums, fundamental medicines, vaccines, measuring tape and weighing balance should be procured.

2. Preparation of nursery: Nursery should be located in a well ventilated area from where the conspecifics can be heard, seen, and smelt. Nursery should be devoid of heavy furniture and should be designed in a manner that would permit easy cleaning. All staff working in the nursery should wear mask, apron and gloves. Temperature of the room should be suitably adjusted for the comfort of the neonate. There should be minimum human intervention in the nursery.

3. Medical check up: A thorough medical check up should be done. Body weight, sex, rectal temperature, body condition, clinical chemistry panel and hydration status should be recorded.

4. Cleaning and comforting the animal: Provide warmth to the animal, particularly during winter. If rectal temperature is not within the normal range, immediate attention should be made. Cleaning of the animal is also very important.

5. Colostrum feeding: Passive immunity is transferred from mother to the neonate through colostrums. It is very important that the neonate receive colostrums during the first 24 h of life. If the calf has not suckled colostrums during that period, its immunity will be seriously compromised and chance of survival greatly reduced. If possible, mother may be milked and colostrums fed to the neonate. Some management suggests administration of the serum of conspecifics other than the mother. Both these propositions are difficult to practice. Bovine colostrums could be a viable alternative. Such products are now commercially available.

6. Fluid therapy: First nutrition provided to a neonate is 5% dextrose solution. If the animal is suckling well, the formula is gradually introduced. Some animals may have poor suckling response. A few training sessions with patience, perseverance and determination will solve the problem.

7. Formula selection: A suitable formula similar to mother milk should be chosen. This issue will be discussed later in this chapter.

8. Amount and frequency of feeding: Factors governing the amount and frequency of feeding will be discussed in detail.

9. Weaning time: The process of weaning is species specific depending upon the body size, growth rate and lifespan of the species.

10. Nursing techniques: The practice of hand rearing is an art which requires scientific inputs, patience, and determination. Irrespective of species, all neonates require some training to suckle from bottle. Selecting of a proper nipple and hole size specific for a species is quite important. Improper hole size may cause milk aspiration. Positioning of the animal is also very important. Species specific positioning of animal during nursing has been detailed later in this manuscript. The temperature of the formula should be near to body temperature. Formula should be prepared in manner that it is not stored for more than 24 h.

11. Toileting: Many neonates may require stimulation for defaecation and urination. Rubbing the anogenital area with cotton wool soaked in warm water is suggested.

12. Clinical problems: Most commonly observed clinical condition during hand rearing is diarrhoea. Formula may either be diluted or withdrawn during the course of diarrhoea. While the animal is maintained on oral or parentral fluid therapy, depending upon the severity of the case. If the condition is corrected then formula may be gradually reintroduced. Persistent diarrhoea would require thorough pathological screening and fluid therapy. Antibiotic should be administered only after the culture test.

13. Data recording: Keep record of all data including date of birth, ISIS identification number, sex, pedigree, TRP, clinical chemistry parameters, amount of formula consumed, type of formula used, strength of formula, frequency of feeding, days on which solid food was introduced, amount of solid food eaten, weekly change in body weight, body measurements, locomotive changes (when started standing, walking, running etc), when eye and ear was opened, and behavioural changes (when first frightened by stranger, when first started playing etc). Data pertaining to food consumption and faecal output may be recorded on daily basis. Body weight may also be taken daily.

Choosing a right formula

Ideally a formula similar in composition to mother milk would be best suited for hand rearing a neonate. Milk composition of different species of wildlife has been compiled by Shad (1963), Oftedal (1984), Hinde (2007), and Meller (1986). Milk composition of some of the common wildlife species is presented in Table 1.

From the data presented in Table 1, it is evident that there is difference in milk composition among different species. Cow or goat milk based formula may not be suitable for hand rearing of those species whose milk composition is completely different from cow or goat milk. Further complication arises due to difference in amino acid and fatty acid make up of milk. Elephant milk contains 2 times higher fat than the cow milk. Even then elephant calf cannot tolerate cow milk because the droplet size of elephant milk fat is much smaller than that of cow milk. Further, predominant (32%) fatty acid in elephant milk is capric and lauric acid, whereas, cow milk contain only 5% of these fatty acids. Most predominant fatty acids in cow milk are palmitic and stearic acid. Milk of carnivorous species contain very low amount of lactose. When formula containing high amount of lactose are fed, they develop diarrhea (Robbins, 1983).

Table 1: Composition of milk of different species

Species	Total solids (%)	Fat (%)	Protein (%)	Lactose (%)	References
Black buck	-	9.3	6.9	4.3	Dill *et al*., 1972
Chinkara	36.1	19.0	12.4	3.3	Shad., 1962
Roe dear	21.5	8.5	7.1	4.5	Robbins, 1983
Caribou	31.8	16.9	9..7	2.6	Cook *et al*., 1970a
Moose	24.9	3.9-10.5	12.3-16.4	0.56-0.65	Park, 2006
Giraffe	14.5	4.8	4.0	4.9	Robbins, 1983
Black tailed deer	25.0	10.4	8.7	4.4	Park, 2006
Zebra	10.-12	1-2	1.6-1.8	6.7	Oftedal and Jennes,1988
Indian Rhino	9.64-9.92	1.37-1.44	1.3-1.5	7.2-7.8	Nath *et al*., 2004
Asian Elephant	17.7	7.3	3.4	4.8	Oftedal, 1984
Slow loris	16.3	7.0	3.9	6.6	Oftedal and Iverson,1995
Rhesus monkey	15.2	5.4	1.8	7.5	Hinde, 2007
Chimpanzee	11.9	3.7	1.2	7.0	Shad, 1963
Wolf	23.4	9.6	9.2	3.4	Meller, 1986
Jackal	24.7	10.5	10.0	3.0	Meller, 1986
Polar bear	46.7	32.0	14.7	0.62	Cook *et al.*, 1970b
Sun bear	27.2	10.8	8.4	3.2	Meller, 1986
Lion	16.7-19.2	11.3-13.4	6.0-8.5	0.27	De Waal *et al*., 2004
Cheetah	23.7	9.5	9.4	3.5	Grant, 2005

When rabbit milk was fed to rabbit kids, a soft protein coagulum, which is easily digestible is formed in the stomach. However, when cow milk is fed, a hard coagulum is formed which is not digestible. Thus, cow milk can not be used for hand rearing of lagomorphs. In spite of these differences, there are many instances when cow, buffalo or goat milk based formula had been used for hand rearing of carnivores whose milk is completely different in make up (Mahodaya, 1990; Saha *et al*., Suklikar *et al*., 1991; Arora, 2001; Dhoot *et al*., 2000). However, to obtain best response, neonates should be fed formula which is similar in composition to their mother milk (Robbins, 1983, Grant, 2005; Emanuelson and Kinzley, 2002; Dierrenfeld, 1996; Rodden, 1995, Gage, 2002).

Now that proximate composition of milk of many different species of wild animals is known and most of the ingredients are commercially available in pure form, it is possible to make many different kinds of required formula. However, balancing all the nutrients including fatty acids and amino acids would not be an easy task. Commercial formula suitable for different species of zoo animals is now available. Kitten Milk Replacer (KMR) and Esbilac (Pet Ag, Inc.) are the 2 most widely used formula for hand rearing of neonatal carnivores in USA. Esbilac is suitable for canids, procyonids, mustelids, viverrids and hyaenid. Both these formulas have been used for large felids, some zoo preferring KMR, while others using Esbilac. In 1993, Borden has changed the composition of both the formula; coconut oil fat was replaced with butter fat. However, most zoos found that the news products are not easily miscible and left behind a greasy film on suckling bottle and utensils making them difficult to clean. Since then, the manufacture have launched new products e.g. Zoological Milk Matrix 33/44 which is similar to original Esbilac (without butterfat) and Zoologic Milk Matrix 42/25, which is similar to original KMR (without butter fat).

Amount and frequency of feeding

The amount of formula intake is influenced by body mass, growth rate, nutrient requirements, efficiency of utilization and gut capacity. Feeding in excess of requirement can cause diarrhoea, whereas, underfeeding will cause delayed growth. It is, thus, obvious that neonates should be fed in correct amount. Basal Metabolic Rate (BMR) or Basal Energy Requirement (BER) is the amount of energy required by an animal to maintain body mass at post absorptive stage in thermoneutral zone. This is expressed as

BER (Kcal/day) = 70 $BW^{0.75}$ (BW is the weight of animal in kg)

Because infants are metabolically more active and require more energy to support optimum growth, BER is multiplied by 3-4 times to calculate their daily calorie requirement. We will consider the hypothetical case of a cub weighing 1.8 kg.

BER (kcal/d) = 70x $1.8^{(0.75)}$ = 70x1.55= 108.8.

The calorie requirement of the cub can then be calculated as 108.8x4 =435.1kcal/d. Stomach capacity of placental neonates ranges from 5-7% (Grant, 2005), so the gut capacity of the said cub would be 90 ml.

Now, we have to know the calorie content of the formula. This could be easily calculated from the nutrient facts provided by the Manufacturer and the dilution factor used. If a reconstituted formula is having 1.3 kcal/ml, the cub will require 435.1/1.3 = 334.7 ml of formula. But the maximum gut capacity of the cub is 90 ml. So, at least 3.8 (say 4) feedings per day will be required. It is always better not to feed at full gut capacity. Increase the number of feeding instead. It is important to note that during initial phase of hand rearing, the full strength formula is not fed to avoid diarrhoea. Hence, the number of actual feedings should be higher.

At least some Information on milk intake by dam reared neonates is now available (Robbins, 1983: Reik, 2011). Such information could be useful for deciding the amount of milk to be fed. A recent report outlines milk intake and average daily gain of different species of wildlife (Reik, 2011). Based upon the data, proportional average daily gain and milk intake of some of the species were calculated and presented in Table 2. The author further suggested that milk consumption (g/day) can be calculated by using the following formula:

All mammals	$0.299\ BW^{0.881}$
Artiodactylids	$0.123\ BW^{1.012}$
Carnivores	$0.684\ BW^{0.75}$
BW= body weight in grams	

Table 2: Average daily gain (ADG) and milk intake (% body weight) by mammals at peak lactation

Species	ADG (%BW)	Milk intake (%BW)
Sus scrofa	4.26	16.4
Oryx orientalis	2.40	16.1
Bos taurus	1.62	15.3
Capra hircus	2.00	19.4
Capra ibex	1.55	9.5
Cervus elaphus	2.09	10.8
Canis lupus	3.08	14.6
Ursus americana	0.88	2.2

Hand rearing of carnivores

Hand rearing of wild carnivore is an art which require scientific inputs. It is one of the most controversial issues in the captive management of wildlife. Ideally neonates are best nursed by their mother. Yet there are situation when animals are to be hand reared. Hand reared animals typically have a lower growth rate than maternally-raised cub. Cubs receive maternal antibodies in-utero before birth, in colostrum and in milk. Thus, it is obvious that hand reared cubs would receive much lesser passive immunity than those are maternally raised. Generally, the cubs forced for hand–rearing are immunologically and nutritionally compromised from the beginning. Our knowledge of lactation physiology of wild carnivore is very limited. Many zoological institutions use cow milk to feed orphaned neonates. Some other may use a formula targeted for dogs to felids. But vast majority of scientific research and most zoos in the West use Kitten Milk Replacer (Pet Ag) for hand rearing of wild felids. London Zoo uses Cimicat (Hoeschst). Nutrient composition of KMR is similar to the milk of domestic and other wild cats. However, recent research indicates that composition of milk in different felines is not the same (Osthoff *et al.,* 2006).

A targeted average daily gain may vary depending upon the species. On an average, cubs should grow @ 5% of body weight on formula and 10% of body weight during the weaning phase (Hedberg, 1993). Weaker cubs may not consume the target volume of formula at each feeding. Hence, they need more diluted formula which may be fed at more frequent interval. Saying so, it is acknowledged that feeding interval of less than 3 h may not be required and could be even more stressful. By the end of the first week, the cubs should be able to consume full strength formula.

Tiger

As a general rule, hand rearing of tiger cubs should be discouraged. Only in exceptional cases when mother is dead, aggressive, agalactic, or severely ill, hand rearing should be chosen as an option. Often zoos receive orphaned cubs from the National Parks whose mother have been killed or lost. In such cases also cubs are to be hand reared.

Strict hygienic measures are to be followed in the nursery. There should be foot bath with disinfectant at entry point. Staff engaged in hand rearing should wear gown, gloves and masks. Such personnel should not have come in contact with domestic or other zoo animals during the entire period of hand rearing. The nursery area should be designed in a manner that easy cleaning and disinfection is facilitated. Heavy furniture and immovable thing should not be kept near the nursery area. All utensils, nipples, feeding bottles etc. should be washed properly in boiling water. All the linens used by the cubs should be washed daily.

The most suitable temperature for tiger cub is 29-32ºC. If the temperature is below 18ºC, they may shiver. The humidity range in the nursery should be 50-60%. A cozy nest box would be appreciated by the cubs. If the cubs are less than 1 month of age, some arrangement of room heating could be made.

