

## DIET PROVISION FOR ZOO ANIMALS IN CAPTIVE CONDITIONS OF LAHORE ZOO, PAKISTAN

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### ABSTRACT

Zoological parks are considered as places or institutions where animals (wild and exotic) are kept within enclosures, are bred and exhibited. Predominantly, zoos are the sites aiming for wildlife conservation, endangered species preservation, scientific research and educational activities, also for recreational purposes for which they are provided with enriched environment and food. The study conducted is based on the diet provided to the animals at Lahore Zoo and further comparison of the food standards with those of diet standards for South Asian zoos. For this purpose, the study included the consultations from books, literature available at websites of zoo present across South Asia, the records and diet charts of animals at South Asian as well as Lahore Zoo and personal observations. The personal observations included parameters like time, hygienic conditions, food dispersal and enrichment of provided diet. The results of the study showed that most of the diet provision met the South Asian standards. Though, there was a variation in diet of some animals but the caloric values were equalized by providing any alternate food. Owing to the observation made it was concluded that the timing, hygienic conditions and dispersal ways of diet were overall satisfactory, however feeding enrichment was least observed.

**Keywords:** Lahore Zoo, diet provision, captive conditions, comparison with standards.

### INTRODUCTION

Zoo is a term used for zoological garden. A zoo can be defined under the legal definition of zoo, "Zoo means all permanent establishments where animals of wild species are kept for exhibition to public for 7 or more days a year". In addition, the animal welfare act of United States of America defines zoo as follows, "Zoo refers to park, enclosures or premise where animals are exhibited for public, irrespective of compensation (Animal welfare act, 1996).

Preserving animals in the zoo has turned to be a capital tool for conservation of enthralling, yet threatened species of the world (Hosey and Melfi 2013). Zoos have emphasized on actions taken for conservations of animals, owing to increased concern of biodiversity loss and animal welfare (Delacour, 1947). Since 1960's, conservation of endangered and threatened species is primordial concern of zoological gardens (Mench and Kreger, 1996).

Energy is prerequisite for the cellular and metabolic mechanism to be carried out in all living things, for physiological process to be operated and in order to attain other life history activities, involving reproduction and growth. Energy is obtained as food, and is lost from body again when utilized for behavioral and psychological activities. Excessive energy is stored as fat when food intake is increased. Contrarily, if energy consumed is less than required, energy is released by metabolizing the fats stored (Hosey and Melfi 2013).

A nutritionally balanced diet comprising of adequate amount of minerals, carbohydrates, lipids, proteins, vitamins, fiber and water is required by the animals. Quantity required differ from one individual to another depending upon factors that encounters age, sex, physical activity and state of health (Rees, 2011). Furthermore, nutrient supplement also contribute for the energy required for growth activity and reproduction (Rees, 2011).

Energy and nutrient requirements of an animal must be satisfied by the food offered, which possess variation depending upon the following factors:

**Age** – More energy and nutrients required by young ones (for growth) than adults with similar size.

**Sex** – Often larger males than females as in polymorphic species, so demands more food.

**Health** – Dietary needs may alter in sick or diseased animals, for example if animal is diabetic or has a deficiency disease.

**Activity level** – More energy required by active animals comparative to inactive animals.

**Environmental temperature** – More energy required by Homeotherms than poikilotherms with same size for maintenance of body temperature (Rees, 2011).

Therefore, an individual animal's physiology, behavior, metabolism, and anatomy are the key factors upon which nutritional requirements to be provided largely depends. Metabolic and energy demands of

animals must be met by the diet upon which animals are being fed at zoo. In other words, the amount of food required and its nutritional composition should be the main concern of zoos.

Beside grasses and hays, foodstuffs consumed by zoo animals are categorized into three types which include:

**Produce-** food tinned or frozen foodstuff, fruit, vegetables, meat, fish, dairy produce etc.

**Commercial formulations-** comprises of formulated diet as seed mixes for birds as well as foodstuffs such as pelleted food or concentrates.

**Browse-** plant material other than grass or hays which includes leaves and willow branches (Hosey and Melfi 2013).

Obesity and malnutrition are two major disorders resulting from nutritional deficiencies. Malnutrition results from nutrition deficiency food shortage in the diet which can give rise to disease (Hosey and Melfi, 2013).

