EVALUATION OF HUSBANDRY PRACTICES IN CAPTIVE ZOO MAMMALS IN KERALA

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"EVALUATION OF HUSBANDRY PRACTICES IN CAPTIVE ZOO MAMMALS IN KERALA"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis, entitled **"EVALUATION OF HUSBANDRY PRACTICES IN CAPTIVE ZOO MAMMALS IN KERALA"** is a record of research work done independently by **Dr. Biju .S.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

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Introduction

1. INTRODUCTION

The exhibition of wild animals, has a universal appeal and there is a constant increase in zoological gardens in many parts of the world. *'Menageries'* have continued to flourish since the Indian and Egyptian civilizations of about 2500 BC and an increase was noted during the renaissance in many European countries. The first true animal collection set up for the public was in the *'Jardin-des-Planta'*, Paris in 1794. The first zoo in India was reported to be the private collection of a variety of birds at the Marble Palace Zoo, Calcutta in 1854. The zoo movement in India got an impetus after independence, and several large zoos were established by the Central and State governments. Today there are about 350 animal collections in India, visited by more than 50 million people annually (National Zoo Policy, 1998). Current concerns about the rights and welfare of animals; focus on the failure to meet the behavioural and psychological needs of the animals in zoos all over the world. Emphasis is more on the better care of the animal's emotional well being also.

The zoological gardens of today, has progressed far beyond the scope and status of the mere *'menagerie'*. The changing world conditions that endanger the fauna of many areas have brought the zoos into new prominence as centres of biodiversity conservation. The United Nation's Convention on biodiversity identified the role of zoos in *ex-situ* conservation of genetic

resources. The objective of conservation can be achieved by captive breeding of endangered species and their eventual re-introduction into natural habitats. The captive animals are resources for basic and applied research, which provide information on biology and contribute knowledge to assist conservation in the wild. In addition, zoos are powerful education centres aiding conservation. They have immense potential for creation of conservation awareness.

Enclosure enrichment and correct diet in captivity are important factors which influence the success of captive births in a zoo (Barat and Poyyamoli, 2000). Proper nutrition plays an important role in the successful maintenance and propagation of wild animals in captivity and sub-optimal levels of nutrients can adversely affect an animal's ability to cope with stress, immunity to infectious diseases and may contribute to development of non-infectious disorders (Wilson, 1996). The environmental quality for captive mammals should not just be assessed by the absence of abnormal behaviours, but by the extent to which it meets their psychological needs (Poole, 1992). Environmental enrichment encourages natural behaviour and improves the animal's psychological well being. Hence research on environmental enrichment will enhance the quality of life of zoo animals. Behavioural enrichment research are in primary stage for Indian animals.

In India while we have some well-designed and efficiently managed zoos; many are still not in a position to provide the conditions congenial to the animals exhibited, nor are they equipped to discharge the multifarious functions

envisioned in a modern and enlightened context. Many studies have been made in the development of maintenance methods that will satisfy the physical and psychological needs of the animals. Studies on the scientific husbandry practices of the mammals in the zoos of Kerala, especially for indigenous fauna are meager. These are critical areas which determine the welfare of zoo animals. So a systematic study on the existing husbandry practices in captive zoo mammals in Kerala was undertaken with the following objectives.

1. To assess the existing feeding, housing and management practices in zoos of Kerala.

2. To identify the problems and prospects of scientific management of zoo mammals.

3. To suggest suitable recommendations in the management of captive zoo mammals in Kerala.

Review of Literature

2. REVIEW OF LITERATURE

2.1 Classification of mammals

Mammals are classified into three groups, based on the difference in the methods which they follow in caring their young *viz*., the egg-laying mammals or monotremes, pouched mammals or marsupials and the placental mammals. These groups are again divisible on the basis of relationships and affinities into Orders, Families, Genera and Species. Of the seventeen such natural orders of placental mammals, thirteen are represented in the Indian region including Rodentia, Primates, Insectivora, Pholidota, Lagomorpha, Chiroptera, Cetacea, Sirenia, Carnivora, Proboscidea, Perissodactyla and Artiodactyla. The order may be divided into sub-orders and the family is the subdivision of the sub-order (Prater, 1971).

The phylum mammalia is divided into three classes namely Allotheria, Prototheria and Theria, and the class Theria is further divided into three subclasses, Pantotheria, Metatheria and Eutheria. Class Eutheria is further sub-divided into 16 orders including Insectivora, Dermoptera, Chiroptera, Edentata, Pholidota, Cetacea, Carnivora, Tubulidentata, Lagomorpha, Proboscidea, Rodentia, Hyracoidea, Sirenia, Perissodactyla, Artiodactyla and Primates. The order Perissodactyla include the two families, Equidae and Rhinocerotidae, and the order Artiodactyla can be divided into three groups, including Bovidae, Cervidae and the third group, including pigs, peccaries and hippopotamuses

with single chambered stomach and the tylopoda which are pseudoruminants (Agarwal, 1996a).

Mammals have been thoroughly described and classified and they include approximately 5,000 living species. There are 18 living orders of mammals, and mammals are first divided into two subclasses, the Prototheria and the Theria. The subclass Theria are subdivided into two living infraclasses, the Metatheria and the Eutheria and Eutherians constitute the vast majority of living mammals arranged in 16 orders *viz.*, Insectivora, Chiroptera, Dermoptera, Edentata, Pholidota, Tubulidentata, Primates, Rodentia, Lagomorpha, Cetacea, Sirenia, Carnivora, Hyracoidea, Proboscidea, Perissodactyla and Artiodactyla. The mammals differ widely in their mode of life and in their adaptations to environment and based on that, they can be divided into groups *viz.*, egg laying mammals, pouched mammals, insect eating mammals, flying mammals, toothless mammals, other ant eaters, gnawing mammals, carnivorous mammals, cetacean mammals, primates and hoofed mammals (Kotpal, 2000).

2.2 Feeding of zoo mammals

In case of monkey troops and herbivores with dominant males; the food supplied should be in excess of the requirement to ensure that the subordinate animals also get their share (Naidu, 1986).

Zoos develop animal diets based on the diet used for similar domestic species and on diets used by other zoos. Modifications are made, considering budget restrictions, staff schedules and feed stuff availability, and it is important to review the diet regularly (Wilson, 1996).

2.2.1 Rodents

The rodents are considered omnivorous, although most species primarily feed on vegetable matter. A diet formulated for omnivorous animals has been fed to most rodents at the Basle Zoological Gardens, with 25 per cent crude protein, 7.5 per cent crude fat, 2.25 per cent crude fibre, 0.8 per cent calcium and 0.7 per cent phosphorus (Clark *et al.*, 1978).

Karsten (1987) stated that squirrels are not strictly herbivores and many rodents require some animal protein in their diet. He advised to provide hard materials like wood or antlers for gnawing to rodents to keep the growing incisors in good condition.

Porcupines at Nandankanan Biological Park were provided with 100 ml milk, 100 g cooked rice, 250 g ripe banana, 200 g sweet potatos, 50 g brinjal, 100 g groundnut, 50 g pumpkin, 50 g Bengal gram and 50 g of maize (Acharjyo and Patnaik, 1990b).

Xavier *et al.* (1996) analysed the stomach contents of a Small Travancore Flying Squirrel, and the contents weighed 100 g comprising of chewed leaves, buds, seeds, seed coats, fruit pulp, barks and parts of an insect.

About 50 per cent of the stomach contents consisted of fruit pulp, 35 per cent comprised chewed leaves, flowers and buds and the rest was bark, seeds and unidentified plant materials.

Kranz (1999) suggested that sciurids can be easily maintained on commercial rodent chow diet or a plant based omnivore dog food supplemented with seeds, nuts, grains, fresh fruits and vegetables. Hard shelled nuts are nutritionally valuable as well as aiding in tooth wear.

2.2.2 Primates

Martin (1978) mentioned that the New World primates need more protein than the Old World primates and a diet with 15 per cent protein is adequate for Old World primates and 25 per cent protein for New World primates. The primates can thrive well on diets with fat levels from less than 5 per cent to as much as 25 per cent. It was also noted that the energy requirement of adult Rhesus Monkey is 100 k.cal/kg and estimates for other species should be increased or decreased according to size.

Karsten (1987) pointed out that it is difficult to supply every individual in a primate group with its fair share of food due to their structure of hierarchy. They also have the habit of wasting food, when too much is offered at once, as they play with their food and soil it. They are typical long period feeders and so it is advisable to feed them with small amounts through out the day.

Acharjyo and Patnaik (1994) reported that Lion-tailed Macaques in Nandankanan Biological Park were provided with diet consisting of a variety of fruits, vegetables, greens, bread, milk and cooked rice.

Manjramkar (1994) suggested a diet for omnivorous animals including monkeys, apes, bears, pigs and rodents with 21 to 24 per cent crude protein, 2 to 4 per cent crude fibre and 6.5 to 9 per cent crude fat.

Mathen (1994) mentioned that the primates need three to five per cent of fat in the diet and the protein supplied should be of high biological value. The Old World primates need 15 per cent of protein and New World primates, 25 per cent protein in their diets. It was also advised to give glucose biscuits in addition to bread, if the caloric intake is found insufficient.

On *ad libitum* feeding, the infants of smaller New World monkeys require 300-500 k.cal energy/kg/day as compared to 200-300 k.cal energy/kg/day by larger Old World monkeys and the primates have relatively low requirements for protein and can adjust to 10 per cent total dietary fat and also on diets much higher in fat (Agarwal, 1996b). It was also mentioned that the diets for primates formulated by National Institute of Health had an average nutrient concentration of 17.80 per cent crude protein, 2.61 per cent crude fibre, 5.27 per cent ash, 60.77 per cent nitrogen free extract, 0.95 per cent calcium and 0.53 per cent phosphorus.

Stump-tailed Macaques in Sri Venkateswara Zoological Park were fed a diet of 100 g bread, 75 g vegetables, 250 g bananas, 50 g vegetable leaves, 100 g Bengal gram and 210 g fruits for each animal (Kumar and Raghavaiah, 1996c).

2.2.3 Mustelids and Viverrids

Civets are omnivores feeding on small vertebrates and insects as well as a considerable amount of vegetable food. Palm Civets feed primarily on fruits along with small vertebrates and insects available. Traditional zoo diets of viverrids consisted of chopped or minced meat or chicken supplemented with vitamins and mineral mixture. Oranges, apples, bananas, chopped carrots, potatoes, chopped half boiled egg, whole mice or baby chicks were given depending on availability (Rettig and Divers, 1978).

Xavier and Balakrishnan (1993) reported that the different food materials offered to the captive civets included, milk, plantain, rice, chevon, beef, egg, fish, frog, rat and garden lizards. Ninety eight per cent of owners keeping civets for civet oil production fed garden lizard, egg, chevon and plantain once or twice a week. Two units offered chevon every day and six per cent gave small fishes and frogs.

Iyer (1997) mentioned that eggs, mutton, chicken, fishes, milk and plantain are delicious food items for the civet. Besides frogs, calotes and cockroaches were also given as food.

2.2.4 Canids and Hyenas

Adult hyenas consume about four per cent of its body weight per day. When they are fed on muscle or organ meat only, it is necessary to supplement the required minerals and vitamins, especially vitamin A and calcium. Occasionally whole animals such as rabbits can be given as appetite stimulants, especially when the animals go off feed without any apparent reason (Divers, 1978).

Canids can be maintained on commercial dog foods or special carnivore diets and deficiency are likely in canids feeding on muscle or organ meat only. Metabolic bone disease is a common problem in canids fed on deficient diet (Heller, 1978).

Manjramkar (1994) suggested a diet for carnivorous animals with 28 to 31 per cent crude protein, 5 to 7 per cent crude fat and a maximum of 1.5 per cent crude fibre.

Mathen (1994) mentioned that the canids need 80 to 90 kilocalories per kg body weight and enhanced by 85 to 100 kilocalories during gestation. The protein in the diet should supply roughly 25 per cent of the energy, which comes to about 4 to 5 g/kg body weight. Cooked carbohydrates can form 65 per cent of the dry matter of the diet. It was also noted that in zoos, jackals were fed on 1 kg beef which satisfy their protein needs, and a supplement along with some cooked rice has to be provided as a source of energy.

Jayathangaraj *et al.* (1998) mentioned that calcium and phosphorus are vital elements for hyaenids in the wild and so their imbalance in dietic regimens might result in derangements in the metabolism of these elements.

2.2.5 Bears

Sloth Bears in Amsterdam Zoo were given a daily diet of 1500 g mixture of meat, oils, vitamins and minerals, 500 g vegetables, 500 g apples, 500 g carrots, 500 g fish, 1000 g ground meat and 300 g of bread (Jacobi, 1975).

Most bear species depend on energy rich diet of plant matter. Sloth Bears in captivity can be fed on commercial dog diet or an omnivorous diet supplemented with fruits and vegetables, and as they are fond of honey, it can be offered two or three times a week (Mathen, 1994).

Chakraborty *et al.* (1998) reported that Himalayan Black Bear (*Selenarctos thibetanus*) at Jawaharlal Nehru Biological Park were fed with 700 g bread, 500 ml milk, 500 g carrot, 500 g sweet potato, 250 g potatoes, 250 g apple, four numbers of banana and 20 ml honey in the morning and 700 g rice and 100 g black gram in the afternoon. The diet was also supplemented with calcium and vitamin preparations at certain intervals.

Bear's primary diets should be based upon a nutritionally complete concentrate. Fruits and vegetables may make upto 40 per cent of the diet by weight depending on whether dry or canned food is the base diet. Brown,

Black and Polar Bears may be fed fish at approximately 20 per cent of the overall diet. Bears should consume 1.5 to 2 per cent of their body weight per day in dry matter and prefer high moisture foods and may leave some dry food uneaten (Johnson, 1999).

2.2.6 Felids

Tigers at Rotterdam Zoo were fed beef, mutton and lean pork. Horse meat was rarely given and freshly killed rabbits, guinea pigs or young goats were fed regularly. Extra vitamins, a mineral mixture and a calcium-yeast mixture were also included in the diet. Even full grown tigers were not provided more than 8 kg of meat and bones daily. The tigers were fed everyday of the week with no fast day (Bemmel, 1968).

Some typical amounts of meat fed to adult cats per day are : Lion, 4.5 to 5.5 kg; Siberian Tiger, 6 kg; Leopards, 2 to 3.5 kg; Bob Cat, 0.5 to 1 kg (Theobald, 1978).

Jungle Cats at Nandankanan Zoo were provided 650 g of beef with bones, six days in a week and half the quantity on the seventh day. Once in a month, one live chicken was given to each animal instead of beef. Multivitamins were also given intermittently (Acharjyo and Patnaik, 1990a).

According to Shoemaker *et al.* (1993), large felids can be easily maintained on prepared diets from beef or horse products. Whole animal carcasses may be substituted to vary the diet occasionally. It was also

recommended to fast felids one or two days in a week and to feed bones especially from joints or knuckles once or twice a week to maintain good oral hygiene and muscle tone.

Basavaraju *et al.* (1994) noted the diet particulars of Asiatic Lions (*Panthera leo persica*) at Arignar Anna Zoological Park. Male animals were fed 10 kg beef and half litre of milk daily and one live chicken on alternate days. Females were given 8 kg beef and half litre milk daily and one live chicken on alternate days. All animals were provided half kilogram of liver twice in a week.

Mathen (1994) mentioned that the protein requirements of felids are much higher than canids and the ideal diet for felids is whole prey of the size to commensurate with normal prey. Liver being a good source of vitamins may also be included in the diet. It was also mentioned that the leopards can be maintained on 2 to 3 kg beef with vitamin and mineral supplements. A female tiger in captivity weighing 123 kg need 5170 k.cal/day and this can be met by feeding 5 to 6 kg of meat and 200 g beef liver. The lions also need more or less the same quantity of food as of tiger.

Phillips (1994) mentioned commercially prepared carnivore diets or properly supplemented carcass meat to be dietary staple for felids. It was noticed that muscle meat is not a complete diet for felids, as it is limiting in calcium, vitamin A, D and E and hence whole prey is a more adequate diet. When whole prey is fed, it should be sufficiently small in size or fed at suitable

intervals to permit total consumption. It was also pointed out that appetite and body condition of felids improve, if they are fasted one or two days in a week. A female Asiatic Lion averaging 150 kg requires 9000 k.cal/day whereas a 200 kg male requires 11000 k.cal/day.

Cats are obligate carnivores and require high levels of animal protein containing a wide range of essential amino acids and they rely on preformed vitamin A from animal tissues in the diet which occurs predominantly in the viscera of prey, particularly the liver. Whole carcasses are the natural food of cats and provide a complete balanced diet and so small sized species like whole mice, rats, guinea pigs or chicken can be given as the major part of the diet. Large cats can be fed joints of meat on the bone or part carcasses from domestic livestock such as sheep, goats, pigs or horses. No brain and spinal cord material from ruminants should be fed to cats and when they are fed with muscle meat and carcass parts, supplementation with vitamins and minerals, especially calcium is necessary. Small felids should be fed atleast once a day (Felid Veterinary Guidelines, 1996).

Wild felids share the same nutritional requirements as the domestic cat, though some species differ with respect to selected nutrients. Commercially prepared diets eventhough well balanced may lead to obesity and contribute to poor oral health. Feeding bones with meat two days per week provide physical stimulation to teeth and gums and provision of small whole vertebrate prey also provide similar benefits to small sized cats and stimulate natural eating

behaviours. If muscle or organ meat comprises the bulk of diet, vitamin and mineral supplementation is needed. The tradition of fasting captive wild felids one day per week is not appropriate for small cats under 10 kg (Mellen, 1999).