Mother's milk is the best food for any infant and tigers are not exception. However, the information available on the composition of milk of the feline is limited to that of domestic cat (Jacobson *et al*., 2004), lion (Green 1991; de Waal *et al*., 2004), and cheetah (Osthoff *et al*., 2006). Fat content of cheetah milk (64.8 g/kg) was much lower than that of domestic cat (108-127 g/kg) and African lion (113-189 g/kg). Lactose content of these three cat's milk was similar. These studies do indicate that inter-species variations in composition of milk do exist. However, till such time the composition of tiger milk is precisely known, a hand rearing formula similar in composition to cat's milk should be used for hand rearing of tiger cubs. Commercial milk formula such as kitten milk replacer (KMR) is very similar in composition to cat's milk. KMR has been widely used in successful hand-rearing of orphaned felines. Many Indian zoos have reared orphaned felines by feeding cow's milk (Mahodaya, 1990; Saha *et al*., 1992; Suhlikar *et al*., 1991; Dhoot *et al*., 2000). Scott (1977) suggested that milk formula for hand rearing of tiger cubs should contain 20% total solids of which 44, 25, 26 and 7% should be crude protein, fat, carbohydrate and ash, respectively. It was further suggested that a mixture of 20 g skim milk powder dissolved in 90 ml warm water to which 10 ml of corn oil or 30 g of egg yolk has been added, should be suitable for hand-rearing of orphaned felines (Bush *et al*.,1987). As a thumb rule, sugar should be avoided as the felines have limitted capacity to utilize high glucose load. The formula preference should be influenced by several factors including the genetic importance of the cub and cost involved in the procurement of imported formula. Irrespective of the formula chosen; basal metabolic rates in cubs are much higher than the conspecific adult. To fulfill the active demand of nutrients for growth, cubs must get proper nutrition. A young cub at 1week of age will be requiring 380 kcal of energy/kg BW. At weaning they will require 250 kcal/kg BW (Miller and Allison, 1958).

Before actually starting the formula feeding, measure accurate body weight of the cub. As a thumb rule, cubs should be fed 25% of BW. Keep record of body weight change, actual amount of feed consumed, consistency of faeces and general body condition of the cub. Body weight should be recorded daily at an exact time. If there is no weight gain for 48 consecutive hours, the issue must be addressed with utmost care.

On receiving the cub at nursery, initially provide it with 5% dextrose solutions. In the meantime suckling reflex of the cub can be tested by spreading dextrose solution in finger and inserting it into cub's mouth. Cubs are vulnerable to formula aspiration. The speed of bottle feeding, kind of nipples etc. should be decided by studying the suckling reflex.

If the KMR or any other powdered formula is used, reconstitute it with sterile warm water to contain 6% total solids initially, which may be gradually increased to 18%. About 2 ml of lactase enzyme and Lactobacillus probiotic may be added to the formula. At a time, the amount of formula to be reconstituted should not exceed the requirement of 24 h, which may be stored in a refrigerator. However, it is to be remembered that, the formula should be warm during feeding. The following feeding schedule may be followed:

Table 3: Feeding schedule for hand reared tiger cubs

Age (Weeks)	Number of feedings	Amount/feeding (ml)
0-1	8	50-60
1-3	7	115-140
3-4	6	140-150
4-6	5	150-175
6-8	4	175-150
9	3	125
10	2	100
11	1	100
12	-	Weaning completed

Exclusive bottle feeding should be encouraged till 6 week of age. At 6-8 weeks of age, they should be shifted to bowl feeding. Minced meat should be introduced to the cubs at an age of 6-8 weeks. Initially, meat should be fed by mixing with milk till such time the cubs readily eat minced meat alone. At 12 weeks of age, chunk meat should be introduced. Initially, give 3 meat meals of 100 g each upto 16 weeks of age. Beyond 16 weeks, 2 meals are sufficient and amount of food may be gradually increased. There should not be any off day for the cubs till they are 2 years of age. The minced and chunk meat should be supplemented with Ca and multi-mineral vitamin supplement. If KMR is not used, we would also suggest supplementing the milk formula with taurine. Give 250mg tab/ cub/ day.

Some practical points

During bottle feeding, the cub may be positioned on sternal recumbency. The foreleg should be freely movable. Do not haste while feeding. One should have considerable amount of patience. The basic principle is to reduce the gas intake as far as possible. If reared with other cubs, each individual should have their own bottle, nipples and other accessories. Special requirement (hard/soft/medium nipple and many other similar things) of each cub should be taken care of. The night feeding hours are difficult for management, but essential for normal growth of the cub. The digestive system of cubs would not permit fewer and bigger meals.

When the cubs are able to suck dextrose without coughing, it is the time to introduce the milk formula. Initially the concentration of total solid is 6%, then it could be increased to 9, 12, 15 and finally to 18% by 4-6 weeks of age. Iron deficiency is not uncommon in tiger cubs. It would be desirable to supplement the formula with iron.

The cub should be stimulated to urinate and defaecate after each meal by rubbing the ano-genital area with cotton wool soaked in warm water. The normal stool should be tooth paste like consistency and mustard in colour, any deviation would indicate diarrhoea or other health problem. A stool culture is recommended before antibiotic therapy. If diarrhoea is severe, all formula feeding should be stopped for 12-18 hours while supporting the cub with oral/ subcutaneous fluid therapy depending upon the severity of the case. After this correction, feed oral electrolyte and restore normal feeding in next 12-24 h.

Another major problem observed at 6-8 weeks of age is hair loss. Feeding of liver homogenate would be helpful to correct such condition and prevent alopecia. Fel-O-Vex should be administered at 10-12 weeks, 16 weeks, six months and one year of age.

Leopard Cat

Birth weight of leopard cat kitten ranges from 75 to 130 g. Their growth rate is quite fast, by 2 weeks they double their body mass and by 5 weeks they are 4 times heavier than their birth weight. To maintain this steady growth rate, proper nutrition is required. As has been already discussed in case of larger cats, the decision of hand rearing depends on various factors. Hand rearing is always adopted as the last measure. Environmental stress, illness and agalactia are some of the reasons behind maternal rejection. It is believed that if a single kitten is born in a litter, it may not provide sufficient stimulus for the mother to secrete milk. The basic goal of the hand rearing programme should be nursing of kitten in a manner that the kittens can normally interact with the conspecifics after nursing. It is once again emphatically mentioned that Small Felid TAG does not recommend hand rearing of any of the small felids.

Leopard cat kitten can be housed in small under seat transport carrier. Sheep skin and flannel blanket could be used as bedding. A bottle with small nipple should be used. The hole should be small and at the centre of the bottle. Neonate kittens are not able to maintain their body temperature. So before starting formula feeding, their body should be provided with warmth. Give warm electrolyte orally. Par-rectal administration of warm water is also suggested. The most comfortable temperature range for leopard cat is 85-90ºF. The animal's response to the ambient temperature could be closely monitored. If burrowed deeply and curled up tightly then the kitten is supposed to be in hypothermia. Comfortably stretched limbs with good suckling reflex indicate normothermia. Fully stretched limb with signs of panting would indicate hyperthermia. Beddings and towels could be sewn in tubular form to mimic mother's arm on which the kitten will sleep. The general principle of record keeping and food hygiene mentioned for larger cat will also be applicable to leopard cat. Colostrum is produced by lactating queens during first 24 h post-partum. Large amount of immunoglobulin is transferred through placenta in felids.

First give 5% dextrose orally for 2 feedings, and then start formula feeding. The KMR has been most widely used for hand rearing of felids. Yet other formula has also been used successfully. Edwards and Howes (1997) have reported that in San Diego zoo, KMR is preferred. Among the commercially available formula, KMR is very similar is composition of cat milk. It also contains higher protein (Table 4) and is enriched with taurine. Blindness due to taurine deficiency has been reported in leopard cat (Howard *et al.* 1987). Addition of lactase enzyme could be helpful to prevent lactose intolerance and could reduce occurrence of non-specified diarrhea (Edward and Howes, 1997).

Table 4: Nutrient composition of Kitten Milk Replacer (Pt Ag, Inc.)

Nutrient	KMR		KMR Powder	
	AFB	DMB	AFB	DMB
Moisture	81.7	0	2.70	0
GE(kcal/g)	0.92	5.03	5.12	5.26
CP (%)	7.70	42.08	43.00	44.19
Fat (%)	4.68	25.57	29.51	30.33
Carbohydrates	4.74	25.90	18.44	18.95
Ca (%)	0.19	1.04	1.01	1.04
P (%)	0.16	0.87	0.89	0.91

(Edwards M.S. and Howes J. 1997) AFB, as fed basis; DMB, dry matter basis

During first 2 days, the formula is reconstituted to have 9.2% total solids. By day 3, the total solid concentration of the formula could be increased to 18%. Targeted formula intake should be 20% of body weight. The number of feedings on day 1 should be 10. Then it should be gradually decreased as per the schedule given below:

Age in days	0-1	3	4	7	19	44	48	58	70
No of feedings	10	9	7	6	5	4	3	2	1

The lactation period of domestic cats is 6 weeks (Loveridge, 1986). Transition of milk to solid food should be started at that stage. After 42 days, bottle feeding is stopped. Formula may be fed on bowl. The minced meat is introduced to the kitten. Minced meat should be mixed with milk. Gradually, the amount of milk is reduced, by 12 weeks of age they are solely fed on meat diet. Meat diet could be supplemented with Ca, multimineral and multivitamin supplements.

Snow Leopard

Frueh (1968) reported that birth weight of snow leopard cubs ranged from 368-708 g. Eyes are generally opened at 6-8 days after birth. First tooth was erupted after 17-22 days of birth. The growth rate of snow leopard cub is more of less similar to that of common leopard (Brunstein, 1978). During first week they gain about 200 g. Till 16-20 weeks they grow @ 400-600 g/week. Then the growth picks up and by six month of age they would weigh around 14 kg.

Since snow leopards are cold weather cats, hand rearing process is slightly more difficult than other cats. Their body is covered with thick fur and they are more susceptible to air borne diseases than other felids. Hence, more strict hygienic measures are to be followed in the nursery. A temperature range of 21-23ºC is more comfortable to snow leopard cubs (Brunstein, 1978). The bedding materials needs to be changed more frequently as snow leopard cubs are known to excrete larger amount of urine. Most commonly observed disease conditions included diarrhoea, eye infection and feline enteritis. Snow leopard cubs may lose body hair in nursery condition due to hotter environment inside nursery. Baby oil may be rubbed once or twice daily to prevent skin dryness and to promote growth of new hair follicles. Code of hygiene measures and principles of hand rearing would be similar to other felids and would be applicable to snow leopard as well.

During the first day, they should be given only 5% dextrose solution. During days 2-10, they are fed seven times in a day and are fed at 2 h intervals at 8 00, 10 00, 12 00, 14 00, 16 30, 22 00 and 5 00 h. During days 11-35, they are fed at 3 h intervals at 8 00, 11 00, 14 00, 16 30, 22 00 and 5 00 h. From day 35 onward, cubs are fed 3 times at 8 00, 12 00 and 16 30 h and night feedings are discontinued. During the same time, minced meat may be introduced to the cubs. Then the bottle feeding is stopped and cubs are offered formula on a bowl. Only one meal of formula (250 ml) is fed at 3 PM. Amount of minced meat is gradually increased to 500 g which is divided into 2 meals at 9.00 and 15.00 h. This is continued till the cubs are 3-4 m of age. By 7 months, the cubs should be able to consume 750 g of minced meat.

Clouded leopard

Clouded leopards are secretive animal. Some females could be unwilling to nurse their kittens and are aggressive to them. In such situations, hand rearing becomes only available option to the manager. Proper record of rectal temperature, kitten weight, average daily gain, formula compositions, amount eaten and general health condition, faecal score etc. should be maintained throughout the rearing period. If possible a companion animal (a domestic or other species of kitten) should be reared with clouded leopard kitten. By 4-5 weeks of age, the kittens are quite active. They should be provided with ample space to learn climbing and leaping.

Normal body temperature of kitten should range between 96-99ºF. Any deviation should be immediately attended by the resident veterinarian. Desirable room temperature is 90ºF which can be decreased gradually as the kittens continue to grow. Before starting the hand rearing, it is of paramount importance to record the body weight. The KMR is the formula of choice. During first week, 8 g of formula is mixed with 92 ml of water. The concentration of formula may be increased gradually and by 7th day, concentration of KMR in the reconstituted formula should be 15%. Addition of lactase enzyme preparation and Lactobacillus would be beneficial.

Table 5: Feeding schedule for hand reared clouded leopard cub

Age	Formula fed (% BW)	Concentration of formula at the end of period (%)	Number of feeding
1-7	25	15	8
8-21	23-25	18	7
22-35	20-23	21	6
36-60	20	22	5

Eliminate bottle feeding during days 36-60 and feed formula/ meat mixture in a pan. From 60 days onwards gradually eliminate formula. By 90 days, kitten could be weaned and fed solely on solid food.

Wild Canids

Tibetan Wolf

Tibetan wolf will whelp in its den. A pup generally comes out of den after 5-6 weeks. During cold months, some heating arrangement of whelping area may be done. The female wolves are known to carry their pups from one place to another place on a regular basis. As the whelping time is approached, provide number of shelter box in the den on different locations. As a precautionary measure, the portion of the zoo may be closed to public. The human interference could be restricted to minimum. Only the keeper (who is known to them) should approach the enclosure. Even males may be separated from the pack as a precautionary measure. After parturition, please observe if the dam is restless, persistently carrying up the pups, licking and mouthing pups or lying apart from the pups. If any of such behaviour is observed, preparation for segregation of the pups from the mother should be initiated. Never remove any of the pups, till all pups of the litter are born.

After receiving the pups at nursery, data regarding sex, body weight, rectal temperature and general body condition must be recorded. Give them warmth if the body temperature is low. First nutrition is provided through 5% dextrose orally. Some amount of immunity is transferred through placenta; however, such immunity is short lived. Majority of immunoglobulin are transferred through colostrums. To get effective immunity pups must suckle colostrums within 24 hours of birth. If the pups have not suckled colostrums, bovine colostrums may be fed. Serum may be procured/ stored as a preparatory step of whelping.