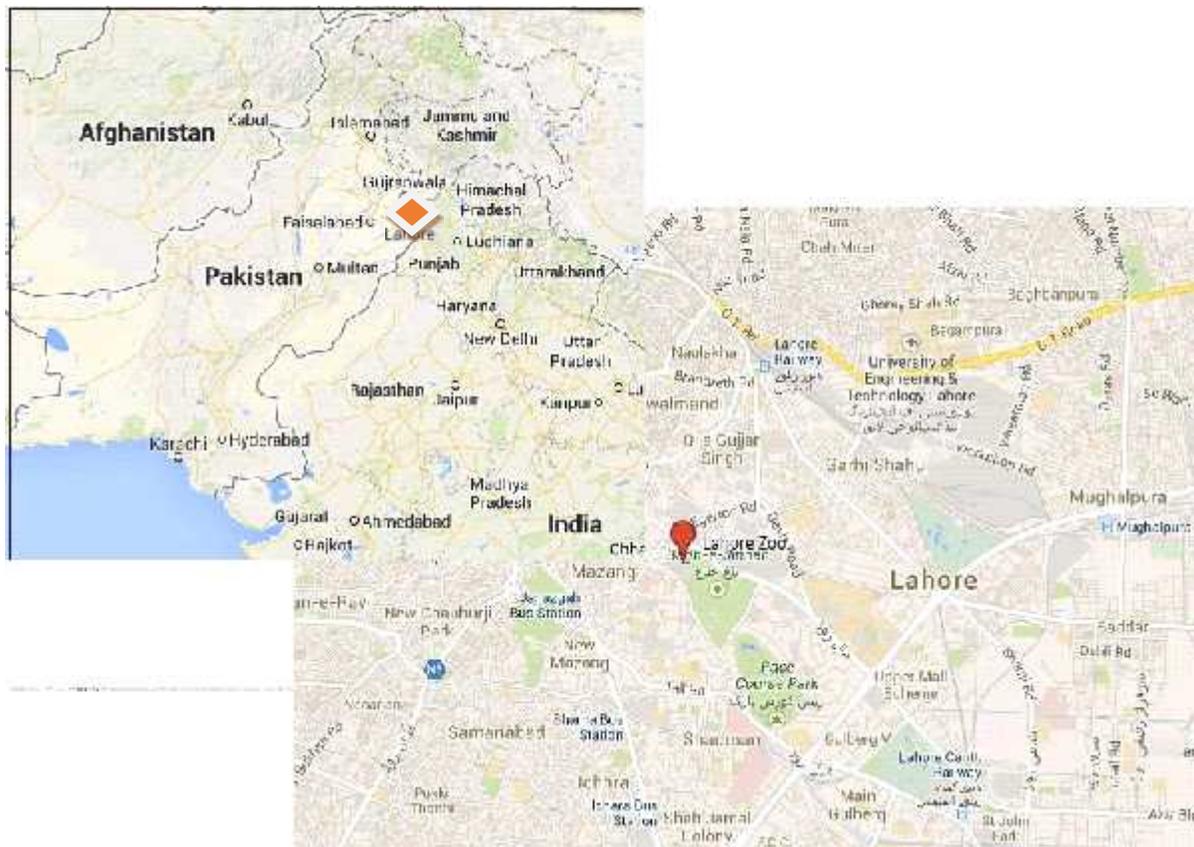
Zoos of Pakistan are also being transformed just like the ones during 1980's in India, when zoos were not even enlisted properly (Mitchell, 1929; Buchanan and

Gibbons, 1906). Lahore Zoological Gardens is the Pakistan's oldest zoo, established in 1872 under the supervision of Government of Punjab with the endowment offered from the Lahore municipality (D'Oyly, 1820; Parks, 1850).

Our goal is to have critical analysis of the diet provided to animals in captive conditions at Lahore zoo, to determine whether nutritional requirements are met and further comparison of the diet provided at Lahore zoo with South Asian Zoo standards. To make suggestions and recommendations for the diet amelioration for animals present at Lahore zoo.