2.2.7 Elephants

The Portland Zoological Gardens has maintained a breeding herd of elephants with a typical daily diet consisting of 45 kg of timothy hay, 1.5 kg oats, 23 kg lettuce, 23 kg carrots, and 0.5 kg rock salt given three times a week. About 180 g of a commercial vitamin-mineral supplement is also fed daily to each elephant (Schmidt, 1978).

Karsten (1987) recommended to feed large amounts of hay to elephants. Amounts of hay for adult elephants are stated as 250-300 pounds per day.

Bist (1996) presented a draft of standards and norms for elephant owners and recommended a minimum of 100 kg of green fodder for an elephant of height below 1.50 m and 150 kg fodder for the 1.50 m to 1.80 m height category and 200 kg for the 1.80 to 2.25 m height category. The elephants above 2.25 m height to be given 250 kg of fodder. Additional concentrates have to be given to all the animals as prescribed by the veterinarian.

Das (1996) detailed the management of elephants in the camps of the Forest department in Kerala. It was noted that the elephants were classified into different classes based on their height. All the classes were given 4 kg wheat, 2 kg horse gram, 200 g salt and 100 g jaggery as rest diet and additional

6 kg ragi as working diet. In addition, class I animals above 244 cm in height were given 20 bundles of 25 kg cut fodder. Class II animals above 213 cm were given 18 bundles, Class III of height above 183 cm, 16 bundles and Class IV above 150 cm, 14 bundles of cut fodder. The elephants above 60 years of age were given 3 kg wheat, 3 kg ragi, 200 g salt and 100 g jaggery.

Krishnamurthy (1998) reviewed the different systems of captive elephant management in India. He noted that in Southern states apart from natural grazings for atleast 15 hours a day, the elephants were provided with grain rations in cooked form twice a day. The grain ration provided consists of some cereal grains and lentils for providing a balanced diet. In Northern and North-eastern states, the animals get a fixed quantity of raw grains consisting of rice or broken paddy and some lentils and this is fed once a day. In addition they are also provided with cut fodder.

Poole and Taylor (1999) suggested that elephant diets should include a variety of species of food plants ideally 25 or more as in the wild and should be accompanied by relevant supplements such as calcium. Elephants also need plenty of sodium in the diet which can be provided by a salt lick.

2.2.8 Perissodactyles

Bhatia and Desai (1975) observed that the diet of Indian Rhinoceros at Delhi Zoological Park consisted of six bananas, 150 kg green fodder, 40 kg leaf fodder and 1 kg molasses, with 1 kg of green gram, 1 kg rice, 100 g turmeric

powder, 100 g linseed and 100 g common salt all mixed and cooked together with one litre of mustard oil.

Pelleted horse feeds are readily accepted by all three species of rhinos and addition of oats, bran, yam, carrots or greens reduce the chance of constipation when fed on hay. The total daily intake for an adult animal weighing 2000 to 2500 kg would be 30 to 40 kg on a dry weight basis (Nelson, 1978).

Jones (1979) pointed out that adult White Rhinoceros of 1800 kg can cope with a daily intake of 25-35 kg of dry matter. The rhinoceros are used in taking a diet of high fibre content and the range of protein in browsing rhinoceros is probably near 10-25 per cent of the dry weight of the diet. It was further noted that Indian Rhinoceros kept by the Zoological Society of London were given a concentrate diet with a crude protein level of 13 per cent and they were given clover or lucerne almost exclusively when it is available in summer and grass or 4 kg of vegetables with a high carotene content everyday as they have no access to growing herbage.

Perissodactyles with simple stomachs feed in shorter intervals and hay should be available for most of the day. Concentrates are best split up over two feedings rather than offered in one feeding per day (Karstèn, 1987). White rhinos do not strip leaves of branches and consume a fair amount of browse including woody material.

Khan and Choudhury (1987) detailed the feed and feed supplements of Indian Rhinoceros at Nehru Zoological Park, Hyderabad. The rhinos were given cattle feed pellets, consisting of wheat bran, rice bran, broken maize, powdered groundnut cake and molasses and to this concentrate mixture, vitamins and mineral supplements were also added. An adult animal was given 8 kg of concentrates per day in two separate meals, one in the morning and other afternoon. Fifty kilogram of greens consisting of ficus leaves, lucerne grass and carrots were also given.

Sabharwal (1989) recorded the feeding of rhinoceros at Kanpur Zoo. It was noted that adult rhinos were given 8 kg per day of commercial cattle feed containing minerals and vitamins. During winter months, they were given kheer in place of concentrate, containing gur, groundnut cake, wheat bran, wheat and rice cooked in milk. Fifty kilogram berseem and 50 kg sugarcane with leaves were given daily in two parts. In addition, they were also fed on 3 kg bananas, carrots and cabbages in the afternoon.

Husbandry survey of zoos holding Indian One-horned Rhinoceros in India, mentioned the diets of the rhinos in different zoos in India (Anon, 1994). In Veeramatha Jijabhai Bhosale Udyan at Bombay, they were provided 15 kg of paragrass, 10 kg lucern grass and 20 kg sugarcane in the evening and 7 kg of carrot and sweet potatos and 0.25 kg of groundnut cake in 25 kg of wheat bran, and soak gram with protein pellets in the morning. Leaves of plants are also fed, once in every fortnight. Mysore Zoo diet consisted of 40 kg of green grass,

20 kg of paddy straw, 1kg of lucern grass, 1 kg of carrot, 6 kg of wheat bran, 5 kg of oats, 0.5 kg of rice, 0.5 kg of cabbage, 1.5 kg of Bengal gram and 100 g Supplivet-M and Ostocalcium syrup and it is given daily distributed twice. Alipore Zoo diet consisted of 10 kg of wheat bran, 0.5 kg of crushed oats, 0.5 kg crushed barley, 1.25 kg of soak gram, 1.25 kg sweet potatoes and carrots, 0.5 kg molasses, 0.15 kg of black salt, 0.5 kg of boiled pulses, 60 kg green leaves and mineral and vitamin supplements. Concentrates were given in the morning and green grass and other fodder in the afternoon.

Grant's Zebra (*Equus burchelli boehmi*) at Arignar Anna Zoological Park were provided a diet of 1.5 kg wheat bran mixed with 100 g of soaked Bengal gram and 500 g soaked horse gram in the morning, and about 30 kg of grass and green leaves in the evening. Minerals were also supplemented to diet once in a month (Rao and Asaithambi, 1995).

Haque (1996) mentioned that zebras can be fed on pelleted horse feed with 12 to 12.5 per cent protein at the rate of 1 to 1.5 kg per 100 kg body weight, along with a low quality high fibre hay of equal amount.

2.2.9 Non-ruminant Artiodactyles

Wild swine can be maintained on commercial swine rations supplemented with carrots, potatoes, greens, apple, bread, chopped meat and hay. Hippos can be maintained on 40 to 50 kg of hay along with 4 to 5 kg of

grain in pellet form daily. Cut potatoes, carrots, apples and bread are also used in some zoos (Boever, 1978).

Prescribed ration for camels at the army camel corps consisted of 1.3 kg each of crushed grams and crushed barley with 0.14 g of salt added and 8 to 9 kg of mixed legume straw (Rathore, 1986).

Pigs and peccaries require more iron than other animals and so supplementation of iron in the diet is needed (Karsten, 1987).

Camels should be fed a high quality grass hay and alfalfa hay *ad libitum*. A concentrate mixture containing 12 to 14 per cent protein should be fed at the rate of 5 to 10 g per kg body weight and a trace element salt block should be made available at all times (Mathen, 1994).

Sahoo (1996) recommended camels to be fed concentrates with 12 to 13 per cent crude protein at the rate of 0.5 to 1 per cent body weight and trace mineral salt block at all times of the year.

Benerji and Pillai (2000) noted that adult Hippopotamus (*Hippopotamus amphibius*) in Nehru Zoological Park, Hyderabad were fed 45 kg of green grass, 3 kg of cattle feed and 1 kg of raw vegetables like carrot, potato, sweet potato or cabbage as daily ration.

2.2.10 Ruminant Artiodactyles

Snyder and Moore (1968) observed that in Philadelphia Zoo, modified diets to herbivores with 12 to 15 per cent protein and about three per cent fat were provided from 1936 to 1965.

Nilgais at Stanley Zoo were given a diet of best quality meadow hay and clover hay *ad libitum*. In addition, each animal received 2.7 kg of ungulate mix, with sheep and lamb nuts, summer milk nuts, rolled oats, flaked maize, linseed cake and bran; and 1.8 kg chopped cabbage, 1.3 kg carrot and six bananas daily. Twice weekly they were fed branches of willow, oak or birch leaves and a salt lick was always available and 56 g vitamin supplement was given daily for each animal (Lacey, 1969).

Fundova (1974) observed that Cape Buffaloes are most adaptable to captive diets and ate any sort of hay and green fodder and accepted carrots in any quantity. Cape Buffaloes in Dvur Kralove Zoo were given 1 kg pellets, 0.8 kg crushed oats, 0.3 kg dried sugar beet pulp, 1.5 kg carrot, 0.2 kg pelleted alfalfa meal and 7 kg hay. The nutrient composition of the above ration showed a crude protein of 9.8 per cent of dry matter and the total dry matter of the diet was 8.18 kg. The Giraffes in the zoo were given 2 kg pelleted ruminant feed, 1.3 kg crushed oats, 0.7 kg maize, 1 kg dried apple, 4 kg carrot, 0.3 kg pelleted alfalfa meal, 6 kg hay and 1.3 kg frozen poplar and the total dry matter content of the diet was 11.51 kg and a crude protein of 11.3 per cent of dry matter.

Diet of Nilgiri Tahr at Memphis Zoo consisted of commercially prepared calf chow, a vitamin supplement and alfalfa hay. Grass hay and mineral salt blocks were also provided *ad libitum* (Wilson, 1980).

Gowda (1986) observed the diet of giraffes in Mysore Zoo, that consisted of oats, wheat bran, boiled horse gram, soaked Bengal gram, broken maize, sag, onion, carrots, cabbage and potato. Also bulk fodder such as dry hay, ragi straw and cut leafy branches were placed in hanging feeding troughs.

Ruminants should receive fibrous bulky foods besides concentrates for proper functioning of rumen. Ruminants inhabiting open grass lands and tundras feed on foods of low nutrient levels and forest animals require high protein level in their diet. Ruminants have a high demand for minerals, particularly cervids with replacing antlers (Karsten, 1987).

Ungulates in Oklahoma City Zoo were fed grains twice daily and hay once daily. A mixed grain sweet feed with 12 per cent protein level, about 1.8 to 2.2 kg were given to Grant's Zebra, 0.5 to 0.7 kg to Hog- deer, 3.6 to 4.5 kg to Giraffe, 2.7 to 3.6 kg to African Buffalo and 0.3 to 0.5 kg to Blackbuck. Gaur in the zoo were given 2.7 to 3.6 kg of herbivore pellet feed with 16 per cent protein level. In addition, locally grown alfalfa and prairie hay were also fed to the ungulates depending on whether it is a grazer or browzer. The enclosures were also provided with mineralised salt blocks containing selenium. Grain ration was increased slightly in winter months to provide additional energy (Grisham and Savage, 1990).

Manjramkar (1994) suggested a concentrate diet for herbivores including ruminants and pseudoruminants with 18 per cent crude protein, seven per cent crude fibre and 2.5 per cent crude fat.

Mathen (1994) suggested to feed good quality grass hay, legume hay, green grass and fresh legume for maintenance and concentrate mixture at the rate of five to ten g per kg body weight for pregnant and lactating ruminants. The non-producing ruminants need 2 kg feed in dry matter for every 100 kg body weight.

Higginbottom (1996) suggested crude protein level of 14 to 17 per cent and acid detergent fibre around 16 per cent to captive ungulates. The importance of crude fibre fraction in the ration of captive ungulates was also stressed.

Kewalramani (1996) recommended that Blackbucks should be fed a concentrate mixture containing about 20 to 22 per cent crude protein and less than 10 per cent crude firbe in dry season at the rate of 1.5 per cent of the body weight along with available fodder.

Sahoo (1996) recommended good quality legume fodder supplemented with commercially available pelleted concentrate at the rate of 0.5 to 1 per cent body weight for deer along with a trace mineral salt block all round the year. For Giraffe, Nilgais and Wild Goats he recommended high quality legume

fodder *ad libitum* and concentrates of 13 to 19 per cent crude protein at the rate of 0.5 to 1 per cent body weight.

2.3 Housing of zoo mammals

Injuries are the most common cause of clinical problems and death in most species of zoo animals. Often this happens as a result of poor housing designs and inadequate facilities to keep them apart (Jones, 1985).

The average home range of animal species in the wild are much more than under captive conditions and the optimum requirements in captivity depend on the species. Generally a carnivore can adapt well to a smaller space as compared to a herbivore, though under natural conditions it is the reverse. The flight distance of a species is also an important factor to be considered in designing the depth of the enclosure and apart from physical space, the enclosures need to simulate natural condition with appropriate cage 'furniture' and hiding areas for successful breeding (Naidu, 1986).

2.3.1 Rodents

The breeding pair of Malabar Giant Squirrel at Arignar Anna Zoological Park were kept inside a large circular cage of four metre diameter and six metre height and on the roof of the cage, two basket shaped and one elongated semicircular frame work structures with wire netting were provided for the construction of nest (Paulraj and Naidu, 1988).

Acharjyo and Patnaik (1990b) observed the management and breeding practices of Indian Porcupine in captivity at Nandankanan Biological Park. It was noted that porcupines were housed in a circular well-type enclosure with a floor space of approximately 38 m^2 and depth of 1.75 m including the parapet on the viewer's side. There was a large and spacious cave-like den with a number of entries where the animals remain almost throughout the day and the floor of the enclosure was made of cement concrete.

Ashraf *et al.* (1993) recorded the enclosure use by a female Malabar Giant Squirrel before and after enrichment by providing a bamboo nest. The study revealed the importance of horizontal bars as a major enclosure location and the nest proved to be successful as the squirrel used it at night.

Wani (1994) described the exhibit design and environmental enrichment for porcupines in Bombay Zoo. They were housed in a cage of 15 x 15 x 12 ft and on the rear side of the cage on the floor space of about 8 x 6 ft a structure of cement, boulders and stones were constructed with a roof at a height of 2.5 ft. In and out tunnel entrances of size 2 x 2 ft on the dark side were provided for their entrance and exit and porcupines used it as a secluded place.

Kranz (1999) in zoo standards for keeping sciurids in captivity, recommended enclosures measuring at least 1.8 x 1.8 x 1.8 m for one or two individuals of Oriental Giant Squirrels. He suggested that enclosures may be constructed of non-coated wire mesh, metal, non-treated wood, glass, concrete, masonry, or combinations thereof. Indoor enclosures can use a variety of

substrate and natural substrates can be used in outside enclosures, although enclosures for burrowing species, should have a secure bottom. Tree squirrels and flying squirrels are to be provided with branches for locomotion, resting, chewing and scent marking and one or more wooden nest boxes to be provided for all species. Hanging baskets stuffed with wood and wool may be used for tree squirrels.

2.3.2 Primates

In the primate house at Dresden Zoo, ten indoor primate cages each measuring 3 x 3 m, are equipped with tubular steel climbing frames. Steel plates attached to the walls provide shelter for animals low in the hierarchial structure (Tempel, 1972).

New World Monkeys at London Zoo were kept in indoor glass-fronted cages ranging in size from 2.2 x 1.8 x 2.2 m to 3.4 x 2.5 x 2.2 m. The walls were fibre glass coated and the asphalt floors were covered in a layer of peat some 30 cm deep. A limited amount of sunlight enters through a skylight in each cage which was supplemented with fluorescent electric light and the cages were furnished using rocks, logs, gravel, sand, branches, twigs and growing plants (Bertram, 1982).

Ponnuswamy and Paulraj (1990) observed environmental enrichment of zoo enclosures as a pre-requisite for captive breeding and noted the enrichment of Lion-tailed Macaque enclosure at Arignar Anna Zoological Park by keeping

them at a wet moated island enclosure of 610 m^2 in area with green trees and shrub vegetation.

Manimozhi and Basavaraju (1992) reported successful breeding of Nilgiri Langur at Arignar Anna Zoological Park. They were kept in open wet moated enclosure (60 x 35 m) with a rock cage at the centre for shelter and feeding and vegetation were also provided for giving a natural look to the enclosure.

Acharjyo and Patnaik (1994) observed that Lion-tailed Macaques at Nandankanan Biological Park were kept in a circular island enclosure with a wide moat 2.5 m deep and 0.6 m high parapet on the viewer's side. Both sides of the moat have vertical walls and the retiring house in the centre of the island measured 2.70 x 1.50 m and a height of 2.10 m, made of concrete. The island had also natural growth of vegetation.

Enclosure of Stump-tailed Macaque in Sri Venkatewara Zoological Park were constructed with an island area of about 275m^2 with a top width of five metre and a depth of 2.3 m and designed as a wet moat. Night house was provided with four cages of 1.2 x 1.65 x 1.5 m size each and drainage channels provided for easy draining of daily cleaning water (Kumar and Raghavaiah, 1996c).