Wolf milk contains 23.4% total solids, 9.2% protein, 9.6% fat and 3.4% sugar, which is very similar to dog milk in composition. Esbilac (Pet Ag) is the most widely used formula for hand rearing of wild canids. A home made formula comprising of 700 ml of cow milk, 200 ml of cream, 50 g of egg yolk and 50 ml of rice gruel have been found satisfactory to raise pups (Sharma *et al.,* 1993). If the dry powdered form of formula is used on day first, it should be reconstituted to concentration of 8%. The concentration of the formula can be increased (2% every day) gradually so that by 5-7 days, the concentration of formula is 20%. If the liquid formula is used on day 1, dilute it with sterile water to have similar connotation. Targeted volume of formula is 20-25% of body weight. Weigh the pups at exactly same hour every day. During first week, the feeding interval should be 3 h. Then the interval is gradually reduced to 4 feeding at the end of 5th week. Human primmie nipple is suitable for smaller pups. As the pups grow, hole size may be increased. Solid food is first introduced at 20 days of age. Weaning process could be started at 4 weeks of age. Initially spread some formula on the minced meat. As the pups start eating meat, stop the formula. The process should be completed by 7 weeks. All minced meat should be supplemented with Ca and other mineral-vitamin supplement.

Like felids, they may also be stimulated to urine and defecate after each meal. Formula should be either diluted or withdrawn in the eventualityy of diarrhoea. All records regarding formula used, dilution made, amount of formula consumed, nipple size and number of feedings should be kept. Data regarding weekly body weight, days on which eyes and ears are opened, age and description of change in pelage, pattern of tooth eruption, locomotive behaviour (when first standing, walking running etc.) and other instinctive behaviour (when first frightened by strangers, playing with litter mates, fighting etc.) should be properly recorded and maintained.

Primates

Hand rearing is sometimes necessary due to maternal neglect due to inadequate milk production, illness and stress. However, it should not be practiced as routine. Basic goal of any hand rearing programme is to reintroduce the baby at an earliest time (Sachet *et al*., 2006). Once a decision on hand rearing has been taken, the baby should be taken to a cage with some kind of surrogate mother. It should be soft in touch and if possible move slowly. Regular checking of the baby is required. All data pertaining to body temperature, general condition, food consumed, faeces output and behavioral activities should be recorded.

After removal from mother the baby should be bathed with warm water and dried thoroughly. After this, the baby may be given 1-2 ml of glucose solution. If the baby is very weak it may require second glucose feed after 1.5 hour. Liquid infant formula is suitable for hand rearing of primates. Gogoi (2006) has successfully hand reared Stump-tailed macaque baby by using "Amul Taaza" infant formula. During first 2 days, formula was diluted to 25% by adding sterile water. From 3rd day onward, straight formula was used without any dilution. Total amount fed was 20 ml during first week which was gradually increased to 70 ml/day by 9th week. The feeding interval was 1 hour during first week, which was reduced to 1.5 h during 2nd week. During week 5-8, they were fed at 2.5 hourly intervals. Finally, the feeding interval was increased to 3 h during 9 to 12th weeks. Solid food like fruits and vegetables were introduced at 4-6 weeks of age. Alternately, milk formula can be made by dissolving 52 g of synthetic baby milk powder and 21 g of lactose in 300 ml sterile water. This formula will provide 1 kcal/ ml. The formula should be made fresh daily and stored in refrigerator. However, formula should be warmed to body temperature before feeding. A few drops of mineral vitamin supplement may be added to the formula. A 5 ml syringe with rubber tip can be used for feeding the baby. Enormous amount of patience is necessary while feeding macaque babies. If forced feeding is done in haste, milk aspiration may take place. By the second day, a baby will be able to consume 5-15 ml of formula. During first week feeding are increased gradually to 60 ml in 3 feedings.

Asian Elephant

Under normal circumstances, hand rearing is not advisable. However, mother may sometimes reject the calf due to stress, illness or less milk production. Every year, a lot of calves are rescued from the wild that have lost their mother due to several reasons. Such calves are fit for hand rearing. Birth weight of Asiatic elephant ranges from 90-110 kg. They are dependent on milk upto 2 years of age and often suckle till the age of 4 or 5. The Asian elephant cows milk contain 17.7% total solids, 7.5% fat, 4.5% protein and 5.2% sugar (Oftedal 1984). In another study, it was reported that Asian elephant milk contain 19.7% total solids, 7.6% fat, 3.4% protein and 8.7% sugar (Mainka *et al.*, 1994).

Nursery should be located on place from where the calf can smell, hear and see other elephants. Once a calf is brought to the nursery, a thorough check-up should be done. If the body temperature is less than 95ºF, immediate effort should be made to provide warmth to the calf either by room heating, wrapping a blanket over the body or combination of both. Disinfection of the navel with Betadine is strongly recommended. A blood sample should be taken and subjected to laboratory analysis for clinical chemistry parameters to rule out any disease or metabolic disorders.

Colostrums feeding is very very important. If the calf has been rejected within 24 hours of birth and have not suckled colostrum, severe immune-compromise would happen. Every effort should be made to feed colostrum. Several methods like milking of cows and feeding colostrums to the calf, oral administration of serum immunoglobulin from other cow, feeding of colostrums from bank and feeding of bovine colostrums have been tried (Emanuelson and Kinzley, 2002). All these propositions are difficult to practice. Nevertheless, all possible efforts should be made so that the calf receives requisite passive immunity and feeding of bovine colostrums would probably the best option.

A right kind of formula is to be chosen for successful hand rearing. Bovine milk contains fatty acids which are longer in chain length. Elephant milk contains several shorter chain fatty acids which are similar to coconut. In most of the American zoos, human infant formula (Grober, Inc.) is used for hand rearing of Asiatic elephant (Emanuelson and Kinzley, 2002). Other milk formula which has been used most widely and successfully is Enfamil. Enfamil contains 12.5% total solids, 1.5% protein, 3.7% fat and 7.0% sugar. Other infant formula like lactogen can also be used, but should be diluted suitably so as to have similar composition like Enfamil. A calf weighing 100 kg would require 6000-8000 kcal/day. A calf would require 9-12 l of formula to fulfill this requirement.

Initially, they may find it difficult to suckle from the bottle. Bovine nursing bottle with nipple attached to it, would be adequate for elephant calf. They may be trained to raise the trunk and rest it either on shoulder or around the arm of the Keeper. They quickly develop strong bond with the keeper and soon start demanding food from the Keeper. They may be safely fed on demand because chance of getting overfed is rare. The targeted daily gain ranges from 0.5 to 1.4 kg with an overage of 0.90 kg (Emanuelson and Kienzle, 2002). Initially they should be fed at 2 hourly intervals till 3 months of age. Then gradually, they are shifted to a schedule of 3 hourly intervals. By nine months, only 4 feedings in a day is required. Solid foods are introduced at 4-6 month of age. A spoonful of rolled barley, oat and shredded coconut is added to formula during each feeding. Then the amount of cereals and coconut is increased gradually to an amount that the formula is more or less porridge like in consistency. By 15-18 months of age, the weaning process is complete. However, bottle feeding of water may be continued till 5 years of age to mimic natural feeding behaviour. Green fodder should be introduced as early as possible. The keeper should encourage the calf to eat green grasses.

Some practical tips for successful hand rearing

1. If diarrhoea is observed dilute the formula. Continue diluted formula for a couple of days. If the condition is corrected, gradually revert back to original formula. Consistent diarrhea should be attended with utmost care. Fluid therapy is recommended in such situation. Culture test should be done before antibiotic therapy is commenced.

2. During constipation, rubbing hind quarter with warm cotton wool is suggested. Enema can also be tried.
3. Tetanus toxoid may be administered (1 ml, I/M) at 3 months of age, followed by second dose at 4 months of age.
4. Provide sufficient exercise to the calf. The Keeper can take them for walk.
5. Interaction with other elephant is very very important. There should be some sessions, during which the calf could interact with other elephants of the collection.
6. Whenever possible, hand rearing should be done with a companion preferably of same species. If companion animal is not available, they should never be left alone, somebody should be there with the calf at all times.

Table 6: Expected consumption of formula (l/day) by Asian Elephant calf

First phase (upto 4th week)					
1st	**2nd**	**3rd**	**4th**		
9.0-19.3	15.8-20.9	19.8-23.8	21.2-21.6		
Second phase (upto 6 months)					
1st	**2nd**	**3rd**	**4th**	**5th**	**6th**
9.0-23.8	21.6-32.4	19.6-36.0	21.7-43.2	26.1-52.2	24.7-55.8
Third phase upto 11 months					
7th	**8th**	**9th**	**10th**	**11th**	
19.6-44.2	22.9-46.5	27.0-51.3	19.0-50.9	22.8-55.4	

Indian Rhinoceros

In their home tract, Indian rhinoceros face severe flood every year during which calves got separated from their mothers. Such calves are sent to the rescue centres and need to be hand reared. In zoos, rhinoceros cow may reject her calf due to stress, severe illness or inability to produce sufficient quantity of milk to nurse. Sometimes, the calf is very weak and ill which require immediate veterinary care. In any case, the basic goal of hand rearing is to reintroduce the calf to the mother as early as possible. If the mother is dead, then hand rearing remains the last available option.

The birth weight of Indian rhinoceros is about 58 kg. Height, girth and length were reported to be 66, 77 and 105 cm, respectively (Nath *et al.,* 1993). The lactation length is 20 months. The calf suckle its mother during every 15 to 20 min. Maximum nursing interval was 1 hour. Rhino milk is ivory white in colour and is aromatic in nature. Concentration of total solids, lactose, protein and fat ranged from 9.64-9.92, 7.21-7.80, 1.37-1.44 and 1.30 to 1.50%, respectively. Oftedal (1984) reported that rhinoceros milk contained 8.8% total solids, 1.4% protein, 0.4% fat and 6.6% sugar.

Before the hand rearing is started, accurate body weight of the calf should be taken. Then take record of rectal temperature. If the temperature is below 96ºF it is a matter of concern. Any deviation should be attended clinically. Take a blood sample and get the clinical chemistry parameters analyzed.

Feeding of colostrums is very important. If the calf has not suckled colostrums, bovine colostrum may be administered orally. Commercial preparations of bovine colostrums are now a day's available in market (Colostx, Protein Technology, INC).

The calf should be reared in a clean hygienic place where strict code of hygiene and sanitation is to be followed.

From the chemical composition data, it is evident that rhinoceros milk is more diluted than the milk of other herbivores. In San Diego Zoo, 3 different formula; early, mid and late lactation formula are used. Early, mid and late lactation formula consists of no-fat cow milk; skim milk, lactose and water in a ratio of 27:9:1:1, 27:9:1:2-3, 27:9:1:3-4 and 27:9:1:6-8, respectively. Alternatively, a formula comprising of 9 parts water, 9 parts skim milk and 1 part syrup can also be used. This formula would provide 8.3% total solids, 1.7% protein, 0.2% fat and 6.6% sugar, which is very similar to rhino-milk in composition (Blakeslee and Zuba, 2002).

The amount of formula to be fed should be determined on the basis of body weight. Targeted formula consumption would be 10-13% of body weight. Initially start with 10% of body weight. On day 1, only cow colostrum without any formula should be fed. A combination of cow colostrum and formula (1:1) should be fed for next 24 h. Continue feeding formula with addition of 10% colostrum till the calf is one month old. Start the rearing protocol with 7 feedings during the first month. Then the number of feedings can be gradually reduced to 5, 4, 3 and 2 feedings by 3, 5, 6, 9, 12 and 16 months of age, respectively. In a singular feeding never feed more than 3% of body weight.

If the calf has not suckled its mother, it will readily accept the nipple. However, if it has already suckled mother it may initially refuse to suckle from nipple. In such situation the calf is to be restrained. Keeper may kneel down facing the same direction. Put its head under your arm and insert the nipple into mouth of the calf. The calf will quickly pick up to suckle. The temperature of the formula should be 37ºC. A cross-cut, 0.6 cm in each direction hole is preferred. If there is coughing, nasal congestion and oozing of milk from the nose then the hole size is too large. If the calf is suckling cozily and small amount of milk is dribbling from the side of the mouth, hole size normal. If the calf is tired during suckling, the hole size is too small. If there is intermittent feeding than either the formula is wrong or milk temperature is not correct.

Solid food items may be introduced at 2-4 week of age. Encourage the calf to eat solid food. Different favoured items like banana, carrot, grain, pulses and molasses may be kept in separate bowls to know the favourite items of the calf, once that is known they should be provided and encouraged to eat these items. Good quality green fodder must also be provided. Rhino calf may be initially reluctant to eat solid food. These items may be fed directly by hand to mouth after each bottle feeding. At 4 months of age, the food items like jaggery and other high energy feed may be replaced with their normal adult food. They should be consuming considerable amount of green fodder, while till continued on formula feeding. The weaning should takes place at 15 months when bottle feeding is completely stopped. The common medical problems occurred during hand rearing are diarrhoea, constipation, hypothermia, hypoglycemia, dehydration and umbilical infection. The general preventive measures suggested to tackle these conditions in elephant should also be applicable to rhinoceros.

Spotted Deer

Birth weight of male fawn ranges from 1.8 to 4.0 kg with an average of 3 kg, whereas, birth weight of female fawn ranges from 1.5 to 3.2 kg with an average of 2.5 kg. Average weaning age is 5 months; however, suckling frequency is significantly reduced after 2 months. At weaning, body weight of male and female spotted deer was 20 and 18 kg, respectively (Azad *et al*., 2006). The most active period of growth is from birth to 3 months of age.