## MATERIALS AND METHODS

**Data Collection:** Lahore Zoo (31.556006° N; 74.325959° E) is one of the oldest zoos in the world, among them it occupies third rank i.e. 3<sup>rd</sup> oldest zoo, established in 1872 covering land area of 25 acres (10 ha) (0.1km<sup>2</sup>) located at Mall Road, Lahore Pakistan (Figure 1). The Zoo harbours about 914 animals of 121 species.



**Figure 1: Lahore Zoo Map**

Data regarding the diet provided to the animals was provided by Administration and Dietitian at Zoo.

Moreover personal observations were made regarding the specification of diet given. Data was collected regarding

the type and amount food provided to the various animals present in Lahore Zoo which was later on compared with the South Asian Zoo standards (SAZARC Training: Zoo Population Management & Zoo Nutrition, 2004).

Zoo was visited three days a week, for continuous six weeks, 6 hours a day, from 9am to 3pm. Observations were made regarding time at which diet was provided, amount of diet, food presentation and dispersal ways, animal's preference for food, induction of any novel object, presence of any feeding enrichment technique, hygienic conditions regarding food given and enclosures, left over by animals and how many times food was given. Furthermore, it was observed that whether visitors offer any eatable to the animals kept in enclosure or throw garbage and polythene bags in the enclosures that may be injurious to their health leading to their death. It was monitored whether any vegetation capable of harming animals was kept out of reach or not. Observation was also made that whether food provided to animals were of nutritive value, quantity provided (bearing in mind the condition size, condition and age) of each animals satisfied their appetite and animals undergoing course of veterinary treatment such as pregnant animals were given any special diet or not.

## RESULTS AND DISCUSSION

Zoo is not a natural habitat for wild animals; although it strives to be as near to natural as possible. Pivotal consideration in welfare of zoo animals is to provide them with a healthy diet fulfilling broader aspects of natural feeding ecology as possible. It is therefore important to maintain a balanced healthy diet for animals kept in captivity so they can keep their strength and vitality. A variety of foods is given to the animals according to their nutritional requirements depending upon size, age, sex and physiology.

In regular management of any zoo, food is evidently an indispensable component. Comprehensively, nutrition occupies not only fundamental importance in animal's welfare but is also crucial for fertility and longevity. Promotion of normal feeding behavior and physiology chiefly encounters factors as physical form of food, food presentation and dietary diversity may be important. Good zoos always have consideration towards provision of optimum nutrition, which exceeds merely from the provision of adequate food and water. Apart from parasite and infections that threatens animal's health; insufficient diet provision in captivity is also a reason. Diet provision to zoo animals may vary from zoo to zoo and area to area although there are norms for diet which should be followed to maintain their health and vigor.

From the data recorded by Lahore zoo the

quantity of the food supplied to animals was quantified as units of grams and kilograms and nutrition chart was prepared in which the quantity to food was converted into caloric values. The difference between the diets given at Lahore zoo was compared to that of South Asian Zoos and the findings were as below.

In the case of carnivores it was evaluated that caloric standards were strictly being followed at Lahore zoo. The caloric need of carnivores like African Lion, Python, Asiatic Wolf, and Gaviol was more or less accurately fulfilled. As for Asiatic Black Bear the nutritional value of the given diet ranged from 3600 to 5595 calories per day. This value showed a sheer difference of caloric range when compared with South Asian zoos i.e. 4000 to 8190 calories per day.

The nutritional value for the diet of herbivores was evaluated in terms of calories per day that included Black Buck, Elephant, Giraffe, Double-humped camel and Samber deer. The South Asian standards for the diet chart of some animals was not found in the available literature and active data bases for example Llama, Giraffe, Double-humped camel etc. When the diet was evaluated, the caloric range of the food provided at Lahore zoo met the caloric requirements as set by South Asian standards, with the exception of diet in case of elephant where caloric value ranged from 526260 to 2920300 calories per day which was more than the nutritional value of the diet provided to the animals at other South Asian zoos (approximately 412000 calories per day).

The evaluation and comparison of diet chart for the primates at Lahore zoo with South Asian standards showed that standards were strictly followed which met and satisfied the per day caloric requirements of the animals.