2.3.3 Mustelids and Viverrids

Xavier and Balakrishnan (1993) observed the husbandry and management of Small Indian Civets under captivity, housed in wooden cages, individually. Traditional way of housing animals in rectangular cages (150-160 cm long, 50-80 cm wide and 35-40 cm high) made of wooden blocks were adopted by all units, except the zoological gardens and about 80 per cent of the civet units provided two compartments for civet cages.

American Association of Zoos and Aquaria guidelines suggested that enclosures for viverrids should be with wall, ceilings and floors that can be easily disinfected. The walls can be of wood, fiber glass, mesh or concrete and if no top is provided it should be non-climbable. Concrete, fiber glass or welded mesh flooring can be used and housing should include tree limbs for climbing and a nest box or elevated platform for retreat. The enclosures need sufficient drainage to prevent standing water. Minimum cage sizes recommended for animals less than 450 mm length category is 1.9 m^2 for single animal, 3.7 m^2 for two animals and an additional of 0.9 m^2 area for each additional animal added and with an enclosure height of 1.2 m. For the medium size category of 450-600 mm body length, single animals require 3.7 m^2 and 6 m^2 for two animals and 1.9 m^2 additional for additional animal. For large sized above 600 mm in body length need 6 m^2 area for single animal, 11.2 m^2 for two animals and 2.8 m^2 area additional for each additional animal and 1.8 m

was the enclosure height recommended for the above two categories (Carnio, 1999).

2.3.4 Canids and Hyenas

The two enclosures for Wolves and Cape Hunting Dogs in the West Berlin Zoo provided these roving animals with enough room and the enclosures were extremely long of 47 x 17 m and 52 x 15 m dimension respectively. They were separated from the public by dry moats, four metre wide and each has a house containing five indoor dens measuring 3.36 m^2 (Klos, 1974).

Rieger (1979) mentioned that the possible parameters influencing rearing success in Striped Hyena in captivity, was the size of the enclosure and denning facilities and an enclosure with ground area smaller than 30 m^2 do not permit natural rearing. It was suggested that the size of the nestbox or maternity den is also a very important factor. It was also recommended that there should be two outside enclosures, each at least 100 m^2 in area with a connecting door for the hyena. The doors must remain open most of the time so that partners can separate when they choose and vegetation should provide a visual barrier between the two sections. The substrate should be such as to enable the female to dig a den and a portion of the enclosure should be under subdued lighting.

Kumar and Raghavaiah (1996b) described the enclosure of wolves in Sri Venkateswara Zoological Park been an island with dimension of 92 x 32 m with a moat forming barrier on three sides and the rear side barrier made of

chain-link mesh to a height of 2.7 m of which 0.45 m overhangs inwards. Night house with seven cages of 1.5 x 2 x 1.5 m size each were provided and four ventillators with grills on it, for sufficient ventilation.

Indian Wild Dog at Arignar Anna Zoological Park were displayed in a large chain-link enclosure of 8 x 4.8 x 2.2 m dimension. They were separated by night and housed in individual night shelters each measuring 2.3 x 2.2 x 2.1 m (Rao *et al.*, 1996).

2.3.5 Bears

Tropical bear exhibit in West Berlin Zoo was described by Klos (1974) comprises 15 indoor dens and four out door enclosures. A group of five, three and two dens, linked to each of the outdoor enclosures, were inter connected. The dens measured 3 x 2.15 m except one large den of 5.05 x 3.33 m and all have under floor heating. The four outdoor enclosures were built of sand stone, which also faces the front of the house and were 152 m^2 in area provided for Sun Bears, 465 m^2 for Sloth Bears, 440 m^2 for Himalayan Black Bears and 478 m^2 for Spectacled Bears. Each contained a pool of about 40.72 m^2 and was bordered by a water moat of two metre depth.

In Amsterdam Zoo eventhough the space provided were limited for Sloth Bears, it allowed breeding facilities for three females. In the inside enclosure, each female had an enclosed breeding den together with an open cage as the 'outside world', where food and water were supplied (Jacobi, 1975).

Himalayan Black Bear at Jawaharlal Nehru Biological Park were accommodated in an open enclosure of 165 x 100 ft dimension with a wet moat as the barrier. The enclosure has seven night shelters of 8.9 x 5.8 x 7 ft size, all with an in-built squeeze cage and a cubbing den (Chakraborty *et al.*, 1998).

American Association of Zoos and Aquaria guidelines for keeping bears suggests that bear enclosures should possess a dry resting and social area, pool and den. They can be maintained in outdoor enclosures employing moats, thick laminated safety glass or bars. Dry moats if used should be at least 3.7 m wide and 3.7 m deep and if vertical walls used, should be 3.7 m high. The dry resting and social area for one or two bears of species other than Brown Bears should possess 300 sq ft and to be increased by 50 per cent for each additional animal. Visual barriers such as logs or boulders should be added to enclosures housing more than one animal and enough shade also must be there. The indoor enclosure for single individual should measure at least 1.5 m in width, depth and height. Pools also can be provided with a mean horizontal diameter of atleast 1.8 m and a surface area of 6 m^2 for two adult bears with a depth of atleast 1 m and the surface area of pool to be increased by 2.7 m^2 for each additional animal (Johnson, 1999).

2.3.6 Felids

Bemmel (1968) noted that at Rotterdam Zoo the lions mated freely even in the small cages of the traditional carnivore houses, whereas when pair of

tigers were kept together, mating seems to occur very rarely and this may be due to their different mating patterns.

Fishing Cats and Jungle Cats at Nandankanan Zoo were housed in chain-link mesh covered enclosure with cemented floor space of approximately 7 m^2 and 2.8 m in height. The top of the enclosure was having thatched roof and had two cave like retiring dens (Acharjyo and Patnaik, 1990a).

Shoemaker *et al.* (1993) suggested that lions and tigers can be easily maintained on traditional barred on heavily wired cages as well as in outdoor exhibits employing moats. It was recommended that the cage for a single animal should measure atleast 20 ft wide, 15 ft deep (300 sq ft.) and cages should be 50 per cent large for every additional animal. Outdoor cages should have vertical jump walls atleast 16 ft high or be provided with tops atleast 10 ft high and if moats are used as barriers, it should be atleast 25 ft wide and 15 ft deep. The enclosure must also have smaller shift facilities to permit stage cleaning. These animals are also benefited from raised platforms or ledges for sleeping and resting and large logs can also be provided for sharpening claws. The other large felids including leopards are generally kept indoors as they are small sized and secretive natured and is not safe in moated facilities. For them, a minimum cage dimension of 200 sq. ft. is recommended for single animals and to be increased by 50 per cent for each additional one. Since they are climbers and leapers, secure tops should cover outside enclosures. They live in

rocky habitats and so should be furnished with ledges or perches for sleeping and resting.

Asiatic Lions at Arignar Anna Zoological Park were displayed in large, dry moated enclosure and it is attached to a cubical concrete house consisting of five rooms. Each room consisted of water trough with clean drinking water (Basavaraju *et al.*, 1994).

Phillips (1994) mentioned that the new trend in felid exhibits is towards open air enclosures with vegetation and soil. He mentioned that 'cage furniture' provides the animal with a variety of sites to stimulate activity and can be constructed with materials that provide a soft and warm place to rest or sleep. It was also recommended that they should be provided secluded areas within the exhibit to hide.

Enclosure for leopard in Sri Venkateswara Zoological Park has a floor area of 45 x 25 m and is a closed enclosure with huge parabola shape, made of iron pipes to which chain-link mesh has been spread and firmly rivetted. The height of the top of parabola from ground is about 11 m. The enclosure has an undulating ground with boulders and rocks and a natural scrub forest vegetation. Natural perches were also provided by planting tree trunks of three big trees and two mounds have been prepared with boulders and soil below the trees for the animals to rest. An artificial cave also has been constructed with cement concrete and a night house with cages of dimension 3 x 1.5 x 2.75 m

with facility of in-built squeeze cage was also attached to the enclosure (Kumar and Raghavaiah, 1996a).

Mellen (1999) recommended enclosure size based on two weight categories of cats. Those under 10 kg requires a minimum space of 2 x 2 x 2.5 m per cat and the category ranging from 10-20 kg requires 4 x 2 x 2.5 m area. The space has to be increased by 50 per cent for each additional animal. The complexity of the enclosure is also important and the cats should have access to atleast 75 per cent of the enclosure's vertical component by providing aerial pathways. Further, small cats prefer perching platforms at or near the top of their enclosure and require logs for 'sharpening' their claws. Each cat also needs a den or secure area that can be defended against a cage mate. A shift or secondary holding area were also strongly recommended to move animals from their primary enclosure for cleaning, feeding and medical procedures.

2.3.7 *Elephants*

Elephant exhibit at Topeka Zoo, houses two female Asian Elephants and measures 9.1 by 6.1 m. The walls were made of reinforced concrete and cast steel tie rings were placed in the floor, on the back wall and on each side wall so that both elephants can be chained by all four legs if necessary. An over sized water line supplies a high pressure water flow if necessary for bathing the elephants daily (Clarke, 1968).

Bist (1996) set a standard and norms for elephant owners and had recommended a minimum floor area of 5 x 2.5 m for weaned calf with height below 1.5 m, and 7 x 3.5 m area for a sub-adult elephant of height ranging from 1.5-2.25 m. For a cow elephant with an unweaned calf or for an adult elephant above 2.25 m in height, an area of 9 x 5 m were recommended. In case of covered sheds, it was mentioned that the height of the structure should not be less than 4.8 m and that corrugated iron sheets or asbestos sheets should not be used for the roofing of elephant stables.

Krishnamurthy (1998) reviewed captive elephant management in India under different systems and it was mentioned that in most of the zoos, elephants were kept tethered in stables and only very few keep their animals in open enclosures with moats around. He noted that the temple elephants of Tamil Nadu have well maintained stables, specially designed for elephants, whereas in Kerala the animals were tethered under the shade of trees within the temple premises.

Poole and Taylor (1999) mentioned that in a sample of 20 zoos which responded to a questionnaire survey, the elephants were provided with a barn like house, the medium size of which was 250 m^2 in area with a surrounding concrete outdoor enclosure typically with a dry moat around it.

2.3.8 Perissodactyles

In Basle, the Indian Rhinoceros were kept in three stalls each of 4.5 x 5.7 m and the floors were fitted with *'stallit'* stall tiles and walls made of concrete, lined with vertical wooden boards to reduce loss of heat. Next to the row of stalls was a heated pool. The dry moat separating the stalls from the public area was 1.5 m deep. The house opens out to an enclosure of some 1000 m^2 surrounded by a ditch of only 170-180 cm wide and 170-190 cm in depth and there was a pool occupying the middle section (Lang, 1975).

The rhinoceros enclosure at Delhi was an open-air enclosure of about one acre in area with luxuriant growth of naturally growing trees and undergrowth and in the centre of the enclosure was a muddy depression where the animals can wallow and the enclosure has a few cells and a large enclosed paddock where the animals may be kept separately if needed (Bhatia and Desai. 1975).

According to Jones (1979), rhinoceros are not animals that habitually tend to destroy the perimeter of their enclosure and neither are they capable of jumping. He recommended dry or water filled moats to be the best method of enclosing the exhibit although strong steel or wooden vertical posts placed a maximum of 0.5 m apart are suitable. The relatively soft sole of rhinoceros foot get easily damaged by abrasive surfaces and so concrete yards if used should be as smooth as possible and an alternative exercise area with a softer surface need to be provided in addition.

A sub-adult male Indian Rhinoceros was kept in a 0.2 ha dry moated oval shaped enclosure with two night houses and an open backyard at Nehru Zoological Park, Hyderabad. The rooms measured 9 x 6 m with a 2 m wall on all three sides and the open exhibit area was separated from the visitors by a 2 m deep and 2 m wide dry moat gently sloping towards the land area. A pool of water in the middle of enclosure serves both for drinking and wallowing purpose and a few tall acacia trees provided the required shade (Khan and Choudhury, 1987).

Sabharwal (1989) observed that a pair of Indian Rhinoceros were kept in an enclosure with two indoor enclosures and a common open run of about 90 x 125 ft size surrounded by a dry moat 6 ft deep and 4 ft wide.

A husbandry survey of zoos holding rhinoceros in India revealed housing details of rhinoceroses in different zoos. In Veeramatha Jijabhai Bhosala Udyan at Bombay they were housed in an open enclosure of 200 x 100 ft area with one animal house measuring 30 x 40 ft and a water tank of 30 x 20 ft dimension. A trapezoid shaped enclosure with a water pond and surrounded by a moat is provided in Mysore Zoo. The animal house was of 8 x 22 m dimension with a wallow pool on one side. In Alipore Zoo the enclosure had an area of 2742 m^2 which includes a water moat and a central pool (Anon, 1994).

Venugopal *et al.* (1994) studied the activity pattern of Indian Rhinoceros in Mysore Zoo housed in an enclosure divided into two compartments, one with

provisions for resting and feeding and a larger one for foraging and wallowing, and observed that wallowing was the most frequent activity.

Grant's Zebra at Arignar Anna Zoological Park were exhibited in a spacious specially designed dry moat island type enclosure (91 x 63 m) and the exhibit had scattered trees and a night shelter with four stalls. Two stalls were of 3.25 x 3.35 x 2.4 m and two were of 4.4 x 3.1 x 2.7 m dimensions (Rao and Asaithambi, 1995).

Miller and Foose (1996) suggested that rhinoceros in breeding situations should preferably have a large yard, and if not, 'run-around' capabilities so that a mate may not be trapped in a 'blind' corner and this is particularly important with Black, Greater One-horned Asian and Sumatran Rhinoceros in which the breeding behaviour is often combative. It was also noted that the large and potentially destructive nature of rhinoceros dictates heavily barred or moated enclosure. Wood treated with creosote or its derivatives should never be used in the construction of rhinoceros enclosure and in situations where bars are used they should be vertical as horizontal bars present a higher risk of horn breakage if caught under the crossbars.

2.3.9 Non-ruminant Artiodactyles

At Topeka Zoo, Hippopotamuses were housed in a barless enclosure with a pool of 1.52 m deep which occupies the entire front section of the exhibit which measures about 9 by 9 m. The land platform behind the pool was raised

4 m above the level of the public area and leading from the platform to the floor of the pool was a 2.9 m wide ramp. Directly adjacent to the exhibit was a transfer stall measuring 4.5 by 6.1 m where feed was given (Clarke, 1968).

Boever (1978) mentioned that both moated or fenced exhibits were used for housing swines in zoos and due to their intense fondness for rooting and digging, their enclosures appear rather barren and rooted through. For hippos, it was suggested that the housing should include a sizeable pool normally of 1.5 m depth and most zoos drain the pool daily and fill it with fresh water. Eventhough hippopotamuses are fairly good climbers for their size, they can be kept in moated or fenced enclosures with adequate housing. They need access to water regularly and showers will suffice when enough pool space is not available. Camels and llamas can be kept in fenced enclosures, moated exhibits or in barns or stalls.

Naidu (1986) stating the role of environment in reproduction of mammals in zoos, mentioned that hippos require pools for their young which are born in water in the wild.

2.3.10 Ruminant Artiodactyles

Giraffe enclosure at Topeka Zoo measured 13.4 x 5.8 m and the animals were kept behind a fence 2.4 m high and set on a curb 1.5 dm high. Bars in the lower half were spaced 1 dm on centre to prevent the animals from getting their hooves caught, and 2 dm in the upper half for better visibility. The giraffe

exhibit was divided into three equal units with sliding gates which allowed the animals access to the entire area, or they can be separated into individual stalls (Clarke, 1968).

Deer exhibit at Washington Zoo consisted of seven exhibit paddocks and one off-exhibit paddock. Each paddock were provided with indoor quarters and an attached open fronted shed with food and water troughs. The hardy hoofed animals like Zebra, Cape Buffalo etc. were displayed in six exhibit paddocks all viewed by looking across dry moats from the visitor's path which encircles the whole area (Maloney, 1968).

Lacey (1969) observed that breeding pair of Nilgais at Stanley Zoo were housed in a half acre paddock with shelter measuring 3 by 6 m.

Nilgiri Tahr at Memphis Zoo were first displayed in a wet moated gunite mountain with approximately 50 x 15 m area with twin peaks rising about 15 m. Later the animals were moved to an enclosure with an earth substrate and this resulted in frequent necessity for hoof trimming and addition of large rocks to this enclosure providing a more abrasive surface reduced this frequency. Later the herd was transferred to another moated display with large earthern mound which led to a resurgence of over grown hooves and then was moved back to the original gunite mountain which proved the most suitable of all environments tested (Wilson, 1980).

Grisham and Savage (1990) observed the management of hoof stock at Oklahoma City Zoo. They were kept in exhibits varying in size from 0.3-1 ha. The holding barns were constructed of concrete blocks with windows for natural lighting and the uneven pattern finish given to the concrete floor helped to prevent hoof problems. Each barn can be divided into individual stalls or be left open for large herds. The animals were displayed in open exhibits containing grassy areas with dry moats and between each exhibit were double chain-link fences 2.5 m high spaced 1.5 m apart.