Before actual bottle feeding is started, all accessories should be procured. Fawn may be transferred to a suitable nursery with provision of heating during cold winter season. A thick heap of straw may be provided as bedding. Get the routine medical checkup done. If colostrum has not been suckled by the fawn, arrange bovine colostrum for the fawn. Total solid content of deer milk is much higher than goat, cow or buffalo milk. Yet many artiodactylids have been successfully reared using formula based on cow milk (Arora, 2001). A suitable formula can be made by mixing 150 g of milk powder with 1 l of water to which 2 egg yolks and 100 ml of cream is added.

On day 1, Ringer's lactate (RL) is the only feed. Formula is introduced on 2nd day (75% RL + 25% formula). On day 3, RL and formula is fed in equal proportion and on day 4, RL is just 25% and formula is 75%. From 5th day onward, only formula is fed. Targeted volume of formula is about 15% of the body weight at the first phase. Weaning process starts during 4-6 weeks of age during which phase volume of formula is reduced to 7.0 and 3% at the end of 6 and 7th week. Frequency of feeding is 4 during days 2-7, 3 during 2-4 weeks, 2 during 4-6 weeks and only once during 7th week. Weaning is completed by 8-10 weeks (Papageorgiou *et al*., 2002).

Proper restraining of the fawn is required during bottle feeding. Cover the eyes with a soft towel. Lateral recumbency is preferred to avoid bloat. Support the head and neck in an upright position. Continue attempt to put the nipples on to the mouth. In order to stimulate suckling response, allow the fawn to lick your finger. Within a day or two the fawn will learn to suckle from the nipple. Once the fawn is consistently suckling from the bottle, allow it to interact with conspecifics and provide exercise.

Fawns will nibble grasses from second week of their life. While hand rearing, they should be provided and encouraged to consume good quality grasses. By 2 to 3 months, their primary diet should be mash and fodder. Most common medical problems encountered during hand rearing include diarrhoea, navel ill, fracture and captive myopathy.

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CHAPTER-5

Standard Guidelines for Feeding of Captive Animals in Indian Zoos

5.0 Standard Guidelines for Feeding of Captive Animals in Indian Zoos

General guidelines for feeding of herbivores

1. The proportion of concentrates in the diet should be restricted to 25-30% on DM basis. In no case, it should exceed 30% of total diet on DM basis. Concentrates may be used as a vehicle for supplementation of minerals and other micronutrients. Concentrate mixture should be supplemented with a balanced mineral mixture @2%. Composition of model concentrate mixture using different ingredients are detailed in Appendix III. Composition of balance mineral mixture is detailed in Appendix VI.
2. Fruits and vegetables are not recommended.
3. To avoid overfeeding/underfeeding concentrate feed should be offered in different feeding stations inside the enclosure.
4. Many zoos feed green fodder *ad lib*. Restricting the amount of concentrates and fodder would not only be economical, but will also reduce the refusals.

Spotted Deer

1. Basal diet of spotted deer should be comprised of good quality green fodder. Best combination would be a leguminous fodder and a cereal fodder fed in equal proportion on dry matter (DM) basis.

   A typical diet for an adult weighing 70 kg:

   Berseem or any other leguminous fodder (having 20% DM): 3.5 kg

   Oat of any other cereal fodder (having 25% DM): 3 kg

   Region wise availability of green fodder during different seasons is listed in

   (Appendix II). This is to be noted that this is a general guideline. Actual amount of forage to be fed should be decided depending upon the DM content of the forage and body weight of the animals. Further, it would be desirable to perform nutrient analysis of different feed ingredients on regular basis.

   Standard concentrate mixture (16% CP, 3940 kcal/GE): 500 g

Model composition of concentrate mixture is detailed in (Appendix III). A suitable concentrate depending upon the availability of ingredients in a particular zoo may be chosen.

2. Spotted deer are mixed feeder. Grasses, legumes and browses may all be fed to them depending upon the availability. However, feed only that fodder and browses which are known not to contain any toxicant.

Swamp Deer

1. As a thumb rule, 10 kg of green fodder (25% DM) and 1 kg of balanced concentrate mixture (Please see Appendix III) would be adequate for an adult weighing 150 kg. The amount of concentrates and green fodder required to fulfill requirements of different weight category of swamp deer is listed below.

Body weight (kg)	Green fodder (25% DM)	Concentrates (90% DM)
100>	8 kg	750 g
150	10 kg	1 kg
180	12 kg	1.25 kg

Actual amount of fodder and concentrate to be fed in a flock may be decided depending upon the number of animals in each body-weight category.

2. Swamp deer are pure grazers. There is no need to feed any legumes or browses. Region wise availability of cereal fodder during different seasons is listed in Appendix II.

Hog Deer

1. On an average, a male hog deer weighs about 50 kg, whereas, a female weighs 30-35 kg. If males and females are housed separately they can be fed according to their respective adult body size, In a mixed population, average body weight could assumed as 40 kg. Amounts of concentrates and green fodder required to fulfill nutrient requirements in different weight category of Hog deer are listed below.

Body weight (kg)	Green fodder (25% DM)	Concentrates (90% DM)
30	2.75	200 g
40	3.75	280 g
50	4.75	350 g

2. Like Swamp deer, hog deer is a grazer and hence roughage portion may comprise solely of cereal fodder. Region wise availability of cereal fodder during different seasons are listed in Appendix II.
3. Similar type of concentrate may be used for all species of deer, For detailed ingredient composition of different concentrate mixture please see Annexure III.

Sangai Deer

1. Considering the average flock body weight of 100 kg, average daily dry matter consumption would be 2 kg. If 75% of it's to be provided through roughages, DMI from roughages should be at least 1.5 kg. Considering the moisture content of green fodder (75-80%), deer should consume 6-7.5 kg of grasses. If we further allow, 20% refusal, than the amount of fodder to be fed would be 7.5-9 kg/animal/day. So, feeding of 7-9 kg of green fodder with as low as 500 g of concentrates would ensure adequate nutrition for an average sized (~100 kg BW) Sangai deer.

Barking Deer

1. A diet containing 250 g of balanced concentrate mixture (Please see Appendix III for detailed ingredient composition) and 2.5 kg of green fodder (25% DM) would provide adequate nutrition to an adult barking deer weighing 20 kg,
2. Cereal, leguminous and tree fodder can be fed to barking deer. If available, a combination of all the 3 categories of green fodder will be desirable as it will add

a lot of variety and will provide behavioural enrichment. Different combinations of fodders which may be fed to Barking deer are listed below.

Combination	Green fodder (25% DM)	Tree leaves (35% DM)	Leguminous fodder (20% DM)	Concentrate (90%DM)
Cereal fodder alone	2. 5 kg	-	-	250 g
Tree leaves alone	-	2.0	-	250 g
Cereal+tree leaves	1 kg	1.25 kg	-	250 g
Cereal +leguminous fodder	1 kg	-	2.0 kg	200 g
Cereal +leguminous fodder + tree leaves	1.25 kg	0.5 kg	0.8 kg	225 g

3. Leguminous fodder should not be fed as a sole roughage source.
4. In nature, barking deer are solitary animals. Feed should be offered at many different places to avoid fighting when they are fed in a group.

Sambar Deer

1. The amount of concentrates and green fodder required to fulfill nutrient requirements of different weight group of Sambar are presented below.

Body weight (kg)	Green fodder (25% DM)	Concentrates (90% DM)
150>	11 kg	1kg
200	15 kg	1.25 kg
250	19 kg	1.50 kg
300	23 kg	1.75 kg

2. If available tree fodder should be included in the diet. In such case the feeding schedule should be as follows :

Body weight (kg)	Cereal fodder (25% DM)	Tree fodder (35% DM)	Concentrates (90% DM)
150>	9 kg	2 kg	1 kg
200	10 kg	4 kg	1.25 kg
250	12.5 kg	5 kg	1.50 kg
300	15 kg	6 kg	1.75 kg

Mouse Deer

1. A diet containing 80 g tubers, 100 g hard fruits (apple, pear guava), 80 g soaked pulse, 100 g vegetable (carrots, bean, cabbage) and *ad lib* green fodder (Lucerne/*Ipoema aquatica*/ groundnut leaves) is suggested.
2. The ration should be divided onto 2-3 equal meals.
3. Fruits and vegetables may be cut into 2-3 cm cubes.
4. At least 500 ml of drinking water may be provided, Water consumption in mouse due is about 280 ml/day.

Blackbuck

1. Blackbucks are primarily grazers. Their basal diet should comprise of grasses. About 2.5-3.0 kg of good quality green fodder should be fed depending upon

the body weight. Amounts of concentrates and green fodder required to fulfil nutrient requirements of different body weight category of Blackbucks are listed below.

Body weight (kg)	Green fodder (25% DM)	Concentrates (90% DM)
20	1.5 kg	125 g
25	2.0 kg	160 g
30	2.5 kg	200 g
35	3.0 kg	225 g
40	3.25 kg	250 g

2. On an average, a male blackbuck weighs about 40 kg (35-45 kg), whereas, a female weighs 35 kg (30-40 kg). If males and females are housed separately they can be fed according to their respective adult body size. Actual amount of fodder and concentrate to be fed in a flock may be decided depending upon the number of animals in each body-weight category.
3. Blackbuck is a grazer and hence roughage portion may be comprised solely of cereal fodder. Region wise availability of cereal fodder during different seasons is listed in Appendix II.

Chinkara

1. Feeding of 200 g concentrates and 2-2.5 kg of green fodder is suggested.
2. Chinkara is a selective browser. Small amount of leguminous fodder may be added in their diet. The following feeding schedules may be practiced depending upon the availability of different types of fodder.

Combination fodder	Cereal fodder (25% DM)	Leguminous (20% DM)	Concentrate (90%DM)
Cereal fodder alone	2.5 kg	-	200 g
Cereal +leguminous fodder	1.5 kg	1.5 kg	150 g

Four Horned Antelope

1. Feeding of concentrates should be restricted to 200 g/animal/day.
2. The amount of roughage to be fed should range from 2-2.5 kg. A combination of cereal fodder, legumes and tree leaves should be fed in 1:1:1 ratio should be preferable. However, depending upon the availability of green fodder one of the following schedules may be followed.

Combination	Cereal fodder (25% DM)	Tree leaves (35% DM)	Leguminous fodder (20% DM)	Concentrates (90% DM)
Cereal fodder alone	2.25 kg	-	-	200 g
Cereal+ tree leaves	1.75 kg	0. 5 kg	-	200 g
Cereal +leguminous fodder	1.5 kg	-	1.5 kg	150 g
Cereal +leguminous fodder+ tree fodder	1.25 kg	0.5 kg	0.75 kg	175 g

3. Leguminous fodder should not be fed alone.
4. Whenever possible, divide the total ration to at least 2 meals.

Gaur

1. In Sri Chamarajendra Zoological Garden, Mysore: An adult male gaur is fed 15 kg of green fodder, 500 g groundnut cake, 1 kg horse gram, 3 kg wheat bran, 5 kg hay and 20 g common salt. This diet was found to be adequate to fulfil requirement of energy protein, Ca, P, Fe, Cu and Zn. This is also perfect with regard to roughage: concentrate ratio. We recommend that other facilities keeping Gaur may adopt this feeding schedule.
2. Trace element mixture (See Appendix VII) may be added to the concentrates for better performance.
3. We do not encourage use of any produce in wild gaur diet. Wild animals do consume fruits, but those are much more fibrous than cultivated one. As such all requirement could be fulfilled without any inclusion of produce.
4. There are evidences which suggest that vitamin E requirement of captive animals are higher than those in free range. We suggest that the part of concentrate should contain germinating pulses.

Wild Pig

1. For a sow, 600 g of mash, 700 g of green fodder, 300 g of tubers and 250 g of vegetables would be adequate. For a boar, 1 kg of mash, 0.25 kg of green fodder, 500 g of tubers and 500 g of vegetables would be sufficient to provide adequate nutrition.
2. The mash should be coarsely ground. Soaking or cooking of the ingredients is not really required.
3. Cotton seed meal should never be fed to pigs as they are highly susceptible to gossypol poisoning.
4. Milk is deficient in iron and copper. Piglets are prone to anemia. A dose of copper and iron (Impheron) may be given on fourth and fourteenth day.

Zebra

1. An adult zebra should be fed concentrates @ 0.5-1.0% BW.
2. Protein requirement of zebras are rather low. Use of leguminous fodder may be reassessed. Non-leguminous green fodder may also be fed @ 1.5-2.0%. of BW
3. Use of produces should be stopped.
4. Browses are not the natural component of zebra's diet. Further, browses are difficult to procure. Hence, their use should be reassessed.
5. The diets should be supplemented with trace element mixture

   (Please see Appendix VII). The requirement of Zn and Cu is higher than the actual concentration in most of the feed ingredients.

Wild Ass

1. A diet containing 2.5 kg of Lucerne, 1 kg of soaked gram (500 g on air-dried basis) and 15 kg of green fodder would provide adequate nutrition. The diet schedule practiced at Shakkarbaugh zoo seems adequate to supply requisite

amount of energy, protein, Ca, P and Fe. However, the diet was marginally deficient in Cu and Zn content. Suitable trace element mixture (Please see Appendix VII) may be added in order to safeguard the marginal Cu and Zn deficiency

2. Feeding of very coarse, tough forage materials such as kadvi, straw etc. may be avoided to reduce the chance of impaction.
3. The grains should not be fed at a time; the entire amount may be divided into 3 equal meals.
4. Wild ass should be fed on proper manger. Do not feed on sandy ground. This may cause colic. Do not feed above shoulder level.
5. The diet should contain adequate amount of fibre. Feeding of very low fiber diet may gives rise to problem of hair licking and formation of caprolith. Feeding of excessive amount of concentrates contribute to colic and laminitis. The Shakkarbaugh zoo diet contained only 13% concentrate on dry matter baize. It gives us immense pleasure to appreciate the feeding schedule.