Evaluation of diet provided to birds exhibited some variations. For example, diet provided to cassowary at Lahore zoo contained 34672.5 calories but comparatively the diet recommended by South Asian standards must contain 19700 cal. This shows that diet provided to zoo animals was higher in calories comparatively. Similar was the case with emus. In case of Ostrich, diet provided by zoo had 47752.5 cal. but South Asian standards, commend to provide a food having 335820 cal. only. The diet had more caloric count than required.

**Diet provided to birds:** The diet includes poultry feed, parched grams, fruits, Bread or Chappati, sunflower seeds, Canary seeds (Kangni in local language), and Millet (Bajra in local language).

The amount of food items varies from bird to bird and is summarized in Table 1 below:

**Table 1. Summary of diet provided to the birds at Lahore zoo and their calorific values**

<b>Animal</b>	<b>Diet provided at Lahore zoo</b>	<b>South Asian Standards</b>
<b>Partridge</b> <i>Chamaecristafasciculata</i>	50-200 g Bajra <b>Calories 720</b>	75kg feed breeder, millet, 10g onions, Garlic, 30g Spinach, 20 g oil seed <b>Calories 316</b>
<b>Black swan</b> <i>Cygnus atratus</i>	275-500 g Poultry feed, 100-150 of Parched grams, 500 g of fodder <b>Calories 3760.5</b>	175g feed, 175 g roasted grams, 30g onion, 100g Spinach <b>Calories 1433.5</b>
<b>Crane</b> <i>Grus americana</i>	200-300 g of Poultry feed, 50-150 g of Parched grams, 100 g fodder <b>Calories 1876.5</b>	200g feed, 50g Roasted grams, 100g Spinach <b>Calories 764.5</b>
<b>Shell duck</b> <i>Tadornaferruginea</i>	100-200 g of Poultry feed, 100-150 g of Parched grams, 100 g Fodder <b>Calories 1657.5</b>	200g feed, 50g Roasted grams, 100g Spinach <b>Calories 754.5</b>
<b>Duck Murghabi</b> <i>Anascrecca</i>	50-150 g of Poultry feed, 100-150 grams of parched grams <b>Calories 1209</b>	100-200g feed, Roasted grams, 100g Spinach <b>Calories 1635</b>
<b>Bar-headed goose</b> <i>Anserindicus</i>	100-250 g of Poultry feed, 200-300 g of Parched grams <b>Calories 1428</b>	100-250g feed, 50g Roasted grams, 100 g Spinach and Chapatti <b>Calories 868.8</b>
<b>Turkey (Peru)</b> <i>Meleagrisgallopavo</i>	200-300 g of Poultry feed, 100-200 g of Parched grams <b>Calories 1428</b>	250g feed, 100-50g Roasted grams, 100 g Spinach and Chapatti <b>Calories 1250.75</b>
<b>Mallard</b> <i>Anasgalericulata</i>	200-300 g of Poultry feed, 50-150 g of Parched grams <b>Calories 1537.5</b>	250g feed, 50g Roasted grams, 100 g Spinach and Chapatti <b>Calories 830.25</b>
<b>Pheasants</b> <i>Phasianuscolchicus</i>	125-350 g Poultry feed, 50-150 g of Parched grams, 50-150 g of Bajra, 200 g fruits <b>Calories 1494.5</b>	125g feed breeder, 20g onions, Garlic, 60g Spinach, 30g Oil seeds <b>Calories 299.25</b>
<b>Indian moorhen</b> <i>Gallinulachloropus</i>	250-300 g fish and meat <b>Calories 701.25</b>	100-350g minced buffalo meat and fish <b>Calories 192.375</b>
<b>White stork</b> <i>Ciconiaciconia</i>	500-1kg Fish <b>Calories 652.5</b>	1-1.5 kg Buffalo meat <b>Calories 1050</b>
<b>Spoon bill</b> <i>Palatalea alba</i>	250-300 g Fish <b>Calories 239.25</b>	100-150g minced buffalo meat and fish <b>Calories 213.75</b>
<b>Pelican finches</b> <i>Pelecanusonocrotalus</i>	1-150 g Fish <b>Calories 130.5</b>	150-300g Fish <b>Calories 195.75</b>
<b>Buzzard</b> <i>Buteobuteo</i>	250-300 g Beef <b>Calories 750</b>	150-250g Chicken/ Mutton <b>Calories 735</b>
<b>Pigeon</b> <i>Columba livia</i>	50-70g Bajra <b>Calories 252</b>	50g feed, millet, 10 g onion and garlic, 30g Spinach <b>Calories 309.4</b>
<b>Gallinule</b> <i>Gallinulachloropus</i>	125-200 g Bajra <b>Calories 720</b>	200 g Bajra, 10 g onion and garlic, 30g Spinach <b>Calories 730.9</b>
<b>Peafowl</b> <i>Pavocristatus</i>	300-400 g of Poultry feed, 100-200 g of Parched grams <b>Calories 1647</b>	30g feed breeder, 30g onion, Garlic, 100g Spinach, 60g Oil seeds <b>Calories 165.2</b>
<b>Mandarin duck</b> <i>Aix galericulata</i>	150-250 g of Poultry feed, 50-150 g of Parched grams <b>Calories 1025</b>	250g feed, 50g Roasted grams, and 2 Chapattis <b>Calories 845.8</b>
<b>Hawk</b> <i>Buteojamaicensis</i>	250-300 g Beef <b>Calories 750</b>	150-200g Chicken/Mutton <b>Calories 735</b>
<b>Owl</b> <i>Tyto alba</i>	250-300 g Beef <b>Calories 750</b>	250g chicken/Mutton <b>Calories 735</b>