Ponnuswamy and Paulraj (1990) observed the enrichment of enclosures at Arigna Anna Zoological Park for Blackbucks and Nilgiri Tahr. Blackbucks were kept in enclosures with undulating terrain, sparse tree cover and large open area. The scattered trees provided shade and the thorny bushes were used for "peri-orbital gland marking" by the animals. Nilgiri Tahrs were kept in a large open type island of about 2500 m^2 surrounded by a dry moat. The enclosure consisted of small rocky patches and the major portion was with grass and shrubs.

2.4 Breeding of zoo mammals

The breeding cycle in mammals even when influenced by captive conditions, still retains traces of its natural periodicity in the occurrence of the marked peak that corresponds to the birth season in the habitat of the species (Cociu and Cociu, 1976).

The environmental factors related to breeding mammals in captivity are food requirements, living space and general husbandry, which also included specific macro and micro climatic requirements like temperature, light and humidity (Naidu, 1986).

Barat and Poyyamoli (2000) noted the enormous potential of the zoo to conserve the species threatened in the wild as evident from the records of successful captive births of the four selected mammalian species, namely *Cervus eldi eldi, Macaca silenus, Panthera tigris* and *Trachypithecus johnii* at Arignar Anna Zoological Park.

2.4.1 Rodents

Paulraj and Naidu (1988) recorded births of Malabar Giant Squirrels and successful rearing of young ones when nesting materials were provided for the squirrels in Arignar Anna Zoological Park. The note revealed no specific breeding season for the Malabar Giant Squirrel as births have been recorded through out the year.

A mean litter size of 1.27 young per litter was observed by Acharjyo and Patnaik (1990b) in Indian Porcupines at Nandankanan Biological Park. Eleven porcupine births were recorded in the zoo with three births in the month of January, two births each in the months of March, June and July and one birth each in February and October.

2.4.2 Primates

A study on the seasons of birth in mammals at San Francisco Zoo by Reuther and Doherthy (1968) showed that White-throated Capuchin (*Cebus capucinus*) birth were in the month of February, Lion-tailed Macaque (*Macaca silenus*) birth in September and Rhesus Macaque (*Macaca mulatta*) births in March, August and October.

Eight births of Rhesus Monkey (*Macaca mulatta*) in the months of February to May, July and October was observed by Cociu and Cociu (1976) at Bucharest Zoo.

Bertram (1982) suggested from his observations on the breeding of New World monkeys at London Zoo, that it is advantageous to keep sub-adults with their natal group until long after the next infant is born, as experience of close contact with infants make the sub-adult group successful parents.

Successful breeding of Lion-tailed Macaque kept in wet moated island enclosures at Arignar Anna Zoological Park was reported by Ponnuswamy and Paulraj (1990). The green trees and shrub vegetation in the island provide physical enrichment for the macaques.

Mating of Nilgiri Langurs were observed by Manimozhi and Basavaraju (1992) in December and young ones were born in July at Arignar Anna Zoological Park.

Observation on keeping of Lion-tailed Macaque in captivity at the National Zoological Park, New Delhi (Acharjyo and Patnaik, 1994) registered total of eleven births in the months of January, March, October and November with a litter size of always one.

2.4.3 Mustelids and Viverrids

Prater (1971) noted that Small Indian Civet breed through out the year with four to five young in a litter and Palm Civets do not have a marked breeding period and produce litters of three to four.

Viverrids generally have a breeding season in spring or summer, but may breed throughout the year. Palm Civets are known to breed well in captivity and pregnant civet females need ample hiding space as they are very stress-prone (Seager and Demorest, 1978).

2.4.4 Canids and Hyenas

Six Oriental Jackal (*Canis aureus*) births with litter sizes ranging from three to seven were recorded by Reuther and Doherty (1968) at San Francisco Zoo in the month of March.

Study on seasons of birth of mammals at Bucharest Zoo has shown nine Jackal (*Canis aureus*) births in the month of April (Cociu and Cociu, 1976).

Breeding of Striped Hyena in captivity (Rieger, 1979) showed that they do not have a fixed breeding season and young ones were produced throughout

the year with a peak during summer. The litter size found to vary between one and five and rearing success is influenced by the size of the enclosure and denning facilities.

2.4.5 Bears

Sloth Bear (*Melursus ursinus*) births were recorded in the months of January and December at San Francisco Zoo by Reuther and Doherty (1968).

Jacobi (1975) observed breeding of Sloth Bears in Amsterdam Zoo and found births in the months of November and December. It was also observed that pregnant Sloth Bears preferred small dark breeding dens.

Cociu and Cociu (1976) recorded eleven Himalayan Black Bear births in the month of January and five in February at Bucharest Zoo.

Captive breeding of Himalayan Black Bear was studied at Jawaharlal Nehru Biological Park by Chakraborty *et al.* (1998). They have observed matings in the month of May and recorded two births in the month of January with gestation periods of 243 and 245 days.

2.4.6 Felids

According to Bemmel (1968), the need for privacy during the last weeks of pregnancy and first week of the new born cubs are more pronounced in tigers than in lions which makes their breeding more difficult. Moreover, the difference in mating pattern is also another possible reason for poor breeding

record in tigers. The breeding den in Rotterdam Zoo, completely isolated from the public, both visually and acoustically, contributed to the birth of 178 tiger cubs of which nearly 70 per cent were raised.

In leopards gestation period of 112 days was noted by Dobroruka (1968). Births were in the month of May in Prague Zoo. Triplets were recorded in two occasions, twins in seven instances and sigletons in two instances.

Study on the season of birth in mammals at San Francisco Zoo by Reuther and Doherty (1968) reported Leopard (*Panthera pardus*) littering in the months of January, April, May, July, August, October and November. Bengal Tiger (*Panthera tigris tigris*) births were recorded in February, March, June, July and August and Lion (*Panthera leo*) births in January, March, April, May, July, August, September, October and November with a peak in April.

Sixteen captive births of Lions (*Panthera leo*) spread throughout the year and seven Leopard (*Panthera pardus*) births distributed throughout the year was noted by Cociu and Cociu (1976) at Bucharest Zoo.

Acharjyo and Patnaik (1990a) reported successful captive breeding of Jungle Cats at Nandankanan Zoo.

Basavaraju *et al.* (1994) concluded that lions in captivity breed throughout the year and cubs are produced during all seasons. Births occurred in June, July, October and November months at Arignar Anna Zoological Park.

Raju *et al.* (1997) reported that there were 44 tiger births in Mysore Zoo in a period of 24 years with an initial parent stock of one male and two female tigers.

2.4.7 Elephants

Gowda (1986) reported two calvings in a female elephant in Mysore Zoo covered by a wild bull when she was left free for grazing during summer months.

Among the 26 zoological parks in India where elephants were maintained, few zoos like the Assam State Zoo, Bannerghetta National Park, Mysore Zoo, Arignar Anna Zoological Park and in Nandankanan Biological Park, calves were born regularly (Krishnamurthy, 1998).

Poole and Taylor (1999) mentioned that greatest success in keeping and breeding elephants are in the source countries in natural or semi-natural conditions and that breeding success in most western zoos is low and young are rarely reared.

2.4.8 Perissodactyles

Jones (1979) observed that adult rhinoceroses are aggressive to another strange adult and hence introduction of mates should be made as slowly as possible with animals initially being separated by bars or fence. As much space as possible should be allowed when they are finally put together as

premating behaviour involves a great deal of chasing and mock fighting in Indian Rhinoceros.

African Black Rhinoceros and Indian Rhinoceros were successfully bred in Mysore Zoo (Gowda, 1986).

Nehru Zoological Park of Hyderabad had recorded birth of three male Great Indian One-horned Rhinoceros from a single pair with gestation periods of 459, 478 and 484 days. Khan and Choudhury (1987) reported the births and have described courtship and mating behaviour of a pair of rhinoceros.

Sabharwal (1989) reported birth of Indian Rhinoceros calves in Kanpur Zoo with a gestation period of 471 to 486 days.

Successful breeding of Indian One-horned Rhinoceros were observed in Sanjay Gandhi Biological Park, Allen Forest Zoo, Assam State Zoo, Mysore Zoo and in Alipore Zoo and constraint in space and fighting are the problems observed while mating rhinoceros (Anon, 1994).

Rao and Asaithambi (1995) observed mating behaviour in a pair of Grant's Zebra (*Equus burchelli boehmi*) at Arignar Anna Zoological Park and noted foaling in November after a gestation period of 372 days.

2.4.9 Non-ruminant Artiodactyles

Birth season of mammals at Bucharest Zoo by Cociu and Cociu (1976) showed that nine Wild Boar (*Sus scrofa*) births occurred with three births in the month of March, four in April and one each in June and October.

Ahsan (1986) recorded six Hippopotamus births in a breeding pair at Kanpur Zoo of which only three survived and observed that hippo births took place in deep water.

According to Gowda (1986) breeding of Hippopotamus is not difficult if the animals were in good health and have appropriate quarters with space for moving about and a water pool.

Benerji and Pillai (2000) noted their observations on the mating behaviour of a pair of Hippopotamus (*Hippopotamus amphibius*) in Nehru Zoological Park, Hyderabad and also recorded seven births in the same pair in the zoo.

2.4.10 Ruminant Artiodactyles

Birth season of mammals at San Francisco Zoo were studied by Reuther and Doherty (1968) and reported Spotted Deer (*Axis axis*) birth throughout the year. Blackbuck births were also observed throughout the year except in October and November. They also observed Reticulated Giraffe births from January to March and in May, August and December and Nilgai births from March to May and August to November.

Lacey (1969) reported breeding of Nilgai (*Boselaphus tragocamelus*) pair at Stanley Zoo. He observed the birth of twins in April after a gestation period of 250 days.

Nilgai births were observed in February, April, May and from July to November in Bucharest Zoo, when Cociu and Cociu (1976) studied the birth season of mammals in the zoo.

Wilson (1980) observed that there is no birth season for Nilgiri Tahrs (*Hemitragus hylocrius*) in captivity. It was also recorded that all eighteen births at Memphis Zoo and four at Minneapolis were singletons.

Birth of seven Giraffe calves between 1934 and 1943 in Mysore zoo was reported by Gowda (1986).

Seasonal breeding in hoof stock by placing males with females in autumn and planning for spring births in April, May and June reduced the loss of calves due to inclement weather and improved the overall survival rate among calves in Oklahoma City Zoo as was observed by Grisham and Savage (1990). They recorded 20 Grant's Zebra offspring, 33 Giraffe offsprings, 56 Gaur offsprings, 32 African Buffalo offsprings and 108 Blackbuck offsprings in the period of 1955-1989.

Ponnuswamy and Paulraj (1990) observed that eventhough Blackbucks reproduce easily in captivity, they will not show all their breeding behaviour as exhibited in wild unless they are provided with simulated conditions. They also

observed that by providing an enriched enclosure with rocky patches, grass and shrubs, breeding occurred in a Nilgiri Tahr pair, at Arignar Anna Zoological Park.

Maradia (1995) found that fawning in Blackbucks at Rajot Zoo took place during the period from January to August and first oestrum observed 16^{th} to 18^{th} day after fawning.

2.5 Disease prevalence in zoo mammals

Health care forms a very important and significant aspect of management for zoo animals (Balain and Swarup, 1994).

According to Acharjyo (1994), health of animals and birds in zoos are directly or indirectly dependent on factors like housing, feeding, sanitation and disease management.

The factors that influence the physiological and social states of the animal may influence the course of the disease. So when developing a plan for disease prevention, behaviour, husbandry, nutrition and environment must all be considered including the control of parasites, bacteria and viruses and other agents of diseases (Vellayan, 1998).

2.5.1 Rodents

Hydatid cysts were observed in the lungs and round worms in the intestines of Common Giant Flying Squirrels at Nandankanan Zoo (Rao and Acharjyo, 1984).

Spirurid, *Strongyloides* and coccidial infection were observed by Varadharajan and Kandasamy (2000) in porcupines at the Coimbatore Mini Zoo.

2.5.2 Primates

The prevalence of helminth infections in zoo animals at Kanpur Zoological Park were studied. *Ancylostoma* infection in Rhesus Monkeys and Nilgiri Langurs and *Ascaris* sp. in Rhesus Monkeys were reported (Gaur *et al.*, 1979).

In a study on the causes of mortality of captive non-human primates of Assam State Zoo (Goswami and Chakraborty, 1996), the following conditions was reported - pneumonia (24.70 per cent), enteritis (16.47 per cent), tuberculosis (12.94 per cent), traumatic injury (11.76 per cent), mycotic infection (4.70 per cent), gastric ulcer (3.52 per cent), malignant neoplasm (2.35 per cent), gastric dilation (1.17 per cent), poisoning (1.17 per cent), neonatal mortality (8.23 per cent), stress (9.41 per cent), dystocia (1.17 per cent) and senility (2.35 per cent).

Thakuria (1996) observed the prevalence of tuberculosis in Assamese Macaque, Lion-tailed Macaque, Golden Langur, Capped Langur, Common Langur and Nilgiri Langur in Assam State Zoo.

Vellayan (1998) listed tuberculosis, shigellosis, pasteurellosis, streptococcosis, pneumonia, leptospirosis, melioidosis, salmonellosis, Herpes B, rabies, Hepatitis A and B, strongyloidosis, entamebiasis, enterobiasis, balantidiasis and giardiasis as the common diseases of primates encountered in Asian rescue centers.

Varadharajan and Kandasamy (2000) observed strongyle ova in faecal samples of Bonnet Monkeys and *Strongyloides* ova in faecal samples of both Bonnet and Rhesus Monkeys in a survey conducted at Coimbatore Mini Zoo.

In Arignar Anna Zoological Park, 57.14 per cent of deaths of Lion-tailed Macaque was due to trauma, 28.57 per cent due to parasitic infectious diseases and 14.29 per cent of other factors (Krishnakumar and Manimozhi, 2001).

2.5.3 Mustelids and Viverrids

Gaur *et al.* (1979) studied the prevalence of helminth parasites in zoo animals of Kanpur Zoological Park and found Toddy Cats infected with *Ancylostoma* sp.

Rao and Acharjyo (1984) reported *Echinoparypium* sp. in the intestine of Common Palm Civet.

Rao and Acharjyo (1995) observed *Artyfechinostomum* sp. and *Rictularia cahirensis* ova in faecal samples of civets.

Thakuria (1996) studied the prevalence of tuberculosis in Assam State Zoo during the period of 1984-1993 and observed one Civet Cat positive for tuberculosis.

Varadharajan and Kandasamy (2000) observed spirurid and *Artyfechinostomum* ova in faecal samples of Civet Cats at the Coimbatore Mini Zoo.

2.5.4 Canids and Hyenas

Chauhan *et al.* (1973) observed toxascarid infection in hyena and *Ancylostoma braziliense* infection in wolves in a survey of parasitic infections conducted at Prince of Wales Zoological Garden, Lucknow.

Rao and Acharjyo (1984) observed *Dirofilaria immitis* and *Dirofilaria repens* in foxes and *Ancylostoma caninum* and *Echinococcus granulosus* in jackals at Nandankanan Zoo in Orissa. They have also observed lesions associated with chronic nephritis in wolves, foxes, jackals and hyenas and verminous pneumonia with fluke eggs in foxes and *Dirofilaria immitis* and *Ancylostoma caninum* infestation in jackals.

Thakuria (1996) studied the prevalence of tuberculosis in Assam State Zoo during the period of 1984-93 and reported a hyena positive for tuberculosis.

Jayathangaraj *et al.* (1998) observed metabolic bone disease in an adult Striped Hyena at Vandalur Zoological Park.

Varadharajan and Kandasamy (2000) reported *Ancylostoma* ova in faecal samples collected from Jackals and Bengal Foxes at Coimbatore Mini Zoo.

2.5.5 Bears

Trichurid infection was observed in Sloth Bears, in a survey of parasitic infections at Prince of Wales Zoological Gardens, Lucknow (Chauhan *et al.*, 1973).

Pal (1997) reported a case of ringworm in a one year old pet bear caused by *Microsporum gypseum.*

Vellayan (1998) listed *Eimeria* sp., *Taenia* sp., *Multiceps* sp., *Diphyllobothrium* sp., *Nanaphyetus* sp., *Uncinaria* sp., *Trichinella* sp., *Dirofilaris ursi*, *Ursicoptes* sp., *Sarcoptes* sp. and *Demodex* sp. as the common parasites in ursidae of Rescue centers.

Mehrotra *et al.* (1999a) noted death of two Sloth Bears due to tuberculosis in Jaipur Zoo.

Mehrotra *et al.* (1999b) reported the death of a male Sloth Bear due to pasteurellosis at Jaipur Zoo, which showed symptoms of lacrimation and nasal discharge.

2.5.6 Felids

In Kanpur Zoological Park, Gaur *et al.* (1979) reported *Toxascaris leonina* infection in lions and tigers and *Ancylostoma* infection in Leopard Cat.

Rao and Acharjyo (1984) observed *Paragonimus westermanni* in Tiger and Golden Cat and *Filaroides osleri* and *Ancylostoma caninum* in Leopard Cats at Nandankanan Zoo, Orissa.

Tanwar *et al.* (1984) reported a case of parasitic gastritis in an Asiatic Lion of Bikaner Zoo due to *Toxascaris leonina* and *Toxocara cati.*

Ahmed *et al.* (1990) recorded a case of anaplasmosis in captive White Tiger at Nehru Zoological Park, Hyderabad.

Infectious feline enteritis in tiger cubs was reported by George *et al.* (1990) at Trichur Zoo.

Tuberculosis was confirmed by post mortem examination in three leopards at Assam State Zoo during the period of 1984-1993 (Thakuria, 1996).