One-horned Rhinoceros

1. Indian rhinoceros are very prone to obesity. Body condition score should be regularly monitored. They should be fed according to their body size. Concentrate portion should be fed individually so that over feeding by dominant animal is under check. A diet containing 2 kg of concentrates and 110 kg of green fodder should be adequate for a female weighing 1600 kg. However, a male weighing 2200 kg may require 3 kg of concentrates and 150 kg of green fodder to fulfill its requirements. The concentrates should not provide more than 30% of the dietary energy. Concentrate mixture used for deer or compounded cattle feed can be used for feeding rhinoceros. The concentrate portion should actually be used as a mean to supply minerals and vitamins. Concentrate ingredients should be supplemented with a good quality mineral mixture @ 2% on dry matter basis (Please see Appendix VI). The diet of rhino in Kanpur and Guwahati zoo contained only 8 and 13% concentrates on dry matter basis, respectively. Yet, both these diets were able to supply adequate amount of energy, protein, Ca, P and Fe. We appreciate and scientifically authenticate these diets. Growing animals require more protein in their diet. Hence, the proportion of concentrates may be increased in their diet upto 25-30%. Following feeding schedule may be practiced.

Body weight (kg)	Green fodder (25% DM)	Concentrates (90% DM)
750	65 kg	4 kg
1000	80 kg	5 kg
1600	110 kg	2 kg
2200	150 kg	3 kg

2. Feeding of fruits and vegetable are not nutritionally important. If fed, they must not contribute more than 2% of the diet on dry matter basis.
3. Food should not be offered on ground. Sand colic has been reported in Indian rhinoceros. They should be either fed on sturdy trough or on concrete pads.

4. To reduce competition, it would be desirable to feed them individually (at least the concentrate portion). Food may be offered in different feeding stations, if the animals are kept in a group. It also acts a measure of behavioural enrichment.
5. Feeding of excessive leguminous fodder should not be encouraged. Use of sugarcane as a roughage source may be reassessed.

Asian Elephant

1. Fruits and vegetables are not required in the diet of captive Asian elephant diet. Concntrates should not be fed as the first meal of the day. First meal of the day may be cultivated cereal fodder. Conncentrates may be fed during noon/ afternoon. High moisture feed may be fed any time, particularly during night.
2. They are very prone to obesity. Body condition should be monitored regularly. Each animal should be fed individually (at least concentrate portion).
3. An adult male weighing 4 ton, 6 kg of concentrates ingredients (air-dried, 10% moisture) and 225 kg of green fodder (75% moisture) will be adequate. Similarly, for a cow weighing 3 ton, 5 kg of concentrates and 165 kg of green fodder would be adequate. Growing animals require more protein in their diet. Hence, the proportion of concentrates may be increased in their diet upto 25-30%. A typical concentrate mixture for sub-adult should include pulse and cereals in 2:1 ratio, which could be supplemented with 100 g of common salt and 50 g of rock salt. Trace element mixture (see Appendix) could be added @ 1.2 g/ kg of concentrate on DM basis. For adult elephants, the ratio of pulses: cerals could be just reverse at 1:2. The following feeding schedule could be practiced

Body weight (kg)	Green fodder (25% DM)	Concentrates (90% DM)
500	35 kg	3 kg
1000	70 kg	4 kg
1500	90 kg	5 kg
2500	135 kg	5 kg
3000	165 kg	5 kg
3500	200 kg	5.5 kg
4000	225 kg	6.0 kg

4. Roughages vary considerably in their moisture content (Reed grass, banana stem contain more than 90%; dal grass, para grass contain 80-85%; cultivated fodder contain 75-80%; tree fodder contain less than 70%; whereas, hays and straws contain less than 10%). It is, thus obvious that the amount of roughages to be fed will depend on the type of fodders and their combination. The basic target is to restrict total dry matter intake to 1-1.25% of body weight in adult and to ensure dry matter intake of 1.5-2.0% of body weight in sub-adult. The proportion of concentrates ingredient could be as low as 10% of the total dry matter in adult, whereas, it could be upto 30% of total dry matter intake in sub-adult.
5. Elephants are very prone to obesity. Body condition should be regularly monitored. Grasses should be the main component of elephant diet. Some amount of

leguminous fodder may be included in the diet of young animals to increase the protein content of the diet. High moisture roughages like reed grass and banana stems may be fed *ad lib*. Other roughages and concentrates should be restricted.

Some amount (10-20% of total diet on dry matter basis) of browses may be added in the diet. Depending upon availability following different types of feed may be fed to captive Asiatic elephant weighing 3000 kg.

Combination	Cereal fodder (25% DM)	Tree leaves (35% DM)	High moisture fodder (10% DM)	Concentrate (90% DM)
Cereal fodder alone	165 kg	-	-	5 kg
Cereal+ tree fodder	110 kg	48 kg	-	5 kg
Cereal + high moisture fodder	100 kg	-	130 kg	5 kg
Cereal +high moisture fodder+ tree fodder	55 kg	45 kg	110 kg	5 kg

General guidelines for feeding omnivores

1. Wild fruit are different in nutrient composition than cultivated fruits. Cultivated fruits contain more sugar, less fibre and less Ca than wild fruit. Thus, it may not always be correct to feed them large quantity of cultivated fruits.
2. To meet the Ca requirement of these fruit eating animals is the most difficult task.
3. Feed large quantity of green leafy vegetables to them.
4. When the animals are fed in a group, the basic idea is to provide adequate nutrition to the weakest one. This approach however may cause obesity to the dominnat members of the group. Food may be scattered aound the enclosure so that every member of the group has access to food.
5. Obesity should be closely monitored.
6. Nuts may be given as a treat, not as a routine food.
7. Do not feed the same fruit or vegetable every day. Variation is desirable.
8. Calcium supplement may be added to the concentrate portion of the diet.

Indian Giant Squirrel

1. A diet containing 50 g banana, 50 g hard fruit (pear/apple/ guava), 100 g vegetables (cabbage/ carrot/ beans/ eggplant/ other), 50 g spinach, 25 g bread, 40 g soaked gram and 4 g of peanut will be adequate.
2. The proportion of nuts should not be more than 5 % of the total diet on dry matter basis. Real nuts i.e. almond, walnut may be used instead of peanut. Peanuts are susceptible to aflatoxicosis. Any fungal mould should be monitored regularly and feed should be got tested for aflatoxins on regular basis.
3. Nuts should be given only after the vegetables have been consumed.

4. The whole ration may be divided into 2 or more meals.
5. Bread could be replaced with equal amount of grains

Crested Indian Porcupine

1. A diet containing 100 g banana, 150 g spinach/ leafy vegetables, 100 g soaked Bengal gram, 200 g carrots and 200 g tubers will be adequate. Porcupine should be fed at least twice daily to maintain gut health. Usually hindgut fermentation is reduced after 12 h of feeding.
2. They can conserve fat very efficiently, diet should contain very less fat. Browses and grasses could be included in the diets.
3. Use of items like bread, milk and egg should be reassessed.

Rhesus Macaque

1. An adult Rhesus monkey should be fed about 800 g of fresh food. The diet should contain at least 400 g of vegetables. The amount of fruits should be restricted to 300 g. Rest of the diet should comprise of other items like cooked/ processed cereals. A typical feeding schedule should be as follows

Time of the day	Type and amount of feed to be fed
Morning	50 g processed cereals (bread/rice/ roti) and 25 g of seeds (sunflower/ peanuts with hull) and 100 g of soaked Bengal gram or germinating pulses
Noon	200 g leafy vegetables, 100 g soft fruits (banana)
Afternoon	200 g vegetables (carrot, cabbage, beans),100 g fruits (apple/ pear/ seasonal fruits), 25g tubers

2. At least 3 meals may be provided in a day.
3. Browses should be added in the diet.
4. Behavioural enrichment could be provided by supplying food in puzzle box, wire ball and other innovative devices.

Bonnet Macaque

Same feeding schedule of Rhesus monkey may be followed.

Assamese Macaque

Same feeding schedule of Rhesus monkey may be followed.

Pig-tailed Monkey

1. Hard fruits may be preferred over soft fruits.
2. An adult should be fed about 1000-1200 g of fresh food depending upon the size. Following feeding schedule is suggested.

Time of the day	Type and amount of feed to be fed
Morning	100 g cereals (bread/rice roti) and 25 g of seeds (sunflower/ peanut with hull), 75 g soaked Bengal gram or other germinating pulses
Noon	200 g leafy vegetables, 100 g soft fruits (banana), 50 g tubers
Afternoon	300 g vegetables (carrot, cabbage, beans),200 g fruits (apple/ pear/ seasonal fruits)

3. Forages may be fed *ad libitum*.
4. Feeding of ingredients like soybean flakes, peanut and gram may not be necessary.

Stump-tailed Macaque

Same schedule of pig-tailed macaque may be followed

Lion-tailed Macaque

1. Fruits are the main components in the natural diet of lion-tailed macaque. Considering the difference in nutritional composition of wild and cultivated fruits; it would not be wise to feed higher proportion of fruits to captive lion-tailed macaque. About 700-800 g of fresh food will be adequate for an adult.
2. Following feeding schedule is suggested.

Time of the day	Type and amount of feed to be fed
Morning	50 g of processed cereals (bread/rice/ roti) ,25 g of seeds (sunflower/ peanuts with hull), a few insects and 50 g soaked Bengal gram or germinating pulses
Noon	200 g leafy vegetables
Afternoon	225 g vegetables (carrot/cabbage/beans/ eggplant/ peas), 200 g fruits (apple/pear/ seasonal fruits) and 50 g animal product (meat/ egg)

3. The first meal of the day should be cooked cereals (50 g) and 50 g of soaked Bengal gram or other germinating pulses which may be given at 8 a.m., followed by some seeds and insects at 11 a.m. At 2 p.m in the afternoon 200 g of vegetables may be offered. Finally before the closure of the zoo, a mixture of fruits, vegetables and other foods may be provided. This meal should comprise of 225 g of vegetable, 200 g of fruits and 50 g of other products like meat/egg/ chicken.
4. Fruits and vegetables may be changed on alternate day to provide variety. Similarly, animal products can also be changed on alternate day. Curd could be a good option to provide probiotics and calcium.
5. Lion-tailed macaque spends a lot of time on active foraging. So for behavioral enrichment, food should be scattered throughout the enclosure and could be concealed. Sometime the dominant male would consume more food and nutritious portion of the ration which may cause obesity. To avoid such problem, disperse the food in most scattered manner so that all individuals get sufficient amount of food.
6. Accurate weighing of animal and food is essential. Amount of food can be changed gradually according to the body condition.
7. Branches, twigs, fodder should be provided *ad libitum*.
8. Hard fruits should be preferred over soft fruit.
9. Some fruits require processing. It is better to provide unprocessed fruits. It provides behavioral stimulation

Common Langurs

1. A diet containing 50 g bread, 50 g tubers, 100 g apple, 100 g pear/ guava/

other fruit, 50 g sprouted pulses, 100 g soaked gram, 300 g mixed vegetables (cabbage/ carrot/ beans), 200 g leafy vegetable and 50 g okra may be fed. Browses should be fed ad lib. (at least- 400 g / langur/d).

2. Green leafy vegetables or browses with young leaves, buds and even flower may be fed ad lib.
3. Peanut or any other nuts or seeds should not be fed regularly. They can be given as a treat.

Nilgiri Langurs

1. A diet containing 50 g bread, 50 g tubers, 100 g apple, 100 g pear/ guava/ other fruit, 50 g sprouted pulses, 50 g soaked gram, 200 g mixed vegetables (cabbage/carrot/beans), and 200 g leafy vegetable may be fed.
2. Like common langurs, they may also be fed leafy vegetables and browses with young leaves, buds and flowers. Browses should be fed ad lib. (at least- 400 g / langur/d).

Phayrei's Leaf Monkey

1. A diet comprising of 150 g bottle gourd, 100 g cucumber, 100 g apple, 100 g beans/ cabbage, 75 g soaked Bengal gram, 200 g (maximum) banana, 100 g spinach/ amaranthus/ leafy vegetables, 100 g leaves/ twigs of China rose and 100 g browse of gulmohur would fulfil the requirements
2. In free range, they spend considerable time in foraging. Food may be spread throughout the enclosure to provide behavioral stimulation. This would also help control over feeding by the dominant male.
3. They should be fed throughout the day. At least 3 meals should be provided.
4. Too much experimentation with browse species is not encouraged. Only those species which have been tested earlier and were found to be satisfactory should be used. China rose and gold mohur is excellent in nutritional make-up.

Capped Langur

1. A diet containing 250 g bottle gourd, 200 g cucumber, 100 g apple, 100 g beans, 200 g other vegetables (carrot/ cabbage/ pumpkin/ eggplant), 100 g soaked gram, 200 g banana, 200 g gold mohur leaves , 100 g spinach and 200 g china rose would be adequate.
2. Natural diet of langurs can contain up to 80% leaves. Thus, browses can be fed unrestricted amount.