**Diet provided to Ungulates and Herbivores:** There are 18 ungulates species present in Lahore Zoo. The diet provided to them encounters Chokar (local language), Oats, Javi, Fodder, Fruits, Chapatti, and Cotton seed cake etc.

**Table 2. Diet provided to ungulates and herbivores in Lahore Zoo in comparison with South Asian standards**

<b>Animal</b>	<b>Diet provided at Lahore zoo</b>	<b>South Asian Standards</b>
<b>Pig/wild boar</b> <i>Sus scrofa</i>	6-8 kg fruit, 1-3 kg Chapatti <b>Calories 118500</b>	1.5-2grams Soaked grams math, 1-2 kg fruits and vegetables <b>Calories 15911.74</b>
<b>Llama</b> <i>Lama glama</i>	2.5-3.5 kg fruit, 250-350 g Chappati, 4-6 Fodder, 1-2 kg Parched grams <b>Calories 40425.34</b>	This animal does not belong to South Asia
<b>Giraffe</b> <i>Giraffe camelopardalis</i>	2.5-3.5 kg fruit, 250-350 g Chappati, 15-20 kg of Fodder 1-2 kg of Parched grams, 1-2 kg Oats, 2-3 kg of Chokar <b>Calories 66021-90700</b>	This animal does not belong to South Asia
<b>Nilgai</b> <i>Boselaphus tragocamelus</i>	2.5-3.5 kg fruit, 250-350 g Chappati, 20-35 kg Fodder, 0.5-1 kg of Parched grams, 0.5 kg Chokar <b>Calories 95600-115970</b>	20-30 kg Chara, 1/2 kg wheat straw, 1/2 kg Wanda, Vitamin mineral iodine salt <b>Calories 67800-103950</b>
<b>Samber deer</b> <i>Rusauinicolor</i>	15-20 kg of fodder, 0.5-1 kg parched grams <b>Calories 73670</b>	1.5-2kg of grams, 3-5 kg Green Fodder <b>Calories 28690</b>
<b>Urial deer</b> <i>Hyelaphusporcinus</i>	4-7 kg fodder, 250-500 g parched grams, 250-350 daal channa <b>Calories 4078.73</b>	5kg Chara, 1/2 kg wheat straw, Vitamin mineral iodine salt <b>Calories 18645</b>
<b>Mouflon sheep</b> <i>Capra algargrus</i>	4-7 fodder, 250-500 g parched grams, 250-350 g Daal channa <b>Calories 4078.73</b>	5-6 kg Chara, 1/2 kg wheat straw, Vitamin, mineral iodine salt and grams <b>Calories 28815</b>
<b>Chinkara deer</b> <i>Gazella gazelle</i>	3-5 kg fodder, 250-350 g parched grams, 250-350 g Daal channa <b>Calories 30294.5</b>	4kg Chara, 1/4 kg wheat straw <b>Calories 14407.5</b>
<b>Double humped camel</b> <i>Camelus dromedarius</i>	20-30 kg fodder, 1-2 kg parched grams, 1-2 kg of daal channa, 1-2 kg oats, 10-15 javi, 1-2 kg choker <b>Calories 84150-14380</b>	This animal does not belong to South Asia
<b>Hippopotamus</b> <i>H. amphibious</i>	20-30 kg fruit, 120-160 kg fodder <b>Calories 1346700</b>	Dry concentrate feed 5-7 kg, Vegetables and 50-100kg green grass <b>Calories 394650</b>
<b>Zebra</b> <i>Equus quagga</i>	10-15 kg fodder, 2-3 kg parched grams, 2-3 kg daal channa, 1-2 kg oats, 4-6 kg javi, 1-2 kg choker <b>Calories 76240</b>	This animal does not belong to South Asia
<b>Black buck</b> <i>Antelope cervicapra</i>	4-6 kg fodder, 250-350 g parched grams, 250-350 kg daal channa <b>Calories 15827.5-26574.5</b>	5kg Chara, 1/2 kg wheat straw, Vitamin mineral iodine salt <b>Calories 18070</b>
<b>Porcupine</b> <i>Hystricomorph hystricidae</i>	250-350 g chapatti, 1-2 kg fruit <b>Calories 16740</b>	100-150 g grams, 500-700 g fruits and vegetables <b>Calories 6445.5</b>
<b>Elephant</b> <i>Loxodonta africana</i>	20-30 kg fruit, 3-10 kg chapatti, 150-250 kg fodder, 1-5 kg parched grams, 2-5 kg javi, 1-5 kg oats <b>Calories 526260-2920300</b>	Total 3 kg sugarcane, 100 kg fodder, 10 kg gur, 10 kg fruit, 10 kg flour, half kg salt <b>Calories 412000</b>