Trypanasomiasis was reported by Singh *et al.* (1997a) in a female tiger in Lucknow Zoo.

Microsporum gypseum and *Microsporum nanum* were isolated from the hair samples of lions of Sanjay Gandhi Biological Park, Patna (Singh *et al.*, 1997b).

Toxocara cati, Toxascaris leonina, Toxocara canis, Aelurostrongylus sp., *Toxoplasma gondii, Eimeria* sp., *Isospora vivolta* and *Isospora felis* were listed as the common parasites in wild felids by Vellayan (1998).

Kumari and Choudhuri (1999) recorded the efficacy of 'Ivermectin' in the treatment of tick infestation in four leopards in S.V. Zoological Park, Tirupati.

Varadharajan and Pythal (1999) investigated the parasitic load of wild animals at Thiruvananthapuram Zoological Gardens and found *Ancylostoma* and *Toxascaris* as the major infections in lions, leopards and tigers. They have also observed heavy *Diphyllobothrium* and *Paragonimus* infections in a male leopard and *Isospora* and balantidial cysts in lions and leopards respectively.

Upadhye and Dhoot (2000) reported a case of trypanosomiasis in a male tiger at Maharaj Bag Zoo, Nagpur and its successful treatment with 'Berenil'.

A survey of gastro-intestinal parasites of wild animals in the V.O.C Park and Mini Zoo, Coimbatore by Varadharajan and Kandasamy (2000) revealed *Toxocara* infection in lions and *Ancylostoma* and spirurid infection in Jungle Cats.

2.5.7 Elephants

The prevalence of helminth parasites in zoo animals of Kanpur Zoological Park was studied by Gaur *et al.* (1979) and observed strongyle infection in five out of the eight elephants examined.

Successful treatment of trichostrongyle infection in six elephants with 'Fenbendazole' were reported by Lakhar and Das (1988).

The effectiveness of 'Fenbendazole' in the treatment of *Murshidia murshidia* in Indian Elephants was reported by Roy and Mazumdar (1988) at Alipore Zoological Gardens.

The incidence and causes of mortality in captive wild herbivores of Assam State Zoo was studied by Chakraborty and Chaudhury (1996) for a period of five years and observed a case of death due to colibacillosis in elephants.

FMD virus infection associated antibodies were found positive in 4.58 per cent of elephant sera collected from 15 camps of the Forest departments of Tamil Nadu, Karnataka and Andaman and Nicobar islands (Bhat and Manickam, 1997).

Modi *et al.* (1997) observed 100 per cent parasitic infection throughout the year in elephants belonging to Sanjay Gandhi Biological Park, Patna and Jawaharlal Nehru Biological Park, Bokaro.

2.5.8 Perissodactyles

Arora (1986) recorded two cases of deaths of Indian One-horned Rhinoceros due to rabies in the Prince of Wales Zoological Garden, Lucknow.

Dutta *et al.* (1990) observed 55.55 per cent of *Rhinoceros unicornis* at Assam State Zoo to be infected by intestinal helminthic infection.

Tape worm infection among rhinoceros were noted in Veeramata Jijabhai Bhosale Udyan, Bombay and new born rhino deaths due to salmonellosis, coliosis, colibacillosis and gastro enteritis were recorded in Assam State Zoo. It also recorded death of a male rhinoceros due to rabies in Allen Forest Zoo, Kanpur (Anon, 1994).

Chakraborty and Chaudhury (1996) investigated the incidence and causes of mortality in captive wild herbivores of Assam State Zoo for a period of five years and mentioned a case of mortality in equids due to botryomycosis and a case due to traumatic injury. They also observed death of rhinoceros due to colibacillosis and complications of injury.

Indian Rhinoceros are notable for uterine leiomyomas, foot infections, and a possibly increased rate of still births and abortions and a case of abortion was associated with infection with *Leptospira interrogans* (Miller and Foose, 1996).

Arora *et al.* (1997) reported a case of rabies confirmed by laboratory tests in a three year old female Wild Ass in the National Zoological Park, New Delhi.

Modi *et al.* (1997) studied the seasonal effect on the prevalence of parasitic diseases among zoo animals of Bihar and found a higher percentage of infection in rhinoceros during monsoon.

2.5.9 Non-ruminant Artiodactyles

The prevalence of helminth parasites in zoo animals of Kanpur Zoological Park was studied by Gaur *et al.* (1979) and found Wild Boars infected with *Oesophagostomum* sp., *Ascaris suum* and *Fasciolopsis buski* and hippopotamus infected with strongyle.

Rao and Acharjyo (1984) observed Wild Boars affected with tuberculosis. They also mentioned about hydatid cysts in the peritoneal cavity and *Stephanurus dentatus* infection in Wild Boars of Nandankanan Zoo.

Chauhan *et al.* (1985) reported enterotoxaemia in four camels of Sirsa district in Haryana.

Cheema *et al.* (1992) studied on the parasitism in Wild Boar in Punjab of Pakistan and found that 67 per cent of the Wild Boars were infested with ectoparasites and 69 per cent with endoparasites. They identified the ectoparasites *Haematopinus suis, Dermacentor variablis* and *D. andersoni.* The endoparasites recorded were *Eimeria* sp., *Ascaris suum*, *Metastrongylus apri, Paragonimus westermanni, Necator* sp., *Bourgelatia diducta, Ascarops strongylina* and *Fasciolopsis buski.*

Lall (1994) observed *Fasciola gigantica* and *F. hepatica* while cutting into liver parenchyma and bile ducts of a hippo died in Ethiopia.

Thiruthalinathan *et al.* (1996) reported death of a male hippopotamus at Arignar Anna Zoological Park, Madras and revealed it to be a case of pasteurellosis.

Sena *et al.* (1999) noticed incidence of sarcoptic mange in camels of National Research Centre on Camel, Bikaner higher during September-December.

Varadharajan and Kandasamy (2000) observed *Trichuris*, spirurid, coccidia and strongyle ova and balantidial cysts in camels at the Coimbatore Mini Zoo.

2.5.10 Ruminant Artiodactyles

The prevalence of helminth infections in zoo animals of Kanpur Zoological Park was studied by Gaur *et al.* (1979) and found strongyle and *Bunostomum* sp. infection in deers and strongyle and *Haemonchus contortus* infection in Blackbucks.

Gairola (1986) noted the death of a male giraffe due to enterotoxaemia in Kanpur Zoological Park.

Amphistomes were observed in the rumen of a dead Spotted Deer at Nandankanan Zoo (Padhi *et al.*, 1987).

A case of tuberculosis in a Spotted Deer at Kamla Nehru Park, Indore was reported by Garg *et al.* (1990).

Intestinal candidiasis was recorded by Chakraborty and Chaudhury (1994) in Blackbucks and Sambar Deers in Assam State Zoo.

Thakuria (1996) studied prevalence of tuberculosis in Assam State Zoo during the period of 1984-93 and observed positive reaction to tuberculin testing in three Barking Deers and three Hog-deers. Post mortem examination conducted also revealed tuberculosis in three Giraffes, 40 Sambar Deers, one Mithun, two Nilgais, one White Fallow Deer, seven Blackbucks, 21 Axis Deers, five Hog-deers, one Ladakhi Goat and five Barking Deers.

A study to observe seasonal effect on the prevalence of parasitic diseases among zoo animals of Bihar by Modi *et al.*, (1997) revealed higher percentage of infection during monsoon in Mithun, Blackbuck and Spotted Deer. They have also observed high infection during winter in Sambar Deer.

A survey of parasites of wild animals in the Thiruvananthapuram Zoological Garden, based on faecal examination revealed helminthic infections in herbivores. Strongyle and amphistome infections were found to be higher in Bovidae and in certain species of Cervidae. Other infections observed in order of prevalence in a variety of herbivores were ascarid, *Strongyloides*, spirurid and *Fasciola* (Varadharajan and Pythal, 1999).

Varadharajan and Kandasamy (2000) observed Strongyle, *Trichuris*, ascarid and coccidial infection in Spotted Deers and *Moniezia* infection in Sambar Deers of Coimbatore Mini Zoo.

Pasteurella multocida was observed on culturing heart blood, lung and liver exudates on blood agar of a male Chital Deer found dead in the enclosure in Maharajbag Zoo, Nagpur (Dhoot and Upadhye, 2001).

2.6 Disease prevention measures in zoo mammals

2.6.1 Vaccination and deworming

Snyder and Moore (1968) quoted the observation of vaccination against panleukopenia in felids, poliomyelitis in primates and distemper and hepatitis in canids in Philadelphia Zoo.

Gairola (1986) described the various preventive measures adopted at Kanpur Zoological Park to check the abnormal mortalities in animals. A deworming schedule for all animals were done after analysis of stool and regular deworming of each and every animal. Positive cases in regular stool examinations was followed by deworming of the whole flock. In case of prevalence of any infectious disease in domestic animals and birds of surrounding area, vaccination programme of the susceptible species in the zoo were also carried out.

Khan and Choudhury (1987) reported that the faecal samples of Indian Rhinoceros at Nehru Zoological Park were screened once a month to detect the

worm load of helminth parasites and the animals were dewormed once in every three months.

High rate of parasitic infections were noted in hoof stock at Oklahoma City Zoo as they were maintained in grassy exhibits (Grisham and Savage, 1990). Faecal floatations were done on a quarterly basis in the zoo and when results found positive, the herds were dewormed with a follow up worming two weeks later. After seven days a repeat faecal examination was performed and if it was still positive, the deworming was repeated.

Deworming of the rhinoceros were carried out once in every three months in Allen Forest Zoo and so also periodic deworming was done in Alipore Zoo, Assam State Zoo and Veermata Jijabhai Bhosale Udyan (Anon, 1994).

Pandit (1994) reported that an outbreak of Anthrax in wild elephants occurred at Jaldapara Wildlife Sanctuary and as a preventive measure all the captive elephants of the sanctuary and the 24 wild rhinoceros in the sanctuary were vaccinated against Anthrax.

Felid Veterinary Guidelines (1996) suggested examination of faecal samples of cats at least twice a year and more frequently where a specific problem is known to exist. If chronic parasite infestations are present, regular treatment with anthelmintics at frequent intervals may be necessary and it is a good practice to alternate the type of anthelmintic employed. It was also

suggested inactivated rabies vaccines and also live FIE and FRT/FCV vaccines. Similarly in areas where felids are at high risk, vaccination against canine distemper with inactivated vaccine can also be adopted and also against leptospirosis.

Miller and Foose (1996) suggested that rhinoceroses should be checked for gastro intestinal parasites and treated accordingly. Except for the use of leptospirosis bacterins in black and perhaps Greater Asian One-horned Rhinoceros, vaccinations were not routinely practiced in rhinoceros.

Vellayan (1998) discussing the preventive medicines for wildlife in rescue centres, suggested polio, rabies and tetanus vaccinations in primates. TB tests or chest X-rays were also recommended for primates yearly, as a good preventive measure. Monthly faecal examinations and faecal or rectal cultures for *Salmonella* sp., *Shigella* sp. and *Campylobacter* sp. once in three months were also recommended. Immuno prophylaxis for canine distemper, feline panleukopenia, canine adenovirus, canine parvo virus, feline viral rhinotracheitis, feline calici virus and also rabies were suggested in carnivores at rescue centres.

In zoo standards for keeping civets and mongooses in captivity, Carnio (1999) suggested periodic faecal examination and treatment. As these species are subject to canine distemper and feline panleukopenia, annual vaccinations were recommended. In areas where rabies, canine leptospirosis and canine hepatitis are a problem vaccination need to be considered against them also.

Mellen (1999) recommended annual vaccination against feline panleukopenia, rhinotracheitis and calici virus (FVRCP) and also prophylaxis against rabies, annually or at three year intervals, depending on the product used. In areas where tetanus is endemic, felids should be vaccinated for this disease on an annual basis. It was also recommended a minimum of two faecal examinations per year and appropriate therapy.

Acharjyo (2001) reviewing the incidence of parasitic diseases among wild mammals in Indian zoos mentioned the control measures to be adopted to reduce the incidence, including periodic faecal examination for three consecutive days and treatment of positive cases with appropriate broad spectrum anthelmintics and mass treatment of animals living in groups. He recommended that a deworming schedule is to be adopted for different species of wild mammals in Indian zoos and a change in the choice of anthelmintic drugs from time to time to avoid drug resistance of the parasite.

2.6.2 Cleaning and disinfection

Fowler (1978) mentioned the importance of sanitation in disease prevention in zoos and suggested that the daily removal of faeces and urine from enclosures control the odour, prevent parasitic infection and prevent insect population build up. It was also recommended to remove uneaten food from the cages before spoilage. Cleaning the floor surfaces prior to feeding prevent the mixing of food with soil and prevent parasitic ova contamination.

Martin (1978) suggested that primate houses with impervious interior surface were easy to clean and the floor of the house should slope towards the drain. Floors should have no unevenness, permiting pools of liquid to form and the waste from one cage should not be flushed within the reach of other non-human primates. All areas of the primate quarters should be cleaned atleast once daily and preferably twice. Excess food and faeces should be flushed away and phenolic disinfectants can be used.

Gairola (1986) reported that in Kanpur Zoological Park; the measures of sanitation and cleanliness of the enclosures were strictly observed and all the food materials that were received daily such as fruits, vegetables and meat were examined thoroughly for quality and freshness and was distributed after proper antiseptic treatment.

Naidu (1986) opined that cleaning, though a necessary operation, must be minimised and use of strong disinfectants may be minimised by better aeration and lighting conditions. The constant keeping of animals in the same enclosure increases the potentiality and proneness of diseases and parasites and this can be minimised by shifting animals to other enclosures in rotation.

Calgary Zoo-keeper training lecture (1989) mentioned that in elephants which are usually fed on the ground, it is important to keep the cage floor clean at all times and the faeces should be removed frequently and as quickly as possible to reduce any contact. In carnivores the walls of the houses need much attention as large male cats will mark the walls with their urine well above their

body height and good ventilation must be provided to dry the exhibits quickly. Pigs and hippos like a mud bath or pools for their skin care which must be frequently cleaned and dried and clean sleeping areas must be provided for them.

Phillips (1994) suggested to offer food for felids on a non contaminated surface and preferably above the enclosure floor or substrate. Cages are to be cleaned frequently using effective disinfectants and phenolic compounds must be avoided due to the susceptibility of felids to this chemical. For effective cleaning, use of hot water, a detergent and physical effort are most effective, coupled with disinfectant cleaning, and the surfaces must be rinsed thoroughly to eliminate all residues of the disinfectant.

In the draft of standards and norms, for elephant owners, Bist (1996) suggested that the stable floor should not be wet and uneven and elephants should not be made to stand on ground saturated with urine and filth. The floor of the stable must be treated with phenyl solution atleast once a week and proper arrangement of drainage of excess of water and arrangements for removal of excreta, left over food items and residual water shall be made.

In the Felid Veterinary Guidelines (1996), it was mentioned that the feed and water containers and the food preparation utensils for the animals are to be cleaned and disinfected daily and that the food and animal waste should be removed daily and disposed of carefully. Use of appropriate disinfectants excluding phenolic disinfectants was also mentioned. Good hygiene around cat

enclosures also help to reduce insect pests and since heavy parasite burdens can build up in top soil, producing constant reinfestations, the top soil has to be changed as an effective solution.

Carnio (1999) recommended spot cleaning of civet enclosures daily, and large enclosures with dirt substrates should be raked and spot cleaned daily and the soil completely removed once a year. In large outdoor enclosures, substrate removal may not be necessary and as these animals scent mark their area, total daily cleaning may cause stress and this problem can be reduced by cleaning the substrate and not the furniture and the furniture can be replaced when soiled.

Regarding the sanitation of sciurid enclosures, Kranz (1999) suggested that the primary enclosures should be routinely cleaned and disinfected. The daily minimum cleaning should include the removal of all faeces, soiled substrates and uneaten food. Fresh substrate should be added as necessary. The feed and water bowls should be cleaned and disinfected daily and the enclosures are to be thoroughly cleaned and disinfected every 7-14 days. In enclosures where perches are used, they should be replaced at regular intervals.

Daily cleaning and disinfection of the hard surfaces of primary enclosures, food containers and water bowls were recommended by Mellen (1999) in minimum standards for keeping small felids in captivity. It was also suggested that the perches and shelves should be kept free of faeces and urine

and the dirt substrates in outdoor exhibits should be raked and spot cleaned daily.

Acharjyo (2001) reviewing the incidence of parasitic diseases among wild mammals in Indian zoos quoted some indirect measures to be adopted to control the incidence of diseases. He suggested daily cleaning and disinfection of the enclosures and surrounding areas and quick disposal of wastes. He has also recommended crack free floors and walls in all retreating housing facilities permiting thorough cleaning and the houses are to be well ventilated and lighted. There should be a good drainage system to prevent water logging, dampness and unhygienic conditions and also suggested periodic lime treatment of animal houses and water moats. The soil or sand of enclosures are to be changed atleast twice a year and to use only clean water from protected water supply in animal houses.

Materials and Methods

3. MATERIALS AND METHODS

3.1 Study area

The Government owned zoological gardens, at Thiruvananthapuram and Thrissur, in Kerala State administered by the department of Museums and Zoos, were selected for the present study.

The Thiruvananthapuram Zoo, one of the oldest zoos in the country, was established in the year 1857 by the erstwhile Maharaja of Travancore, is spread over 22 hectares of land, in the heart of Thiruvananthapuram City.