Golden Langur

1. A diet comprising of 100 g of apple/pear/ guava, 100 g of citrus fruits, 100 g of tubers, 100 g of beans, 100 g of cabbage, 200 g of other vegetables (carrot/ cauliflower/ pumpkin/ eggplant), 200 g of spinach/ leafy vegetables, 300 g of browses, 100 g of soaked gram and 50 g of bread would be adequate.
2. In nature, only 10% of golden Langurs diet is comprised of fruits. It is recommended that 75% of the total diet dry matter should comprise of green leafy vegetables and browses. Fruits can be used as a supplement and for behavioural enrichment. In no case, fruits should contribute to more than 25% of the total diet. A fruit mixture of 100 g banana, 100 g apple/ pear/ guava and

100 g of citrus fruit would contribute about 60 g of dry matter which will be roughly 25% of the total dry matter intake of the Langurs.

3. Animal managers and caretakers should be aware that some leaf-eating primates may initially be reluctant to accept new higher-fiber diets in place of traditional fruit based diets. With patience and persistence, most individuals can be managed in a healthier way on high fibre diet.
4. There is no need to make the diet too much complicated. Some tubers, 2 fruits, 2 coloured vegetable and 3-4 green vegetable are realistic.
5. Replace soft fruits with hard fruits.
6. Seeds can be given as a treat, not as a regular item.
7. It is mandatory to offer food at least 3 times to maintain proper gut health.
8. Raw tubers can be added to the diet by replacing bread. Such item should not constitute more than 15% of the total diet.
9. Any dietary change however should be implemented in a gradual manner.

Slow Loris

1. A diet containing 50 g banana, 50 g citrus fruit, 50 g apple/ pomegranate/ pear/guava, 25 g bread, 25 g grape, 25 g chiku, 50 g cucumber, 25 g carrot, and 35 g egg may be fed.
2. Fruits and vegetables may be washed and peeled before use to reduce the pesticide residues.
3. Slow loris may be allowed to hunt live prey. Crickets and lizards may be allowed to graze in the Loris enclosure.
4. They readily consumed commercial gums, spread it on foods poles tree branches or any other feeding devices.
5. Insects should constitute of at least 5% of the total diet.
6. Liquid iron and calcium supplements may be spread over preferred food items like banana.

Hoolock Gibbon

1. A Hoolock gibbon may be fed 150 g banana, 100 g soaked gram, 50 g apple, 100 g pomegranate/ pear/ guava/ locally available fruit, 100 g cabbage or other cruciferous vegetables, 100 g beans, 50 g leafy vegetable, 100 g tubers, 50 g egg and browses *ad lib*.
2. Gibbons have sensitive digestive systems and have an inability to cope with fruits with a high acid content such as tomatoes, grapes, pineapples, or citrus fruits. Large quantities of these fruits may result in severe physiological reactions
3. Fruits and vegetables could be cut into 3-5 cm pieces to prevent choking
4. Browse with long fibres should also be avoided.
5. Peanuts are avoided because they can be a source of aflatoxin.
6. Fruit, tuber, pulses should be predominately fed in the morning and vegetables in the afternoon.
7. Half of the foods may be fed on the platform not lower than 1.5 m. Rest of the food can be scattered throughout the enclosure.

8. Behavioural enrichment may be provided by scattering food, providing seeds in straws and placing it in cardboards boxes and smearing low calorie jams in utensils, poles etc.

General guidelines for feeding carnivores

1. Order Carnivora includes many species of animal with diversified food habit. This generalization is limited to largely meat eating species.
2. Muscle meat is deficient in Calcium. However, if bones are regularly chewed problem of metabolic bone diseases can be easily averted.
3. Donot feed eggs, mik etc to obligate carnivores. If you are intended to improve vitamin supply then go straight for a vitamin supplement.
4. Liver can be used as supplement. But, I would prefer straight supplement because a lot of hygienic issues are involved in feeding liver.
5. Smaller felids, growing animal, and lactating mother do not require an off day.
6. Freezing and thawing the meat before feeding is helpful in reducing parasitic load.
7. Strict code of hygiene should be maintained at all time

Jackal

1. Feeding of 1 kg of meat is adequate for male and 750 g of meat is adequate for a female.
2. Variation could be provided by supplying equal amount of chicken *in lieu* of meat.
3. In nature, they prey on rodents, smaller vertebrates and also eat fruits and tubers. Fruits and tubers should be added in the diet.
4. Ensure that bone piece is attached to the chunk offered.
5. In nature, they have to take a number of meals in a day. Fasting is really not required.

Tibetan Wolf

1. A diet comprising 2.0 to 2.5 kg of meat would supply adequate amount of energy, Ca, P, Fe, Zn and Cu. As all the animals chewed significant amount of bone, deficiency of Ca is unlikely. All the diets supplied adequate amount of Ca to fulfil requirement.

   Following feeding schedule is suggested.

Description of animal	Type of feed	Amount of feed (kg/d)	Supplement	Frequency of feeding
Average sized male	Beef/ buffalo meat	2.5	3000 IU of vitamin A and 150 IU of vitamin E per kg feed	6 times per week
Average sized female	Beef/ buffalo meat	2.0	3000 IU of vitamin A and 150 IU of vitamin E per kg feed	6 times per week

2. Meat should be offered late in the evening/afternoon to avoid spoilage under high ambient temperature. Wolves should be fed approximately one half hour prior to the end of the work of the day. Most wolves are reluctant to eat when personnel are around.
3. Feeding location should be protected from elements. There should be at least one feeding location per wolf for those housed together. Feeding station should be spatially and visually separated to discourage dominant animal to take more food. This would also encourage subordinate animal to consume more.
4. The one day fasting may be practiced. It gives good opportunity to give medication on the day following fasting. Bitches may be fed 25% higher food during last trimester of pregnancy. Lactating animals would require 1.5 times more food than maintenance. Frequency of feeding may be increased to 2-3 feedings during these high demand periods.

Tiger

1. Constant monitoring of captive diet is required. A tiger must be fed according to its body size, physiological status, any special requirement, and health. It is emphasized that the following suggestion should be better treated as general guideline.
2. An average size adult male may be fed 8 kg of meat on bone, whereas, 6 kg of meat on bone will be adequate for an adult female tiger. Following feeding schedule is suggested.

Description of animal	Type of meat	Amount of meat (kg/d)	Supplement	Frequency of feeding
Average sized male	Beef/ buffalo meat	8	3000 IU of vitamin A and 150 IU of vitamin E per kg meat	6 times per week
Average sized female	Beef/ buffalo meat	6	3000 IU of vitamin A and 150 IU of vitamin E per kg meat	6 times per week

3. Boneless meat requires supplementation with 7-10 g of $CaCO_3$.
4. Each kg of fresh meat should be supplemented with 3000 IU of vitamin A and 150 IU of vitamin D to every kg of fresh meat.
5. Use of liver, egg and milk as a supplementary source of minerals and vitamins is not encouraged. It is safer to use commercial vitamin supplement.
6. Feeding meat on bone provides great source of behavioural enrichment to tigers as it simulate natural feeding behaviour of tiger. The chunk should be cut in a manner that the requisite quota of an animal could be provided in a singular piece.
7. Further behavioural enrichment could be provided by keeping meat in gunny bags suspended from the roof of the enclosure; concealing the meat inside the enclosure or by simply keeping the chunk in a bag tightly secured with ropes.

8. Freezing the meat, and thawing it before feeding would significantly reduce the microbial and parasitic load.
9. Meat should be provided as late as possible. Indore zoo fed their tigers at night. This is tremendous source of behavioural stimulation and also good for maintaining general hygiene.
10. Feeding of chicken is not necessary under normal circumstance; however, it can be given in a particular animal which refuses to chew bones.
11. Use of milk, egg etc. are not required and may be discontinued.
12. Lactating animals do not require any off day. They should be fed *ad lib* every day. If possible her quota of meat should be spread over several meals.
13. Amount of meat could be increased by 10-20 % during severe cold.

Asiatic Lion

1. Based upon the results of our experiments and comparison with the similar studies conducted in this and other species of felids we suggest that a diet containing 6.75 kg of buffalo meat for lion and 5 kg of buffalo meat for a lioness would be adequate. Following feeding schedule is suggested

Description of animal	**Type of meat**	**Amount of meat (kg/d)**	**Supplement**	**Frequency of feeding**
Average sized male	Beef/ buffalo meat	6.75	3000 IU of vitamin A and 150 IU of vitamin E per kg meat	6 times per week
Average sized female	Beef/ buffalo meat	5.0	3000 IU of vitamin A and 150 IU of vitamin E per kg meat	6 times per week

2. If boneless meat is fed, each kg of meat should be supplemented with 7-10 g of $CaCO_3$ and 2 tsp of multi-vitamin supplement.
3. Behavioural enrichment could be provided by hanging up the meat in gunny bags, hiding it inside enclosure or by applying many other innovative ideas.
4. It is preferable to freeze the meat and then thaw it before feeding. This freezing and thawing will significantly reduce parasitic and microbial load.
5. During summer meat offered should be reduced by 500 g.
6. Body condition should be monitored regularly and adjust the amount of meat accordingly.
7. A diet chart should be maintained for each individual in the collection.
8. Lactating animals should be fed *ad lib*. They may be fed their daily *ad lib* ration distributed over 2-3 equal meals.
9. Feeding time should be set so as to minimize exposure of meat to high ambient temperature. Regular record of actual food consumption must be kept.

Leopard

1. All the animals should be fed according to the body size. An average male should be fed 2.5 kg of meat, whereas, 2 kg of meat should be fed to an average sized female. Regular monitoring of body condition is of utmost importance. Amount of food can be adjusted according to the body condition. Following feeding schedule is suggested.

Description of animal	Type of meat	Amount of meat (kg/d)	Supplement	Frequency of feeding
Average sized male	Beef/ buffalo meat	2.5	3000 IU of vitamin A and 150 IU of vitamin E per kg meat	6 times per week
Average sized female	Beef/ buffalo meat	2.0	3000 IU of vitamin A and 150 IU of vitamin E per kg meat	6 times per week

2. When boneless meat is fed, meat should be supplemented with 7-10 g of $CaCO_3$/kg of fresh meat.
3. During cold winter, amount of meat may be increased by 20%.
4. Growing and lactating animals may be fed *ad lib* without any off-day.
5. Chicken may be given to bring variety in the diet on once or twice a week without increasing the total amount of food.
6. Provide 1500 IU of vitamin A and 150 IU of vitamin D in every kg of fresh meat. If liver is fed as a part of diet, this supplement may not be necessary. However, it is preferable to use vitamin supplement than liver.
7. As discussed for other felids highest standard of general hygiene should be maintained throughout.

Snow Leopard

1. Depending upon the body weight, feeding of 2.0-3.5 kg of meat would provide adequate amount of nutrients. Following feeding schedule is suggested.

Animal Description	Type of meat	Amount of meat (kg/d)	Supplement	Frequency of feeding
Average sized male	Beef/ mutton meat	2.5	Two tsp of muli-vitamin supplement	6 times per week
Average sized female	Beef/ mutton meat	2.0	Two tsp of muli vitamin supplement	6 times per week

2. Mutton would be a better source of nutrients than beef.
3. Food should be offered in the latest hour of the afternoon as would be practicable for the management.

4. One time feeding is sufficient except for nursing mothers whose total ration may be divided into 2 -3 equal meals.
5. If bones are consistently chewed, metabolic bone diseases are unlikely to occur. However, if excessive of bone is left over than precaution might be taken. In such case calcium carbonate may be supplemented @ 5-7g/ kg meat.
6. Advantage or disadvantage of weekly off day has not been scientifically authenticated. Zoo management may take an appropriate decision.
7. A few drops of vitamin A concentrate may be supplemented. However, excessive supplementation is harmful.
8. Most important is regular monitoring of body condition. Whenever animals are sedated, body weight should be measured and entered into the record. Diets could be modified accordingly with response to the change in body weight. However, such change should be gradually implemented.
9. Water should be made available at all times.

Clouded Leopard

1. Feeding of 1.3 to 1.5 kg of dressed chicken was found to supply adequate amount of energy, protein, Ca and P. The results of the present investigation indicate that the current feeding schedule practiced at Sepahijala Biological Park is adequate.
2. Following feeding schedule is suggested for an adult.

Type of feed	**Amount of feed (kg/d)**	**Supplement**	**Frequency of feeding**
Dressed chicken	1.3-1.5 kg	Two tsp of muli-vitamin supplement	6 times per week

3. For variety, goat meat can be fed occasionally. However, the total amount of meat to be fed should remain the same.
4. Clouded leopard being arboreal means there is more scope of behavioural enrichment. Basic idea is to stimulate their instinctive behaviour.

Leopard Cat

1. Feeding of 250 g of meat to leopard cat is adequate.
2. If meat with bone is fed there is no need to use any calcium supplement. Supplementation of calcium and fat soluble vitamins are must if boneless meat is fed. Chicken resembles more to it’s natural diet. Chicken may be preferred over beef, buffalo meat or mutton, whatever your choice is restrict the amount to 250 g.
3. Variation could be brought by offering meat/chicken on alternate day.
4. There is no need of fasting in this and other small felids.

Himalayan Black Bear

1. A diet containing 400 g cereals, 200 g pulses, 1200 g of high protein high calcium vegetables (spinach, beans, cabbage and small amount of seasonal fruits), 45 g jaggery, 1 kg of milk or yoghurt and 15 g honey may be fed . This should be supplemented with 30 g of balanced mineral mixture.