**Diet provided to Carnivores:** The diet provided includes Milk, Beef, Chicken and Offal. Diet variation exists in them depending upon age, size and sometimes climatic conditions.

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**Table 3: Diet provided to Carnivores in Lahore Zoo in comparison with South Asian standards**

<b>Animal</b>	<b>Diet provided at Lahore zoo</b>	<b>South Asian Standards</b>
<b>African lion</b> <i>Panthera leo</i>	7-10 kg beef, 1 half kg packet of milk] <b>Calories 175,00-25,210</b>	7-10 kg beef or mutton, 1 liter milk <b>Calories 17,500-25,420</b>
<b>Common leopard</b> <i>Panthera pardus</i>	4-5 kg beef, 3 half kg packets of milk <b>Calories 25210</b>	4-5 kg beef or mutton, 1/2 liter milk <b>Calories 25294</b>
<b>Asiatic wolf</b> <i>Canis lupus</i>	1.5-2.5 kg beef, 1 half kg packet of milk <b>Calories 3750-6460</b>	1-2 kg meat, 1/2 liter milk, 2 chapattis <b>Calories 2500-5450</b>
<b>Jackal</b> <i>Canis mesomelas</i>	1-2 kg beef <b>Calories 5000</b>	1.5 kg beef and mutton, 1/4 liter milk, 2 chapattis <b>Calories 9336</b>
<b>Otter</b> <i>Lontra felina</i>	1-2 kg fish <b>Calories 1740</b>	2-2.5 kg fish, 2 pieces of carrot <b>Calories 2225</b>
<b>Hyena</b> <i>Crocuta crocuta</i>	2.5-3 kg beef, 2 half kg packets of milk <b>Calories 7920</b>	1.5-2 kg buffalo meat <b>Calories 1700</b>
<b>Civet cat</b> <i>Paradoxurus hermaphroditus</i>	0.5-1 kg beef, 1 half kg packet of milk <b>Calories 2710</b>	1/2 kg beef, 1/4 liter milk <b>Calories 2426</b>
<b>Jaguar</b> <i>Panthera onca</i>	5-7 kg beef, 1 half kg packet of milk <b>Calories 17710</b>	5-6 kg beef, 1 liter milk <b>Calories 15294</b>
<b>Gavial</b> <i>Gavialis gangeticus</i>	0.4-2.5 kg beef <b>Calories 625-6250</b>	2-4 kg fish <b>Calories 1740-5740</b>
<b>Asiatic black bear</b> <i>Ursus americanus</i>	6-7 kg fruit, 1.5-2 kg Chapatti <b>Calories 3600-5595</b>	250 g chapatti of gram flour, 2 liter milk, 500 g rice, fruits and bread <b>Calories 4000-8190</b>
<b>Python</b> <i>Python anchietae</i>	1-1.5 kg rabbit or chicken per week <b>Calories 1750-2625</b>	White mice, rat, rabbit as per requirement <b>Calories 1750-3000</b>
<b>Black leopard</b> <i>Panthera pardus</i>	3-4 kg mutton, offal <b>Calories 20580</b>	3-5 kg buffalo meat <b>Calories 25202</b>