The State Museum and Zoo in Thrissur was originally started in 1885 at Viyyur and was subsequently shifted to Chembukkavu in 1912. The zoo has a total area of 4.5 hectares.

3.2 Animals

The detailed list of the captive mammals in this study are given below.

Captive mammals of Thiruvananthapuram Zoo
(Stock as on 31.03.2001)

Sl. No.	Species	Male	Female	Unknown	Total
1	Indian Giant Squirrel (*Ratufa indica*)	-	1	-	1
2	Indian Porcupine (*Hystrix indica*)	4	3	-	7
3	Bonnet Macaque (*Macaca radiata*)	4	3	-	7
4	Rhesus Macaque (*Macaca mulatta*)	-	1	-	1

5	Lion-tailed Macaque (*Macaca silenus*)	4	4	-	8
6	Common Langur (*Presbytis entellus*)	3	2	-	5
7	Nilgiri Langur (*Trachypithecus johni*)	1	-	-	1
8	Capuchin Monkey (*Cebus capucinus*)	3	-	-	3
9	Common Palm Civet (*Paradoxurus hermaphroditus*)	1	-	-	1
10	Indian Fox (*Vulpes bengalensis*)	1	-	-	1
11	Jackal (*Canis aureus*)	4	1	-	5
12	Striped Hyena (*Hyaena hyaena*)	-	1	-	1
13	Himalayan Black Bear (*Selenarctos thibetanus*)	1	1	-	2
14	Sloth Bear (*Melursus ursinus*)	1	1	-	2
15	Jungle Cat (*Felis chaus*)	1	1	-	2
16	Leopard (*Panthera pardus*)	1	1	-	2
17	Tiger-hybrid (*Panthera tigris*)	1	2	-	3
18	Indian Lion (*Panthera leo persica*)	-	1	-	1
19	Lion-hybrid (*Panthera leo*)	4	7	-	11
20	Indian Elephant (*Elephas maximus*)	-	1	-	1
21	Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)	2	-	-	2
22	Zebra (*Equus burchelli*)	1	1	-	2
23	Indian Wild Boar (*Sus scrofa*)	8	8	2	18

24	Nile Hippopotamus (*Hippopotamus amphibius*)	2	3	-	5
25	Barking Deer (*Muntiacus muntjak*)	5	2	-	7
26	Hog-Deer (*Axis porcinus*)	7	21	-	28
27	Spotted Deer (*Axis axis*)	19	40	19	78
28	Sambar Deer (*Cervus unicolor*)	17	43	-	60
29	Giraffe (*Giraffa camelopardalis*)	-	1	-	1
30	Blackbuck (*Antilope cervicapra*)	11	5	1	17
31	Nilgai (*Boselaphus tragocamelus*)	3	5	2	10
32	Mithun (*Bos frontalis*)	2	2	-	4
33	African Cape Buffalo (*Syncerus caffer*)	1	2	-	3
34	Nilgiri Tahr (*Hemitragus hylocrius*)	1	-	-	1

Captive mammals of Thrissur Zoo (Stock as on 23.02.2000)					
Sl. No.	Species	Male	Female	Unknown	Total
1	Indian Porcupine (*Hystrix indica*)	1	1	-	2
2	Bonnet Macaque (*Macaca radiata*)	18	16	-	34
3	Rhesus Macaque (*Macaca mulatta*)	-	1	-	1
4	Lion-tailed Macaque (*Macaca silenus*)	3	-	-	3
5	Common Palm Civet (*Paradoxurus hermaphroditus*)	-	-	3	3

6	Small Indian Civet (*Viverricula indica*)	1	2	-	3
7	Jackal (*Canis aureus*)	1	-	-	1
8	Himalayan Black Bear (*Selenarctos thibetanus*)	1	-	-	1
9	Sloth Bear (*Melursus ursinus*)	1	-	-	1
10	Jungle Cat (*Felis chaus*)	1	-	-	1
11	Leopard (*Panthera pardus*)	2	-	-	2
12	Black Panther (*Panthera pardus*)	1	-	-	1
13	Lion-hybrid (*Panthera leo*)	3	3	-	6
14	Indian Wild Boar (*Sus scorfa*)	3	2	-	5
15	Camel (*Camelus dromedarius*)	1	1	-	2
16	Nile Hippopotamus (*Hippopotamus amphibius*)	1	2	-	3
17	Barking Deer (*Muntiacus muntjak*)	1	-	-	1
18	Hog-Deer (*Axis porcinus*)	4	4	1	9
19	Spotted Deer (*Axis axis*)	42	71	13	126
20	Sambar Deer (*Cervus unicolor*)	12	6	3	21
21	Blackbuck (*Antilope cervicapra*)	5	-	-	5

The existing animal husbandry practices in captive wild mammals exhibited in the Thiruvananthapuram and Thrissur Zoos were observed.

3.3 Classification of zoo mammals

The captive mammals in the zoos were classified based on their taxonomic relationship and their food habits.

3.4 Feeding of zoo mammals

3.4.1 Feed allowance

The rations prescribed for the mammals were noted and based on that, recordings were made on the daily feed intake of captive mammals in the zoos. The quantity and quality assessment of the food materials were also taken up.

3.4.2 Feed evaluation

Proximate analysis of the compounded feeds given to the zoo mammals were undertaken, AOAC (1990). Details of the nutrient content in the components of other feeding materials used were compiled and based on that, total nutrient content in the prescribed rations were worked out.

3.5 Housing of zoo mammals

The housing systems adopted for the above categories of animals were documented and photographed. The animal enclosures and floor space of cages were measured with a standard measuring tape. The environmental enrichment in the enclosures were also observed.

3.6 Breeding of zoo mammals

Data on the breeding of zoo animals were collected from the birth registers maintained in the zoos for a period of 10 years from 1991 to 2000. Based on this, the breeding performance of the captive mammals were assessed.

3.7 Disease prevalence in zoo mammals

Data on the disease occurrence in these zoo animals were codified from the registers of the zoos for a period of five years from 1996 to 2000. Based on this, the incidence of different classes of disease was assessed.

3.8 Disease prevention measures in zoo mammals

3.8.1 Vaccination and deworming

The present disease prevention protocol including vaccinations and deworming strategies adopted in the zoos during the five year period were documented from the registers maintained in the zoos.

3.8.2 Cleaning and disinfection

The cleaning and disinfection procedures routinely carried out in the zoos were observed during the study period. The disinfectants used in the enclosures were also noted.

Results

4. RESULTS

4.1 Classification of zoo mammals

The mammals of the zoos in the state were classified into ten groups based on their taxonomic position and food habits. They are

1. Rodents
2. Primates
3. Mustelids and Viverrids
4. Canids and Hyenas
5. Bears
6. Felids
7. Elephants
8. Perissodactyles
9. Non-ruminant Artiodactyles
10. Ruminant Artiodactyles

The list of mammals under each category in Thiruvananthapuram and Thrissur Zoos are given in Table 1.

Table 1. Classification-wise list of mammals in Thiruvananthapuram and Thrissur Zoos

No.	Category	Thiruvananthapuram Zoo	Thrissur Zoo
1	Rodents	Indian Giant Squirrel (*Ratufa indica*) Indian Porcupine *(Hystrix indica)*	Indian Porcupine *(Hystrix indica)*

Table 1 (Contd.)

2	Primates	Bonnet Macaque *(Macaca radiata)* Rhesus Macaque *(Macaca mulatta)* Lion-tailed Macaque *(Macaca silenus)* Common Langur *(Presbytis entellus)* Nilgiri Langur *(Trachypithecus johni)* Capuchin Monkey *(Cebus capucinus)*	Bonnet Macaque *(Macaca radiata)* Rhesus Macaque *(Macaca mulatta)* Lion-tailed Macaque *(Macaca silenus)*
3	Mustelids and Viverrids	Common Palm Civet *(Paradoxurus hermaphroditus)*	Common Palm Civet *(Paradoxurus hermaphroditus)* Small Indian Civet *(Viverricula indica)*
4.	Canids and Hyenas	Indian Fox *(Vulpes bengalensis)* Jackal *(Canis aureus)* Striped Hyena *(Hyaena hyaena)*	Jackal *(Canis aureus)*
5.	Bears	Himalayan Black Bear *(Selenarctos thibetanus)* Sloth Bear *(Melursus ursinus)*	Himalayan Black Bear *(Selenarctos thibetanus)* Sloth Bear *(Melursus ursinus)*
6	Felids	Jungle Cat *(Felis chaus)* Leopard *(Panthera pardus)* Tiger *(Panthera tigris)* Lion *(Panthera leo)*	Jungle Cat *(Felis chaus)* Leopard *(Panthera pardus)* Lion *(Panthera leo)*

Table 1 (Contd.)

7	Elephants	Indian Elephant *(Elephas maximus)*	
8	Perissodactyles	Great Indian One-horned Rhinoceros *(Rhinoceros unicornis)* Zebra *(Equus burchelli)*	
9	Non-ruminant Artiodactyles	Indian Wild Boar *(Sus scrofa)* Nile Hippopotamus *(Hippopotamus amphibius)*	Indian Wild Boar *(Sus scrofa)* Camel *(Camelus dromedarius)* Nile Hippopotamus *(Hippopotamus amphibius)*
10	Ruminant Artiodactyles	Barking Deer *(Muntiacus muntjak)* Hog-Deer *(Axis porcinus)* Spotted Deer *(Axis axis)* Sambar Deer *(Cervus unicolor)* Giraffe *(Giraffa camelopardalis)* Blackbuck *(Antilope cervicapra)* Nilgai *(Boselaphus tragocamelus)* Mithun *(Bos frontalis)* African Cape Buffalo *(Syncerus caffer)* Nilgiri Tahr *(Hemitragus hylocrius)*	Barking Deer *(Muntiacus muntjak)* Hog-Deer *(Axis porcinus)* Spotted Deer *(Axis axis)* Sambar Deer *(Cervus unicolor)* Blackbuck *(Antilope cervicapra)*

4.2 Feeding of zoo mammals

The ration for captive mammals in Thiruvananthapuram and Thrissur Zoos are given in Tables 2 to 19 and the total nutrient contents of the ration are presented in Tables 20 to 37.

Table 2. Ration for Rodents in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Indian Giant Squirrel *(Ratufa indica)*	Indian Porcupine *(Hystrix indica)*
Groundnut	0.025	-
Bengal gram	0.015	-
Apple	0.025	-
Grapes	0.025	-
Guava	0.025	-
Orange	0.025	-
Cabbage	-	0.05
Carrot	-	0.05
Cucumber	-	0.05
Amaranthus	0.05	0.20
Tapioca	-	0.50
Bread	-	0.10

Table 3. Ration for Rodents in Thrissur Zoo

(All values in kg)

Ingredients	Indian Porcupine *(Hystrix indica)*
Cabbage	0.05
Carrot	0.05
Cucumber	0.05
Pumpkin	0.075
Amaranthus	0.05
Tapioca	0.05

Table 4. Primate rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Bonnet Macaque (*Macaca radiata*)	Rhesus Macaque (*Macaca mulatta*)	Lion-tailed Macaque (*Macaca silenus*)	Common Langur (*Presbytis entellus*)	Nilgiri Langur (*Trachy-pithecus johni*)	Capuchin Monkey (*Cebus capucinus*)
Bengal gram	0.042	0.042	0.042	0.042	0.042	0.042
Groundnut	-	-	0.025	0.1	-	-
Coconut	0.03	0.03	0.03	0.03	0.03	0.03
Banana	0.05	0.25	0.05	0.1	0.05	0.15
Plantain	0.1	0.25	0.125	0.1	0.3	0.1
Grapes	-	-	0.075	-	0.1	-
Orange	0.045	0.045	0.045	0.045	0.045	0.045
Cabbage	-	-	-	0.05	-	-
Carrot	-	-	-	0.05	-	0.05
Amaranthus	-	0.1	0.025	-	-	-
Cooked rice	0.017	0.017	0.017	0.017	0.017	0.017
Bread	0.025	-	0.1	0.025	0.05	0.15
Boiled egg	-	-	0.025	-	-	0.05

Table 5. Primate rations in Thrissur Zoo

(All values in kg)

Ingredients	Bonnet Macaque (*Macaca radiata*)	Rhesus Macaque (*Macaca mulatta*)	Lion-tailed Macaque (*Macaca silenus*)
Groundnut	0.125	0.125	0.125
Coconut	0.01	0.01	0.01
Banana	0.22	0.22	0.22
Plantain	0.22	0.22	0.22
Cabbage	0.05	0.05	0.05
Carrot	0.03	0.03	0.03
Cucumber	0.03	0.03	0.03
Amaranthus	0.05	0.05	0.05
Cooked rice	0.4	0.4	0.4
Bread	0.18	0.18	0.18
Milk	0.1	0.1	0.1

Table 6. Mustelid and Viverrid ration in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Common Palm Civet (*Paradoxurus hermaphroditus*)
Plantain	0.05
Bread	0.025
Milk	0.025
Beef	0.1

Table 7. Mustelid and Viverrid rations in Thrissur Zoo

(All values in kg)

Ingredients	Common Palm Civet (*Paradoxurus hermaphroditus*)	Small Indian Civet (*Viverricula indica*)
Plantain	0.05	0.05
Cooked rice	0.12	-
Bread	0.06	-
Milk	0.02	0.165
Egg	-	0.05
Beef	0.115	0.115

Table 8. Canid and Hyaena rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Indian Fox *(Vulpes bengalensis)*	Jackal (*Canis aureus*)	Striped Hyena (*Hyaena hyaena*)
Beef	0.1	0.25	2
Salt	Added	Added	Added

Table 9. Canid ration in Thrissur Zoo

(All values in kg)

Ingredients	Jackal (*Canis aureus*)
Beef	1.36

Table 10. Bear rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Himalayan Black Bear (*Selenarctos thibetanus*)	Sloth Bear (*Melursus ursinus*)
Banana	0.1	0.25
Plantain	0.1	0.1
Apple	0.125	0.125
Grapes	0.1	0.1
Orange	0.125	0.25
Sugarcane	0.143	0.143
Jaggery	0.2	0.2
Honey	0.036	0.036
Cooked rice	0.3	0.3
Bread	1	1
Milk	1.5	1.5
Boiled egg	0.05	0.05
Cooked beef	0.25	-
Turmeric	0.002	-
Grass	-	0.5

Table 11. Bear rations in Thrissur Zoo

(All values in kg)

Ingredients	Himalayan Black Bear (*Selenarctos thibetanus*)	Sloth Bear (*Melursus ursinus*)
Carrot	0.1	0.1
Cucumber	0.1	0.1
Honey	-	0.1
Jaggery	0.225	0.225
Cooked rice	0.5	0.5
Bread	0.4	0.4
Milk	1	1

Table 12. Felid rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Jungle Cat (*Felis chaus*)	Leopard (*Panthera pardus*)	Tiger (*Panthera tigris*)	Lion (*Panthera leo*)	
				Male	Female
Beef	0.1	3	8	8	7
Chicken	-	-	0.29	-	-
Milk	-	0.5	0.5	0.5	0.5
Salt	Added	Added	Added	Added	Added

Table 13. Felid rations in Thrissur Zoo

(All values in kg)

Ingredients	Jungle Cat (*Felis chaus*)	Leopard (*Panthera pardus*)	Black Panther (*Panthera pardus*)	Lion (*Panthera leo*)	
				Male	Female
Beef	0.115	3.175	3.175	7.265	5.9
Milk	-	-	1	0.5	-
Egg	-	-	0.1	-	-
Salt	-	Added	Added	Added	Added

Table 14. Elephant ration in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Indian Elephant (*Elephas maximus*)
Banana	0.5
Plantain	1
Sugarcane	0.643
Jaggery	0.29
Cooked rice	3.45
Fodder grass	50
Coconut palm leaves	30
Caryota leaves	11.5
Asafoetida	0.014

Table 15. Perissodactyl rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)	Zebra (*Equus burchelli*)
Plantain	1	-
Sugarcane	0.36	-
Cabbage	0.5	-
Carrot	0.5	0.25
Jaggery	0.14	-
Cooked rice	0.75	-
Bengal gram	1	-
Horse gram	-	2
Green gram	0.5	0.5
Wheat bran	1	4
Broiler starter	1.5	-
Green grass	45	-
Fodder grass	50	15
Fodder leaves	55	-
Asafoetida	0.003	-
Salt	Added	Added

Table 16. Non-ruminant Artiodactyl rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Indian Wild Boar (*Sus scrofa*)	Nile Hippopotamus (*Hippopotamus amphibius*)
Plantain	-	0.4
Tapioca	0.6	-
Bread	0.15	-
Cooked rice	0.14	0.75
Wheat bran	-	7.5
Compounded feed	-	4
Broiler starter	1	-
Green grass	-	22.5

Table 17. Non-ruminant Artiodactyl rations in Thrissur Zoo

(All values in kg)

Ingredients	Indian Wild Boar (*Sus scrofa*)	Camel (Camelus dromedarius)	Nile Hippopotamus (*Hippopotamus amphibius*)
Banana	-	-	2
Cucumber	0.25	-	-
Pumpkin	0.25	-	-
Amaranthus	-	-	2
Tapioca	0.9	-	-
Bengal gram	-	1	-
Black gram	-	1	-
Horse gram	-	1	-
Green gram	-	1	-
Cooked rice	0.75	-	5
Bread	-	-	0.8
Wheat bran	1	-	10
Green grass	-	-	40
Jack leaves	-	20	-
Salt	Added	Added	-