2. The guidelines suggested above are for an adult weighing 95 kg. Bears are prone to obesity. Body condition should be monitored regularly and the amount of food needs to be adjusted accordingly.
3. Soft food items should be fed first, followed by hard roughages. This will ensure cleaning of tooth and better dental health.
4. Behavioural enrichment could be provided by spreading the honey on utensil, suspending the food from the roof of the enclosure by keeping the fruits and vegetable in a gunny bag and any other innovative way that may suit the local condition.

Sloth Bear

1. A diet containing 400 g cereals, 200 g pulses, 1200 g of high protein high calcium vegetables (spinach, beans, cabbage and small amount of seasonal fruits), and 45 g jaggery, one kg of milk / curd and 15 g honey is suggested. This should be supplemented with 30 g of balanced mineral mixture. This ration will supply adequate amount of nutrition for an adult weighing 95 kg.

Binturong

1. A diet containing 250 g soaked gram, 350 g banana, 100 g apple, 75 g orange, 35 g egg and 400 g of bottle gourd will be adequate.
2. This diet maybe supplemented with calcium. Add 1.5 g of calcium carbonate to small amount of milk. This should be fed before the main feeding so that animal consumes it.

Indian Palm Civet

1. Diet should comprise of 30% meat and 70% fruits and vegetables.
2. When animals are group housed, provide food in different locations to avoid overfeeding by dominant animals.
3. It is better to scatter the food inside the feeding cubicles which will stimulate foraging instinct.
4. Feeding should be done at night hours.
5. Feeding of milk is not encouraged. Milk is provided to increase Ca content of the diet. It is better to supplement Ca directly.
6. A diet comprising of 100 g of meat and 200 g of banana could provide adequate calorie and protein. However, such diet would require Ca supplementation as had already been discussed.
7. Body weight should be monitored regularly. Any animal heavier than its wild counterpart should be suspected for obesity. Amount of food to be offered can then be decided accordingly. Any eventual change in diet should be made gradually.

Otter

1. Feeding of fresh fish would be preferred. Freezing and thawing process will increase the thiaminase activity and will also cause nutrient loss.
2. When fish is the only food item, add 25-30 mg of thiamin and 1000 IU of vitamin E to each kg of fish on fresh basis.

3. Fish having excessive fat may be avoided. Excessive intake of fat will increase the requirement of vitamin E.
4. Pesticide residue is one of the major contributors to destruction of natural habitat of otter. While it may not be possible to eliminate the pesticide residues (if already present in fish) completely, washing will certainly help in reducing the amount of some of the residues.
5. Always procure fish from a reliable vendor.
6. Feeding of 1.0-1.25 kg of fresh fish would be adequate for adult maintenance. However, lactating animal will require more energy. Increase the amount of fish by 25% for lactating animals.
7. During cold winter they require more energy. So, increase the amount of food by 25% during winter.

Red panda

SSP guidelines for feeding of red panda are followed worldwide. For the benefit of the readers the guidelines is reproduced. SSP recommends that diet should contain 18% CP, 0.5% Ca, 0.4% P and not more than 5% fat. It further states that Ca: P ratio should ranges between 1:1 to 2:1.

1. There is no need to feed milk under normal circumstances. Milk/ sweetened gruel could be used for younger animals who refuse to take their normal diet. Milk/gruel can also be used for medication.
2. Young pandas at the time of weaning, at 5-7 months of age are susceptible to death due to starvation. Such cubs could be fed with sweetened gruel/ milk.
3. Use of fruits and produces should be reassessed. They can be used for medication. The non-bamboo portion of the diet may be reduced to 20% of the total diet on dry matter basis. Please ensure that an adult Red Panda actually consume at least 1.5 kg of bamboo leaves. That amount will ensure all nutrition a red panda require. Bamboo is a complete package of nutrition for this species. In case the consumption of bamboo is inadequate some amount of non-bamboo fruits can be included in the diet. A diet containing 200 g of hard fruits (apple/ pear/ guava/ pomegranate), 200 of carrots , 100 g of banana and 3 kg of bamboo (minimum) should be fed.
4. All ingredients should be fresh. Spoilage of food should be avoided. Feeds should be inaccessible to vermin. Feeding inside the feeding cubicle is appreciated. They should be provided at least 2 meals. Old food may be removed before offering fresh food.
5. Food consumption should be monitored closely. Wild panda weigh 4.3 kg, but in most of the captive facilities they weigh much higher. Red panda require more energy during winter and lactation. The feed left over should be at least 5% for those categories of animals.
6. When animals are housed in pair or in group several feeding stations should be provided in the feeding cubicles to avoid over/ underfeeding.
7. Drinking water should be always available. When water is deprived food intake will also decrease. The waterer should be ceramic bowl which when inverted would make noise and the keeper would easily know that waterer is to be filled immediately.

Pea Fowl

1. For maintenance, a diet comprising of 100 g of green leafy vegetables, 50 g coloured vegetables (carrot/ capsicum/ tomato), 5 g garlic, 50 g onion, 25 g boiled egg/ insects, 100 g of poultry mash and 100 g of grain (jowar- bajra) mixture was found to be adequate.
2. For breeding birds, a ration should comprise of commercial poultry mash preferably layer ration (25%), green leaves (15%), wheat grain (10%), paddy grain (10%), mixed (preferably coloured) vegetables (5%), soya bean meal (15%), egg/ insects (15%), lime grit (3.5%) and mineral vitamin premix (1.5%). Some garlic (5g/bird) and onion (50 g/ bird) may also be added. All these ingredients should be made into a blend and fed to the birds @ 300-350 g/ bird/ day depending on the size of the bird.
3. Access to water and feed should be provided as soon as possible after hatching. However, all newly hatched chicks should be given access to clean, cool water 1-2 hours prior to the introduction of feed.
4. Young chicks generally have a higher requirement for protein than adult birds ; a 28-30 percent protein turkey starter feed will usually provide well balanced nutrition for newly hatched chicks. Be sure this feed is in a mash or very fine crumble form, otherwise the newly hatched chicks may not be able to physically consume the feed simply because of the size of the particle.
5. During the first five to ten weeks of life, peafowl chicks should be fed only the high protein starter feed. Grain, high quality fresh grass and legumes may be introduced gradually at eight to ten weeks of age. Start with an evening feeding of grain and give only a small amount that the birds will consume without wastage. Supply smaller size grit in a separate feeder when whole grain and other green supplements are fed. Do not overfeed grain or green feed. If such feeding practice is continued young chicks may not get a proper balance of the essential nutrients contained in the commercial feed.
6. Nutritional requirements for peafowl change at breeding time. For good hatchability and fertility, a high quality breeder ration should be fed. Breeder ration should be introduced at least one month before the breeding season is expected to start. For best results, the change from a maintenance feed to a breeder diet should occur gradually over a 5-7 days period. To change feeds, mix equal quantities of the two feeds together at first, then remove 25 percent of the maintenance feed each day until the breeder diet is the only feed.
7. Provide plenty of feeder space (3 to 4 inches per bird). Do not offer feed on ground or onto the litter. This could lead to eating litter which can have disastrous results. Keep the height of the feeders at about the level of the birds back. When changing feeder and watering equipment, do so gradually, otherwise, the birds may not recognize new equipments and starve to death.

Pelican

1. Feeding of 750 g of good quality fish containing 4500 kcal GE/kg DM is adequate to fulfill nutrient requirements of a pelican weighing 5 kg. A big pelican weighing 10 kg of body weight would require 1-1.5 kg of fish depending upon fat content.

2. Very small and very large fish should be avoided. Cutting the large fish to smaller piece will not solve the problem.
3. Feeding should be monitored to ensure that all birds get their quota. It would not be difficult as pelicans are instant feeder.
4. In normal feeding situation, no supplement would be required. If the fish is too oily, consider vitamin E supplementation. Supplementation of vitamin E source @ of 100 IU/ kg fresh fish will be helpful in combating the environmental stresses.
5. Accept the fish only after through examination. Fresh fish has bright red gill, clear eyes and firm pliable body. Stale fish will have darker gill, cloudy eyes and soft body on which finger impression would be easily made and the impression remains.
6. If by any reason frozen fish is to be used, please ensure that it is thawed before feeding.

Parakeets

1. Alexandrine parakeet is almost 3 times bigger than a blossom headed parakeet. Yet, their diet chart is similar or same in most zoos. Diet chart of many zoos even do not recognize them as different species.
2. Nuts are very high in calorie content. Peanuts could be easily replaced with grains. Millets are closest to the wild grains and may be preferred over other grains
3. Grains and produces should be fed in separate feeder.
4. If intended breeding, add supplementary Ca to increase its content to 3% of diet. Add 4 g limestone and 1 g of dicalcium phosphate to each 100 g of grain mixture. If the birds are selectively not consuming the limestone part, then apply liquid calcium preparation on the fruit mixture like a salad dressing so as to achieve the desired level of calcium intake.
5. If chicks are being raised, increase the Ca content of the diet to ~1% by adding 2.2 g of dicalcium phosphate and 1.1 g of limestone for each 100 g of feed.
6. Ten gram of cereal grains, 5 g of pulse seeds, 30 g of fruits like banana, 30 g of other fruits and vegetables should be sufficient for Alexandrine parakeet. For blossom headed and Ring-neckeds, the amount should be just 50 and 60% of that being fed to Alexandrine parakeet.

Hornbill

1. **Indian pied hornbill**: A bird weighing 1 kg could be fed with following food items

   Maintenance diet :Banana, 50 g: apple/ pear/ plum/ seasonal fruits (having about 15% DM), 100 g; rice or roti, 20 g; sattu/besan (grounded Bengal gram flour blended with water) ball, 20 g. This diet should be supplemented with 0.5g $CaCO_3$ which could be mixed thoroughly with rice of sattu ball. This diet should be adequate for maintenance.

   Breeding and chick rearing diet: Banana, 50 g; apple/pear/plum/seasonal fruits, 100 g and minced meat/insects 60 g. The amount of $CaCO_3$ may also be increased to 1 g.

Great hornbill

Maintenance diet: A diet containing 150 g banana, 300 g apple/pear/plum/ seasonal fruit, 60 g cooked rice/ roti, 60 g sattu ball supplemented with 1.5 g of $CaCO_3$ would be adequate.

Breeding and chick rearing diet: A diet containing 150 g banana, 300 g seasonal fruits, 300 g minced meat/ insects/ animal matter supplemented with 4-5 g of $CaCO_3$ would be adequate.

During this period, the male should be fed on demand without any restriction to food.

2. The feed tray should be placed 1.5 cm above the ground.
3. Non-breeding birds should be fed at least twice a day, whereas, breeding birds should be fed at least thrice a day. During chick rearing period, males should be fed on demand.

Star Tortoise

1. No food of animal origin should be fed to star tortoise
2. A typical diet should comprise of green leafy vegetables, 95%, and fruits (5%). It should provide 20% protein, 75% carbohydrates and 5% fat. Diet containing more than 12% fat is contra-indicated. A diet comprising of 100 g lettuce, 100 g amaranthus, 100 g cabbage, 75 g beans and 75 g cucumber would be adequate.
3. Green vegetables like mustard, radish, cabbage, turnip, spinach, leguminous fodder and cut grasses can be fed to star tortoises. It is to be remembered that cruciferous vegetable contain goitrogenic substances, whereas, spinach, cabbage and beet leaves also contain considerable amount of oxalates. So, an array of variety of vegetables should be fed. Vegetables of choice may be changed on daily basis. The key to chelonian nutrition is variety. Never allow your tortoise to feed selectively on a few preferred food items
4. Flowers of China rose, carnations and rose may also be fed to tortoises.
5. Star tortoises like sugar rich food items like fruits. But, the amount of fruit should not exceed 5% of the total diet.
6. Cuttle fish bone may be kept inside the tortoise enclosures.
7. At least 6.4 g of $CaCO_3$ or 2.6 g of Ca may be added per kg of fresh food.

Gharial

1. Following feeding schedule may be followed:

Body weight of the animal (kg)	Type of feed	Amount of feed (g/d)	Supplement	Frequency of feeding
100	Fish	750	Not required	Daily
150	Fish	1000	Not required	Daily
200	Fish	1250	Not required	Daily
100	Fish	1750	Not required	Thrice a week
150	Fish	2300	Not required	Thrice a week
200	Fish	2950	Not required	Thrice a week

2. Frozen fish should not be fed.
3. Live fish can be fed sometimes for behavioural stimulation.
4. If compelled to feed frozen fish, then add 25-30 mg thiamin and 1000 IU of vitamin E to each kg of feed.

Python

1. They should be fed once in 2 or 3 weeks. If two week schedule is followed, they may be fed chicken weighing 1.25-1.50 kg. If 3 weeks feeding schedule is followed chicken/rabbit weighing 2.0-2.25 kg may be fed.
2. Live animals that have been purchased for use as prey should be housed, fed and managed by maintaining highest ethical standards.
3. Sick animals cannot be fed to pythons. Prey animals should be thoroughly screened for parasitic diseases and other pathogens. It is not ethical to keep live prey in python cage beyond a reasonable time. Usually, if the python is hungry, it will grasp the prey within a few minutes.