**Diet Provided To Primates:** There are six species of primates present in zoo. The diet provided to them encompasses Milk, Fruits, Bread or Chapatti and Parched grams etc. Amount of diet offered varies from one animal to other depending upon sex, age, physiology and some other factors.

**Table 4. Diet provided to Primates in Lahore Zoo in comparison with South Asian standards**

<b>Animal</b>	<b>Diet provided at Lahore zoo</b>	<b>South Asian Standards</b>
<b>Rhesus/pig tail monkey</b> <i>Macaca mulatta</i>	1-1.5 kg fruits, 250-300 g Chappati <b>Calories 1515</b>	1/2 -1 kg fruit, 2 Chapatti, 100g grams and sugarcane <b>Calories 1662</b>
<b>Languor</b> <i>Canis mesomelas</i>	1.5-2 kg fruits, 250-300 g Chappati <b>Calories 1515</b>	150g of soaked grams, 100ml of milk and 50g of nuts <b>Calories 1259</b>
<b>Chimpanzee</b> <i>Pan troglodytes</i>	3-4 kg fruits, 250-400 g Chappati, 3-4 kg milk <b>Calories 1743</b>	2-4 kg fruits, 2-3 Chapatti, sugarcane, 100-200 g grams <b>Calories 2689</b>
<b>Mandrill/baboon</b> <i>Mandrillus sphinx</i>	1.5-2 kg fruits, 250- 400 g Chappati <b>Calories 1575</b>	2kg fruits. 2 -3 Chapatti <b>Calories 1395</b>

**Conclusion:** Foremost, personal observations made at Lahore zoo regarding diet provided and its various aspects that encounters time at which food being provided, dispersal techniques, food condition and enrichment, showed that enrichment techniques were least employed which may lead to refusal of food by animals, however other factors with respect to diet were

satisfactory. Furthermore, the diet provision to zoo animals followed the standards set by South Asian zoos to a larger extent in terms of quantity and items variation with respect to season as in case of carnivores and primates e.g. African lion was given 7-10 kg beef, 1 half kg packet of milk by Lahore zoo, whereas, standards recommend to provide 7-10 kg of beef or mutton, 1 liter

milk. Although variations were observed in case of some animals as in case of birds and some herbivores e.g. Pigeons were made to be fed on food having 252 cal. by Lahore zoo, whereas South Asian standards mentioned a food having 1610.9 cal. to be appropriate.

**Recommendations:** Diets devised for zoo animals must meet their nutritional and health requirements, but also, if possible, their behavioral requirements, because foraging for and processing food are activities that often occupy a large part of an animal's time in the wild. Dietary problems can lead to poor health or even poisoning if inappropriate food items, such as toxic plants or plastic bags are consumed. Hence, deliberate feeding (for example, soft drink cans or beer bottles given to chimpanzees; penguins ingesting coins or lollipop sticks) of animals offered by visitors should be strictly prohibited that may be fatal. Zoo enclosure design should, ideally, ensure that grazers and browsers have sufficient vegetation within their enclosure to meet their needs as zoo grounds can be a great source for animal feed. Zoos also need to take measures to exclude pests such as rats, mice, and cockroaches from food storage and preparation areas. Many zoo animals are fed once or twice a day, but as animals in the wild often forage for a large part of the day, therefore better to feed more often and providing a greater number of smaller feeds throughout the day may be a useful form of enrichment. Moreover, Zoos should incorporate seasonal variation in diet to enhance both physical and psychological condition of animals kept in captivity.

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