Table 18. Ruminant Artiodactyl rations in Thiruvananthapuram Zoo

(All values in kg)

Ingredients	Barking Deer (*Muntiacus muntjak*)	Hog-Deer (*Axis porcinus*)	Spotted Deer (*Axis axis*)	Sambar Deer (*Cervus unicolor*)	Giraffe (*Giraffa camelo-pardalis*)	Blackbuck (*Antilope cervicapra*)	Nilgai (*Boselaphus tragocamelus*)	Mithun (*Bos frontalis*)	African Cape Buffalo (*Syncerus caffer*)	Nilgiri Tahr (*Hemitragus hylocrius*)
Banana	-	-	-	-	0.25	-	-	-	-	-
Plantain	-	-	-	-	0.5	-	0.2	-	-	0.25
Cabbage	-	-	-	-	0.5	-	-	-	0.3	0.1
Carrot	-	-	-	-	1	-	-	-	0.25	0.1
Bengal gram	0.1	-	-	-	0.25	0.1	0.2	-	0.3	0.1
Green gram	0.1		0.1	0.1	-	0.1	0.3	0.25	0.3	-
Cotton seed	-	-	0.1	0.1	-	-	-	-	-	-
Wheat bran	0.2	-	0.5	0.75	-	0.2	1	0.5	1.5	0.25
Compounded feed	0.3	0.5	0.3	0.75	1.5	0.3	1	1	4.5	0.25
Green grass	-	-	-	-	-	1.5	-	-	-	-
Fodder grass	2	1	2	3	-	-	8	10	25	2.5
Fodder leaves	3	1	3	5	20	1.5	8	10	20	1
Salt	Added	Added	Added	Added	-	Added	Added	-	Added	added

Table 19. Ruminant Artiodactyl rations in Thrissur Zoo

(All values in kg)

Ingredients	Barking Deer (*Muntiacus muntjak*)	Hog-Deer (*Axis porcinus*)	Spotted Deer (*Axis axis*)	Sambar Deer (*Cervus unicolor*)	Blackbuck (*Antilope cervicapra*)
Plantain	-	0.1	-	-	-
Carrot	0.1	-	-	-	-
Cucumber	0.1	-	-	-	-
Amaranthus	0.25	-	-	-	-
Bengal gram	0.125	0.125	0.04	-	0.075
Black gram	0.125	0.125	0.04	-	0.075
Green gram	0.125	0.125	0.04	-	0.075
Horse gram	0.125	0.125	0.04	-	0.075
Cotton seed	-	-	0.45	0.68	-
Compounded feed	-	0.2	0.9	0.9	0.375
Green grass	-	0.9	4.5	4.5	1.5
Jack leaves	-	0.9	5.4	5.4	1
Salt	Added	Added	Added	Added	Added

Table 20. Total nutrient content in the ration for Rodents in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabolisable energy (k.cal)
Indian Giant Squirrel (*Ratufa indica*)	0.0605	0.0127	0.0112	0.0042	0.0294	268.9*
Indian Porcupine (*Hystrix indica*)	0.304	0.022	0.0029	0.0045	0.267	1174*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 21. Total nutrient content in the ration for Rodents in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Indian Porcupine (*Hystrix indica*)	0.0467	0.0056	0.0007	0.0021	0.0365	171*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 22. Total nutrient content in the ration for Primates in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Bonnet Macaque (*Macaca radiata*)	0.128	0.013	0.0152	0.003	0.095	565.53*
Rhesus Macaque (*Macaca mulatta*)	0.246	0.0203	0.016	0.0037	0.198	1015.03*
Lion-tailed Macaque (*Macaca silenus*)	0.222	0.0302	0.0292	0.0062	0.154	996.03*
Common Langur (*Presbytis entellus*)	0.252	0.042	0.056	0.0074	0.142	1231.03*
Nilgiri Langur (*Trachypithecus johni*)	0.210	0.018	0.016	0.006	0.167	878.03*
Capuchin Monkey (*Cebus capucinus*)	0.259	0.031	0.0231	0.0042	0.202	1126.03*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 23. Total nutrient content in the ration for Primates in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Bonnet Macaque (*Macaca radiata*)	0.507	0.067	0.06	0.007	0.367	2286.77*
Rhesus Macaque (*Macaca mulatta*)	0.507	0.067	0.06	0.007	0.367	2286.77*
Lion-tailed Macaque (*Macaca silenus*)	0.507	0.067	0.06	0.007	0.367	2286.77*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 24. Total nutrient content in the ration for Mustelids and Viverrids in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Common Palm Civet (*Paradoxurus hermaphroditus*)	0.0566	0.0258	0.0037	0.0001	0.0266	241.75*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 25. Total nutrient content in the ration for Mustelids and Viverrids in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Common Palm Civet (*Paradoxurus hermaphroditus*)	0.113	0.034	0.0042	0.0001	0.073	470.61*
Small Indian Civet (*Viverricula indica*)	0.076	0.038	0.016	-	0.02	376.85*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 26. Total nutrient content in the ration for Canids and Hyenas in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabolisable energy (k.cal)
Indian Fox (*Vulpes bengalensis*)	0.0257	0.0226	0.0026	-	-	114*
Jackal (*Canis aureus*)	0.0643	0.0565	0.0065	-	-	285*
Striped Hyena (*Hyaena hyaena*)	0.514	0.452	0.052	-	-	2280*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 27. Total nutrient content in the ration for Canids in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabolisable energy (k.cal)
Jackal (*Canis aureus*)	0.35	0.307	0.035	-	-	1550.4*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 28. Total nutrient content in the ration for Bears in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabolisable energy (k.cal)
Himalayan Black Bear (*Selenarctos thibetanus*)	1.354	0.207	0.117	0.02	1.0082	5901.45*
Sloth Bear (*Melursus ursinus*)	1.433	0.152	0.0724	0.0613	1.131	5724.63**

* Calculated by consulting metabolisable energy values of feedstuffs for humans

** Calculated by consulting metabolisable energy values of feedstuffs for humans and ruminants

Table 29. Total nutrient content in the ration for Bears in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Himalayan Black Bear (*Selenarctos thibetanus*)	0.725	0.0732	0.0393	0.0023	0.606	3073.53*
Sloth Bear (*Melursus ursinus*)	0.805	0.0733	0.0393	0.0023	0.686	3393.53*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 30. Total nutrient content in the ration for Felids in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Jungle Cat (*Felis chaus*)	0.0257	0.0226	0.0026	-	-	114*
Leopard (*Panthera pardus*)	0.833	0.6945	0.096	-	0.024	3745*
Tiger (*Panthera tigris*)	2.2	1.9	0.2277	-	0.024	9761.1*
Lion – Male (*Panthera leo*)	2.12	1.82	0.226	-	0.024	9445*
Lion – female) (*Panthera leo*)	1.86	1.6	0.2	-	0.024	8305*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 31. Total nutrient content in the ration for Felids in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Jungle Cat (*Felis chaus*)	0.03	0.026	0.003	-	-	131.1*
Leopard (*Panthera pardus*)	0.82	0.72	0.08	-	-	3619.5*
Black Panther (*Panthera pardus*)	0.97	0.77	0.129	-	0.048	4442.5*
Lion – Male (*Panthera leo*)	1.93	1.66	0.21	-	0.02	8607.1*
Lion – female) (*Panthera leo*)	1.52	1.33	0.15	-	-	6726*

* Calculated by consulting metabolisable energy values of feedstuffs for humans

Table 32. Total nutrient content in the ration for Elephants in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Indian Elephant (*Elephas maximus*)	28.09	2.24	0.86	8.44	14.24	38737.55*

* Calculated by consulting metabolisable energy values of feedstuffs for elephants, ruminants and humans

Table 33. Total nutrient content in the ration for Perissodactyles in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)	48.52	5.49	1.56	11.59	24.73	120072.41*
Zebra (*Equus burchelli*)	8.81	1.45	0.268	1.54	5.025	20408.5**

* Calculated by consulting metabolisable energy values of feedstuffs for ruminants, humans, poultry and horse

** Calculated by consulting metabolisable energy values of feedstuffs for ruminants, horse and humans

Table 34. Total nutrient content in the ration for Non-ruminant Artiodactyles in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Indian Wild Boar (*Sus scrofa*)	1.28	0.1599	0.046	0.044	0.911	3741.02*
Nile Hippopotamus (*Hippopotamus amphibius*)	16.23	2.24	0.47	2.98	8.80	38567.57**

* Calculated by consulting metabolisable energy values of feedstuffs for pigs, humans and poultry

** Calculated by consulting metabolisable energy values of feedstuffs for ruminants, humans and pigs

Table 35. Total nutrient content in the ration for Non-ruminant Artiodactyles in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Indian Wild Boar (*Sus scrofa*)	1.49	0.181	0.0426	0.108	1.088	4156.62*
Camel (*Camelus dromedarius*)	11.88	2.02	0.417	1.71	6.75	36392.45**
Nile Hippopotamus (*Hippopotamus amphibius*)	21.78	2.49	0.58	4.27	12.2	54551.9***

* Calculated by consulting metabolisable energy values of feedstuffs for pigs and humans

** Calculated by consulting metabolisable energy values of feedstuffs for ruminants and humans

*** Calculated by consulting metabolisable energy values of feedstuffs for pigs, ruminants and humans

Table 36. Total nutrient content in the ration for Ruminant Artiodactyles in Thiruvananthapuram Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Barking Deer (*Muntiacus muntjak*)	2.279	0.332	0.0828	0.428	1.23	6061.61*
Hog-Deer (*Axis porcinus*)	1.067	0.161	0.033	0.195	0.57	2627.00**
Spotted Deer (*Axis axis*)	2.55	0.348	0.11	0.474	1.35	6727.61*
Sambar Deer (*Cervus unicolor*)	4.20	0.631	0.169	0.767	2.25	10976.52*
Giraffe (*Giraffa camelopardalis*)	10.3	1.480	0.38	1.75	5.66	28238.73*
Blackbuck (*Antilope cervicapra*)	1.63	0.234	0.0516	0.298	0.871	4307.17*
Nilgai (*Boselaphus tragocamelus*)	7.21	1.040	0.2561	1.38	3.91	18849.07*
Mithun (*Bos frontalis*)	7.73	1.060	0.27	1.62	4.07	19668.93*
African Cape Buffalo (*Syncerus caffer*)	19.31	2.734	0.657	3.88	10.27	48567.85*
Nilgiri Tahr (*Hemitragus hylocrius*)	1.54	0.2065	0.052	0.303	0.859	3993.45*

* Calculated by consulting metabolisable energy values of feedstuffs for ruminants and humans

** Calculated by consulting metabolisable energy values of feedstuffs for ruminants

Table 37. Total nutrient content in the ration for Ruminant Artiodactyles in Thrissur Zoo

Species	Dry matter (kg)	Crude protein (kg)	Ether extract (kg)	Crude fibre (kg)	Nitrogen free extract (kg)	Metabo-lisable energy (k.cal)
Barking Deer (*Muntiacus muntjak*)	0.5	0.1233	0.0129	0.0195	0.3227	1883.65*
Hog-Deer (*Axis porcinus*)	1.25	0.212	0.0347	0.182	0.718	3734.25*
Spotted Deer (*Axis axis*)	4.73	0.672	0.2223	0.9734	2.34	12347.78*
Sambar Deer (*Cervus unicolor*)	4.8	0.686	0.266	1.01	2.3	12507.08**
Blackbuck (*Antilope cervicapra*)	1.4	0.212	0.0374	0.25	0.751	3751.78*

* Calculated by consulting metabolisable energy values of feedstuffs for ruminants and humans

** Calculated by consulting metabolisable energy values of feedstuffs for ruminants

4.3 Housing of zoo mammals

The housing systems and the modifications for behaviour enrichment for the mammals of the two zoos are described below as per the classification of the mammals given.

4.3.1 Thiruvananthapuram Zoo

The housing systems (Plate I) of the different categories of mammals in Thiruvananthapuram Zoo are described below.

4.3.1.1 Rodents

4.3.1.1.1 Indian Giant Squirrel (*Ratufa indica*)

These rodents are housed in closed cages of 4.25 m length, 3.8 m width and 1.95 m height, with two cubicles at the back of the enclosure. These cubicles are made of cement concrete. The elevated cubicles had two nest boxes also. The front portion is made of iron bars with rivetted wire mesh on three sides and on top, the roof is also covered with an asbestos sheet for shade. The floor is cement concrete. The cage is enriched with two tree trunks and a horizontal bar, aiding aerial path ways. The water trough is located at the front area.

4.3.1.1.2 Indian Porcupine (*Hystrix indica*)

An open enclosure, fenced with chain-link mesh fixed to iron pillars, with dimension 14.5 x 7 m house the porcupines. A metal sheet runs around the enclosure at the base of the fencing. The floor of the enclosure is cement concrete with dens and boulders of concrete at the rear area of the enclosure. A wooden log is also provided in the enclosure.

4.3.1.2 Primates

4.3.1.2.1 Bonnet Macaque (*Macaca radiata*), Rhesus Macaque (*Macaca mulatta*), Lion-tailed Macaque (*Macaca silenus*), Common Langur (*Presbytis entellus*), Nilgiri Langur (*Trachypithecus johni*), Capuchin Monkey (*Cebus capucinus*)

The primate housing is similar for all these different groups of monkeys. The housing system is closed cage with a raised rear part enclosed with walls on three sides and a RCC (Reinforced cement concrete) roofing. The front part of the enclosure is covered with chain-link mesh fixed on iron pillars which runs over to the concrete roof at the rear part. A retiring platform is fixed on the top and iron rings are provided near to the platform. Swings are also located in the enclosure. These structures form the enrichment tools. Shift to adjacent cage is also possible in the enclosure. The primate cage has a length of 4.90 m and a breadth of 3.9 m and a height of 4 m each.

4.3.1.3 Mustelids and Viverrids

4.3.1.3.1 Common Palm Civet (*Paradoxurus hermaphroditus*)

These animals are housed in closed cages. For exhibiting them the front part of the cages have iron bars and welded and rivetted wire mesh over it. These cages have a length of 4.25 m and a breadth of 3.8 m and a height of 1.95 m. The floor is RCC and the nest boxes are in the cubicles on the back side.

4.3.1.4 Canids and Hyenas

4.3.1.4.1 Indian Fox (*Vulpes bengalensis*)

A closed cage with two concrete cubicles are provided for the Common Fox. The front portion of the cage has wire mesh all over its sides and roof. The cage is 4.25 m in length and 3.8 m in breadth and 1.95 m in height. The concrete floor also has two nest boxes and a water trough.

4.3.1.4.2 Jackal (*Canis aureus*)

A chain-linked mesh fenced area of dimension 12 x 9.5 m, with a retiring den at the back, is provided for the jackal. There is a shade tree in the center of the enclosure. This enclosure has a slide door and a water trough and a hollow log placed in it.

4.3.1.4.3 Striped Hyena (*Hyaena hyaena*)

An enclosure with cement concrete walls on three sides and the front open part covered with chain-link mesh secured to iron pillars formed the housing for these animals. It had a RCC floor. The enclosure has a length of 6.8 m and a breadth of 4.7 m. A water trough is provided in the front part and it has two retiring cubicles at the back with dimensions 2.4 x 2.4 m. A shift cage is also provided in this enclosure.

4.3.1.5 Bears

4.3.1.5.1 Himalayan Black Bear (*Selenarctos thibetanus*)

This bear house is also located in an undulating terrain and is an open enclosure with RCC walls around. The parapet walls are having curved pointed iron bars lined at the top. Metal sheets are welded to the top of it. The shade tree in the center of the enclosure has a cemented water pool under it. The two retiring cubicles are having RCC floor. A wooden log forms the enrichment tool in the enclosure. The retiring cubicle has a dimension of 3.9 x 3.0 m.

4.3.1.5.2 Sloth Bear (*Melursus ursinus*)

The bear enclosure is located in an undulating terrain with a few logs fixed vertically in it for enrichment. The open enclosure has iron bar fencing running all around. Hard thick metal sheets are fixed on the top rim of the fencing. An artificial den with a water pool in its front is also provided in this enclosure. A shift cage and a feeding trough are also provided.

4.3.1.6 Felids

4.3.1.6.1 Jungle Cat (*Felis chaus*)

The smaller felids are also housed in closed cages of 4.25 x 3.8 x 1.95 m dimensions. There are elevated cement concrete cubicles and the front portion of the cages are made of wire mesh welded to iron bars. The floor is RCC with a water trough, and nest boxes are located at the rear end.

4.3.1.6.2 Leopard (*Panthera pardus*) and Lion (*Panthera leo*)

The larger cat cages are dome shaped with strong iron bars attached to the basement, bending and blending to the RCC walls at the back. Metal sheets are covering the roof at the back one third portion forming a shelter. A water trough and wooden logs in the leopard cages are the fittings inside. The cage has a length of 7.5 m and a breadth of 3.75 m.

4.3.1.6.3 Tiger (*Panthera tigris*)

The only large cat provided with an enclosure simulating the natural environment is the tiger. A large area with lot of trees, shrubs and grasses, with a water pond in the center is the abode of tigers. An artificial earthern mound with large boulders around, is also provided. For the visitors to see the tiger a high parapet wall is constructed. The enclosure has large iron bar framed fencing on one side. A retiring room with two compartments having iron bars on sides with RCC floor is also provided. The water trough is also at this end. This retiring cage is 8.35 x 4.4 m in dimension.