Appendix I

List of zoos visited to conduct feeding trials and collection of information regarding general nutrition, feeding practice and nutrient composition of feedstuff

Animals on which feeding trial was conducted	Information and samples collected
Kanpur Zoo Rhinoceros (4), Sangai deer (18), Leopard (3), Sarus crane (2) and Blackbuck (1)	*
Lucknow Zoo Swamp deer (4), Sambar deer (3), Otter (3), Giant squirrel (4) Tiger (5), Leopard (8), Parakeets (22), Himalayan Black bear (4), Sloth bear (5) and Elephant (2)	*
M.C. Zoological Park (MCZP), Chattbir Tiger (7), Elephant (5), Chowshingha (4), Chinkara (3), Kalij pheasants (7), Saras crane (6), Red jungle fowl (4) and Comb duck (3)	*
Ludhiana Zoo Collected diet chart and feed samples	
Sanjay Gandhi Biological Park, Patna Peafowl (12), Rhinoceros (10), Slow loris (1), Kalij pheasants (2), Saras crane (3) and Horn bill (3)	*
Assam State Zoo cum Botanical Garden, Guwahati Pig tailed macaque (3), Golden langur (5), Slow Loris (9), Hoolock gibbon (4), Indian palm civet (16), Tiger (7), Elephant (10) and Rhinoceros (4)	*
Itanagar Biological Park Hoolock gibbon (6), Slow Loris (2), Indian Palm civet (1) and Horn bill (2)	*
Shillong Zoo Collected diet chart and feed samples	
Sepahijala Biological Park (SJBP), Tripura Binturong (7), Leaf monkey (7), Capped langur (5), Clouded leopard (7), Elephant (3), Porcupine (4) and Horn bill (2)	*
Gangtok Zoo Tibetan wolf (4), Snow leopard (1), Common leopard (2), Leopard cat (4) and Red panda (5)	*

Deer Park, Aonla Collected diet chart and feed samples	
V.J.B. Udyan, Mumbai Hill myna (5), Hornbill (1), Chowshingha (7), Wild boar (9) and Blackbuck (7)	*
Ahmedabad Zoo Peafowl (17), African crowned crane (2), Flemingo (14), Otter (4), Nicobar pigeon (12) and Blackbuck (15)	*
Sakkarbaugh Zoo, Junagarh Wild ass (11) and Lion (6)	*
Nandankanan Biological Park (NKBP), Bhubaneshwar Tiger (12) and Elephant (5)	
Gandhi Zoological Park, Gwalior Chinkara (9), Gharial (7), Jackal (5), Leopard (3) and Tiger (2)	*
Pt. G.B. Pant High Altitude Zoo, Nainital Zoo Tibetan Wolf (4), Kalij Pheasant (13), Snow leopard (2)	*
Kamla Nehru Zoological Garden , Indore Jackal (5), Langur (2), Tiger (7) and Pea fowl (11)	*
Sarahan Pheasantry Western tragopan (20) and Monal pheasant (5)	*
National Zoological Park (NZP), Delhi Kalij Pheasant (3), Shikra (3), Four horned antelope (3), Gaur (2), Leopard (3), Lion (5) and Tiger (13)	*
Vanvihar National Park, Bhopal Leopard (12) and Tiger (5)	*
Nehru Zoological Park (NZG), Hyderabad Barking deer (3), Swamp deer (4), Mouse deer (10), Elephant (5), Leopard (6), Lion (4), Tiger (11) and Kalij pheasant (2)	*
Zoological Garden, Alipore ,Kolkatta Bhutan pheasant (7), Golden pheasant (4), Peafowl (18) and Swamp deer (5)	* *
Marble Palace Zoo, Kolkata Collected diet chart and feed samples	
Rajiv Gandhi Zoological Park and Wildlife Research Centre,Pune Tiger (8), Jackal (5), Leopard (3) and Wolf (2)	*
Jaipur Zoo Chinkra (2), Jackal (3), Leopard(4), Tiger (6) and Lion (1)	*

Jodhpur Zoo Tiger (3), Lion (1), Leopard (2), Chinkara (6), Jackal (3) and Tortoise (13)	*
Himalayan Nature Park (HNP), Kufri Tibetan wolf(3), Barking deer (19) and Monal pheasant (5)	*
Bannerghatta National Park, Bangalore Leopard (10), Tiger (6) and Leopard cat (5)	*
Sri Chamarjaendra Zoological Garden (SCZG), Mysore Gaur (37), Nilgiri (2), Common langur (2), Elephant (8), Lion tail macaque (9) and Tiger (8)	*
Thiruvavnanthapuram zoo Lion tail macaque (9), Giant squirrel (1) and Porcupine (3)	*
Maharaj Bagh Zoo, Nagpur Peafowl (4)	
Dr. Shivaram Karanth Pillikula Biologiocal Park, Manglore Himalayan palm civet (10), Jungle cat(2), Leopard (4) and Tiger (7)	*
Vanya Prani Udyan IVRI, Bareilly Several well designed experiments were conducted under control experimental protocol	*

*Diet chart and other relevant information regarding existing feeding system, feeding behaviour, feed related problems and feed ingredients were collected and feed, faeces and feed refusals were sampled.

Appendix II: Region-wise availability of green fodder during Kharif and Rabi season

S. No.	Name of the state	Seasonal availability of green fodder		
		Rabi	Kharif	Perennial
1	Himachal Pradesh	Oats, lucerne, berseem, red clover and Shaftal	Cowpea, maize, sorghum, guar, millet Setaria and bajra	Guinea Grass, Napier grass and Tall Fescue grass
2	Jammu and Kashmir	Oats and Shabzaar	-	-
3	Punjab	Oat, fenugreek, cluster beans and berseem bean	Sorghum, pearl millet, bajra, maize, teosinte and cluster	Guinea Grass and Napier grass
4	Haryana	Oats, lucerne, and berseem	Sorghum, cluster beans and cowpea	-
5	Uttarakhand	Oat and berseem	Cowpea, maize, sorghum and bajra	Fodder trees: Oak, Phalyat, Moru, Kharsu and Pharbanj
6	Rajasthan	Oats and Lucerne	Cowpea, sorghum, pearl millet and cluster beans	Guinea grass and Napier grass
7	Uttar Pradesh	Oat and berseem	Jowar, bajra, maize, cluster beans, cowpea and sorghum	-
8	Jharkhand	Oat	Maize, cowpea and rice bean	-
9	West Bengal	Oat	Rice bean, bajra maize and Stylo	Napier grass and Guinea grass
10	Odisha	Oat	Maize, cowpea, sorghum, bajra,rice bean and Stylo	Napier grass and Guinea grass
11	Assam	Oat	Sorghum, cowpea, maize, Teosinte, rice bean, Lablab bean and Setaria	Napier grass, Guinea grass, Dinanath grass and para grass
12	Gujarat	Lucerne	Maize, sorghum, pearl millet	Napier and Marvel grass
13	Madhya Pradesh	Oat, lucerne and Berseem	Maize, sorghum and guar	-
14	Maharashtra	Oat and Lucerne	Sorghum, cowpea, maize and Stylo	Guinea grass and Napier grass

15	Karnataka	Lucerne	Sorghum, cowpea, bajra, maize and pearl millet	Napier grass
16	Tamil Nadu	Lucerne	Sorghum, cowpea, bajra and pearl millet	Kolukkattal, Napier grass, Subabool , Guinea grass and Dinanath grass
17	Kerala	-	Sorghum, cowpea, maize, bajra, rice bean stylo and cluster bean	Hybrid Napier, Guinea Grass, Congo signal grass, Para grass Fodder trees: Subabool, Sesabnia and Glyricidia
18	Andhra Pradesh	Lucerne and berseem	Sorghum andcowpea,	Napier grass

Appendix III: Model composition of concentrate mixture for captive ruminants

Ingredients (%)	CM1	CM2	CM3	CM4	NZP	NKBP
Maize	47	30	-	25	13	-
Barley	-	-	-	-	16	-
Oat	-	-	-	-	8	-
Wheat	-	17	-	-	-	-
Bajra	-	-	25	-	-	-
Jowar	-	-	22	-	-	-
Ragi	-	-		20	-	20
Wheat bran	35	-	34	-	22	10
Rice bran	-	25	-	25	-	24
Groundnut cake	-	15	-	15	-	19
Gram chuni	-	10	-	12	-	-
Soyabean meal	15	-	16	-	-	-
Horse gram	-	-	-	-	12	25
Turmeric powder	-	-	-	-	1	-
Mineral mixture	2	2	2	2	1	1
Common salt	1	1	1	1	1	1
			Calculated nutrient content			
CP (%)	16.35	16.71	16.34	16.20	18.26	20.13
TDN (%)	70.75	70.43	70.76	68.55	66.41	65.94

CM1, concentrate formulation 1; CM2, concentrate formulation 2; CM3, concentrate formulation 3; CM4, concentrate formulation 4; NZP, concentrate mixture of National Zoological Park, Delhi; NKZP, concentrate mixture of Nandankanan Biological Park, Bhubaneswar; CP, crude protein; TDN, total digestible nutrients

Appendix IV: Model composition of concentrate mixture for captive granivorous birds during breeding and laying period

Ingredients (%)	BM1	BM2	BM3	BM4	BM5
Maize	25	-	-	-	-
Wheat	20	20	10	-	30
Broken rice	-	-	10	-	-
Bajra	-	-	21	16	10
Jowar	-	20	25	25	25
Ragi	21	26	-	26	-
Groundnut cake	-	13	12	13	10
Soybean meal	28	15	16	15	18
Horse gram	-	-	-	-	
Limestone	4.85	4.85	4.85	4.85	4.85
Di-calcium phosphate	0.70	0.70	0.70	0.70	0.70
Trace element mixture	0.20	0.20	0.20	0.20	0.20
Choline Chloride	0.10	0.10	0.10	0.10	0.10
Coccidiostat	0.05	0.05	0.05	0.05	0.05
	Calculated nutrient content				
CP (%)	18.74	18.30	18.75	18.62	18.85
ME (kcal/kg DM)	2667	2651	2668	2633	2688

BM1, bird mash formulation 1; BM2, mash formulation 2; BM3, bird mash formulation 3; BM4, bird mash formulation 4; BM5, bird mash formulation 5; CP, crude protein; ME, metabolizable energy (calculated on the basis of ME value for poultry)

Appendix V: Model composition of concentrate mixture for captive granivorous birds for maintenance

Ingredients (%)	BM1	BM2	BM3	BM4
Maize	40	20	30	
Wheat	26		18	
Broken rice	-	10		
Bajra	-			15
Jowar	-	20		50
Ragi	-	25	20	
Wheat bran	10			
Rice bran	-		7	10
Soybean meal	22	23	23	23
Horse gram	-			
Limestone	1.15	1.15	1.15	1.15
Di-calcium phosphate	0.50	0.50	0.50	0.50
Trace element mixture	0.20	0.20	0.20	0.20
Choline hloride	0.10	0.10	0.10	0.10
Coccidiostat	0.05	0.05	0.05	0.05
	Calculated nutrient content			
CP (%)	18.55	17.54	18.57	17.82
ME (kcal/kg DM)	2722	2827	2755	2693

BM1, bird mash formulation 1; BM2, bird mash formulation 2; BM3, bird mash formulation 3; BM4, bird mash formulation 4; CP, crude protein; ME, metabolizable energy (calculated on the basis of ME value for poultry)

Appendix VI: Model composition of mineral mixture for captive herbivores

Ingredients	Amount (g)
Di-calcium phosphate	706.00
Limestone	172.00
Magnesium sulfate	61.58
Copper sulfate	4.71
Cobalt chloride	0.60
Ferrous sulfate	7.44
Zinc sulfate	42.40
Potassium iodide	0.40
Manganese sulfate	4.61
Sodium selenite	0.26

Twenty gram of above mineral mixture may be added to each kg of compounded concentrate mixture.

Appendix VII: Model composition of trace mineral mixture for captive herbivores

Ingrdients	Amount (g)
Copper sulfate	7.78
Cobalt chloride	0.99
Ferrous sulfate	12.28
Zinc sulfate	70.27
Potassium iodide	0.66
Manganese sulfate	7.59
Sodium selenite	0.43

Accurately weighed amount of 1.2 g of trace element mixture may be added to each kg of feed.

Appendix VIII: Model composition of trace mineral and vitamin mixture for pheasants and other granivorous birds

Ingredients	Amount
Magnesium sulfate	6.15 g
Copper sulfate	0.0392 g
Ferrous sulfate	0.4464 g
Zinc sulfate	0.3533 g
Potassium iodide	0.0004 g
Manganese sulfate	0.2146 g
Sodium selenite ($Na_2SeO_3 . 5H_2O$)	0.6896 g
Vitamin A	5000 IU
Vitamin D	1200 ICU
Choline-Cl	2000 mg
Riboflavin	4 mg
Pantothenic acid	12 mg
Vitamin B_{12}	0.012 mg
Folic Acid	1 mg
Niacin	80 mg
Biotin	0.25 mg
Vitamin K	1.5 mg
Thiamin	2.5 mg
Vitamin E	15 IU
Pyridoxin	5 mg

This mixture should be mixed to each one kg of bird mash

Das A., Saini M., Datta N., Sharma K., Saha S.K., Das B.C., Swarup D., and Sharma A.K. 2013. Standardization of Animal Diets in Indian Zoos. Indian Veterinary Research Institute, Izatnagar and Central Zoo Authority, New Delhi. pp 303.

This book describes feeding behaviour and diet schedule of 53 selected species of birds, mammals and reptiles. Basic data on feed consumption, diet digestibility and utilization of macro and micro nutrients are generated. Nutritional adequacies of diet schedules followed by different zoos have been evaluated and specific measures for improvement have been suggested. Finally species specific dietary guidelines have been provided for improvement of health and welfare of selected species of animals. The contents of the book will be helpful for Zoo Veterinarians, Zoo Managers, Zoo Keepers, Academicians, Students, Biologists and Research Workers in their efforts towards conservation of endangered species.

Central Zoo Authority, New Delhi

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