4.3.1.7 Elephants

4.3.1.7.1 Indian Elephant (*Elephas maximus*)

An open area with dry moat as the barrier in an undulating terrain with lot of trees and shrubs, form the enclosure for elephants. A large pool is also provided in this area. The retiring rooms are three in number and it has iron rings as fittings. The length of this enclosure is 5 m and breadth 5 m.

4.3.1.8 Perissodactyles

4.3.1.8.1 Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)

The enclosure for the rhino has a dry moat around it. Shade trees are planted in the area and a central pool is provided for wallowing. The open area has two retiring cubicles also. Adjacent to these cubicles are two small open enclosures with RCC walls and iron gates. There is mud wallow in one, and a fresh water wallowing tank in the other. The retiring cubicles has a length of 4.65 m and breadth 4 m.

4.3.1.8.2 Zebra (*Equus burchelli*)

A fenced paddock enclosed with cement concrete half walls and iron bars above it, forms the zebra enclosure. A shade tree and permanent feeding and watering troughs are in this area. A covered shelter of dimension 2.4 x 2.4 m is also provided.

4.3.1.9 Non-ruminant Artiodactyles

4.3.1.9.1 Indian Wild Boar (*Sus scrofa*)

Two open enclosures with RCC walls all around it and a connecting gate, houses the wild boars. On the visitor side is a parapet wall for easy viewing. A concrete floored covered area is a shade area for these animals. The water trough is also provided at this part. The open part is provided with a mud filled wallowing area. The open enclosure has a dimension of 22.5 x 22.5 m. The covered area has a length of 3.6 m and a breadth of 3.1 m.

4.3.1.9.2 Nile Hippopotamus (*Hippopotamus amphibius*)

An open enclosure with dry moat as barrrier and an RCC parapet on the back, forms the enclosure for the hippos. A large pool is located at the open area. There is also an artificial stream into this pool. Shade trees, bamboos and vines in this undulating terrain gives a natural look to this area. Two retiring rooms with strong iron gates and showering facilities are also provided for these animals. Adjacent to the paddock there is also an area with a concrete floor and a fresh water pool with RCC walls all around. The retiring cubicles are 4 x 3.1 m in dimension.

4.3.1.10 Ruminant Artiodactyles

4.3.1.10.1 Barking Deer (*Muntiacus muntjak*)

These animals are housed in an open run with dry moat on one side which is sloping on the enclosure side. Chain-link mesh fixed over iron bars form the fencing. It is an undulating terrain with very few herbs and trees. At the back of this enclosure is a pair of compartment, which is also covered. The covered area has a dimension of 6 x 2.5 m.

4.3.1.10.2 Hog-Deer (*Axis porcinus*)

This deer enclosure is also an open run with a dry moat on one side and sloping towards the enclosure side. Chain-link mesh is fixed over iron bars and forms the fence. This undulating terrain has large trees, providing shade. A water

pool is provided at the center. There is also a covered area at the back with a length of 6.5 m and breadth 5.8 m.

4.3.1.10.3 Spotted Deer (*Axis axis*)

A 45.90 x 25.30 m enclosure is an open run with fences around. Concrete walls are also forming the base of the fences. The terrain slopes to the center and has a mud wallow at the center. Feed and water troughs are provided at the visitor side. A shade tree is present at the center and a covered area with tin sheet roof. The dimension of the covered area is 2.4 x 2.3 m.

4.3.1.10.4 Sambar Deer (*Cervus unicolor*)

A dry moat separates the open run on the three sides and a chain-link wire meshed fencing on the side of the adjacent enclosure. The terrain is undulating and sloping towards the moat. A water pool is also provided. A covered area with two compartments is provided at one side and at one end of the paddock is a cement concrete floor, where fodder is provided. A feeding and watering trough is located in the paddock. The covered area has a length of 4.65 m and a breadth of 3.5 m.

4.3.1.10.5 Giraffe (*Giraffa camelopardalis*)

The open grassy paddock with a fencing of iron bars and wire mesh, house a single animal. This area also has a covered part with two compartments in it which is of 11.5 x 9 m dimension. One of these compartments has a wooden

platform where feed is kept. The water troughs are also kept in an elevated position in the open area.

4.3.1.10.6 Blackbuck (*Antilope cervicapra*)

A fenced paddock with a concrete half wall and iron bars over it with rivetted wire mesh running over it is the Blackbuck enclosure. Feed and water troughs are provided in the open area. In the corner of the enclosure is a covered space with two compartments. The open enclosure has a dimension of 24.20 x 19 m, whereas the covered portion is 5.3 x 2.9 m.

4.3.1.10.7 Nilgai (*Boselaphus tragocamelus*)

The open area of 45.90 x 18.40 m has a cement concrete wall on all sides. The visitor side is having parapet walls to help easy viewing of the animals. The terrain is sloping towards the center from the sides. There is a mud wallow in the center. The covered area with cement concrete floor has a length of 3.4 m and a breadth of 2.8 m. Feed and water troughs are provided in the open area.

4.3.1.10.8 Mithun (*Bos frontalis*)

A grass land surrounded by cement concrete walls and iron bars and mesh fencing over it forms the enclosure. It has a covered area with two compartments also. The covered area has a length of 5.3 m and breadth 2.9 m.

4.3.1.10.9 African Cape Buffalo (*Syncerus caffer*)

Open run with dry moat all around it and chain-link mesh fencing on the side of adjacent enclosure, houses the African Cape Buffalo. The terrain is undulating and shade trees are spread all over. There is a water pool in the center. There is a closed area with cement concrete floor at the corner. It has RCC walls around it. The gate of this opens into the paddock. The water trough is provided here. The feeding troughs are located in the open paddock. The covered area has 3.5 m length and 2.25 breadth.

4.3.1.10.10 Nilgiri Tahr (*Hemitragus hylocrius*)

A single animal in an open run with iron bars around and wire mesh over it, has artificial rocky mounds in it. The paths are paved with rocks in it. There is also a covered area with a roof in this enclosure. The open area has a dimension of 26 x 18.3 m and the closed area has a length of 8.9 m and a breadth of 3 m.

4.3.2 Thrissur Zoo

The housing systems (Plate II) of the different categories in Thrissur Zoo are described below.

4.3.2.1 Rodents

4.3.2.1.1 Indian Porcupine (*Hystrix indica*)

The two porcupines of this zoo are housed in an open enclosure fenced with chain-linked mesh and with a natural flooring. A small covered area of 2.6 x

0.5 x 0.7 m is provided on one end and has a cemented flooring and a galvanized iron roofing. A water trough and a log of wood are the fittings inside. The open area has a dimension of 8.2 m length and 7.2 m breadth.

4.3.2.2 Primates

4.3.2.2.1 Bonnet Macaque (*Macaca radiata*), Rhesus Macaque (*Macaca mulatta*)

These monkeys were housed in closed cages with central asbestos covered area, having two concrete walls on two sides and opening area enclosed by iron bars with wire mesh rivetted to the outside; which bends inwards on the top to the concrete structure and forms the top of the central covered area. In the central covered area there is a log fixed vertically on to the floor. Few RCC slabs are also provided on the walls. The floor is of cement concrete with cemented water troughs fixed permanently on the sides. An adjacent shift cage is separated with a slide door. The dimension of the cage is 6.5 x 3.45 x 3.7 m.

4.3.2.2.2 Lion-tailed Macaque (*Macaca silenus*)

These monkeys are housed singly in closed cages of dimension 3.7 x 2.4 x 2.15 m, having concrete walls on three sides. The visitor side of the cage has wire mesh rivetted to iron bars, and forming the roof of the front portion. A wooden log is placed horizontally in the cage and a water trough is provided in the front portion. The floor is of cement concrete and a shift cage is also present.

4.3.2.3 Mustelids and Viverrids

4.3.2.3.1 Common Palm Civet (*Paradoxurus hermaphroditus*), Small Indian Civet (*Viverricula indica*)

The viverrids are housed in closed cages with concrete walls on three sides and wire mesh barrier on visitor side. The floor of the cage is of cement concrete and a water trough is provided on the front part of the cage. Wooden platforms are also provided and a wooden log is placed horizontally in the enclosure of the Common Palm Civet. The cage has a length of 3.7 m, breadth of 2.45 m and height of 2 m. A shift cage is also present.

4.3.2.4 Canids and Hyenas

4.3.2.4.1 Jackal (*Canis aureus*)

The jackal is housed in a closed cage of dimension 3.3 x 2.55 x 2.1 m with concrete walls on three sides and concrete flooring. The visitor side of the cage has wire mesh rivetted to iron bars, and forms the roof of the front portion. A wooden log is fixed vertically in the cage and a water trough is provided on the front portion. A shift cage is also provided.

4.3.2.5 Bears

4.3.2.5.1 Himalayan Black Bear (*Selenarctos thibetanus*)

An open enclosure with dry moat barrier, having shrubs and grasses in the terrain houses the bear. A cemented water pool is provided at the centre. A retiring house with three compartments, having a water trough is also located adjacent to the open enclosure. The dimension of the retiring house is 4.3 x 3.3 m.

4.3.2.5.2 Sloth Bear (*Melursus ursinus*)

An oval shaped open enclosure with iron bar fencing on one half and concrete wall on the other half forms the Sloth Bear enclosure. Metal sheets are welded on the top of the iron bar fence. A water pool is provided on the brick paved open area. Two retiring cubicles each of dimension 2.6 x 1.8 m with water and feeding trough is also present.

4.3.2.6 Felids

4.3.2.6.1 Jungle Cat (*Felis chaus*)

A closed cage with concrete walls on three sides and wire mesh barrier on visitor side. A wooden platform is placed on the cage. The floor is of concrete with a water trough on the front portion. The dimension of the cage is 3.7 x 2.45 x 2 m and a shift cage is also provided.

4.3.2.6.2 Leopard (*Panthera pardus*), Black Panther (*Panthera pardus*)

The large cat cages are dome shaped with strong iron bars attached to the basement, bending and blending to the RCC walls at the back. In the back wall is a sliding door leading to a shift cage. The floor is of cement concrete with a water trough placed on one side. The dome shaped structure is covered by tiled roof and the dimension of the cage is 6.5 x 3.85 m.

4.3.2.6.3 Lion (*Panthera leo*)

A dome shaped, closed cage with strong iron bars attached to the basement, bending and blending to the RCC walls at the back is provided for lions. The floor is of cement concrete and a water trough is also provided. The entire cage is covered by tiled roof and the dimension of the cage is 6.5 x 3.85 m. The cage is connected to an open enclosure of dimension 16.4 x 12.6 m with strong iron wires on all sides and top. At the centre of this area is an artificial earthern mound with wooden logs fixed vertically.

4.3.2.7 Non-ruminant Artiodactyles

4.3.2.7.1 Indian Wild Boar (*Sus scrofa*)

The wild boars are housed in a fenced enclosure with concrete floor having cement concrete half walls and iron bars above it. A covered area of dimension 2.35 x 1.4 m is provided at the corner of the enclosure and a wallowing pool is also provided. The dimension of the open enclosure is 10.6 x 7.7 m and a shift enclosure is also present.

4.3.2.7.2 Camel (*Camelus dromedarius*)

The animals are kept in an open paddock with fencing of concrete walls on three sides and iron bars on the visitor side. An asbestos roofed covered area of dimension 10.1 x 2.8 m is present and feed and water troughs are located in the open area. A shade tree is present in the open enclosure of dimension 30.6 x 9 m.

4.3.2.7.3 Nile Hippopotamus (*Hippopotamus amphibius*)

An open paddock with a central large pool, and on the visitor side is a parapet wall for easy viewing. Shade trees are also planted in the open area. Adjacent to this paddock is a concrete floored open enclosure with a large pool fenced on all sides with cement concrete wall, where two females are kept. The dimension of this enclosure is 10 x 4.75 m excluding the pool area. A single male is housed in an adjacent similar enclosure.

4.3.2.8 Ruminant Artiodactyles

4.3.2.8.1 Barking Deer (*Muntiacus muntjak*)

A single animal is exhibited in a closed cage of dimension 5.9 x 3.8 m with concrete floor and wire mesh fixed to iron pillars on the three sides and on the roof. The back of the enclosure is an RCC wall with a covered area of dimension 1.6 x 1.5 m. A water trough is also provided in the area.

4.3.2.8.2 Hog-Deer (*Axis porcinus*)

An open paddock, fenced with chain-link mesh fixed to concrete pillars on the visitor side and concrete walls on other sides, houses the Hog-Deer. A covered area of dimension 8.7 x 2 m with a feed trough is present. Water trough is provided in the open area and shade trees are also planted in the area.

4.3.2.8.3 Spotted Deer (*Axis axis*)

A large open paddock with part of it paved with bricks, houses the herd of Spotted Deers. A shade tree is present in the middle of the area. Two covered areas of dimensions 11 x 5 m and 8.4 x 2.1 m each are present with feed and water troughs provided in it. The area is fenced with chain-link mesh fixed to iron pillars on two sides and concrete walls on the other sides. There is an adjacent open paddock with a gate leading to it, for shifting the animals. The dimension of the open paddock is 58 x 30.6 m.

4.3.2.8.4 Sambar Deer (*Cervus unicolor*)

This large deer enclosure is an open paddock with shade trees and mud wallows with a dry moat barrier on the visitor side and concrete walls fenced on other sides. A covered area of dimension of 10 x 8.5 m is provided where a feed and water trough is also present.

4.3.2.8.5 Blackbuck (*Antilope cervicapra*)

A fenced paddock with chain-link mesh fixed to concrete pillars on the visitor side and concrete walls on the other sides form the enclosure. A covered area of dimension 5.7 x 2.2 m is present with a feed trough. The water trough is placed in the open area. The open enclosure is having a dimension of 20.35 x 17.25 m with shade trees present in it.

Porcupine - open enclosure

Primate - cage

Viverrid - cage

Jackal - open enclosure

Bear - open enclosure

Large Felid - cage

Plate 1.Housing Systems in Thiruvananthapuram Zoo

Plate 1.(Contd.)

Plate 1.(Contd.)

Plate 2.Housing Systems in Thrissur Zoo

Plate 2.(Contd.)

4.4 Breeding of zoo mammals

Thirty three different mammalian species were housed in Thiruvananthapuram Zoo and 23 species among them were in breeding pairs and successful breeding were recorded in 19 species of them during the study period 1991-2000. The total number of species in each group kept in Thiruvananthapuram Zoo to the number of species having breeding pairs and those breeding among them are depicted by bar diagram in Fig.1.

In Thrissur Zoo were housed 20 mammalian species of which 11 species were in breeding pairs and successful breeding was observed in 8 species among them during the study period 1991-2000. The total number of species in each group kept in Thrissur Zoo to the number of species having breeding pairs and those breeding among them are depicted by bar diagram in Fig.2. The group-wise breeding data are detailed below.

4.4.1 Rodents

Two species of this group were kept in Thiruvananthapuram Zoo *viz.* The Indian Giant Squirrel (*Ratufa indica*) and the Indian Porcupine (*Hystrix indica*). Though the Indian Porcupines were in breeding pairs, successful breeding was not reported so far.

In Thrissur Zoo also, though a pair of Indian Porcupines (*Hystrix indica*) were housed together, no successful breeding was reported.

4.4.2 Primates

Six species of primates were housed in Thiruvananthapuram zoo and breeding was observed in all the four species, which were in pairs.

In Thrissur Zoo, only one species was kept in breeding pairs and breeding was observed in that species. The detailed breeding data of the primate group in the two zoos are given in Table 38.

Table 38. Breeding data of Primates in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo			Thrissur Zoo		
	Availability of breeding pairs	Number of births	Number of young ones	Availability of breeding pairs	Number of births	Number of young ones
Bonnet Macaque (*Macaca radiata*)	Yes	3	3	Yes	37	37
Rhesus Macaque (*Macaca mulatta*)	No	-	-	No	-	-
Lion-tailed Macaque (*Macaca silenus*)	Yes	1	1	No	-	-
Common Langur (*Presbytis entellus*)	Yes	3	3	*	*	*
Nilgiri Langur (*Trachypithecus johni*)	No	-	-	*	*	*
Capuchin Monkey (*Cebus capucinus*)	Yes	3	3	*	*	*

* The species not present in the zoo

4.4.3 Mustelids and Viverrids

Common Palm Civet (*Paradoxurus hermaphroditus*) of Thiruvananthapuram Zoo were not in breeding pairs.

Of the Common Palm Civet (*Paradoxurus hermaphroditus*) and Small Indian Civet (*Viverricula indica*) of Thrissur Zoo, the Small Indian Civet was in breeding pairs and no breeding was noticed in the species.

4.4.4 Canids and Hyenas

Three species of this group were housed in Thiruvananthapuram Zoo of which the Jackals (*Canis aureus*) were in breeding pairs and they were successfully bred. The detailed breeding data of this group are given in Table 39.

Table 39. Breeding data of Canids and Hyenas in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo			Thrissur Zoo		
	Availability of breeding pairs	Total number of births	Total number of young ones	Availability of breeding pairs	Total number of births	Total number of young ones
Indian Fox (*Vulpes bengalensis*)	No	-	-	*	*	*
Jackal (*Canis aureus*)	Yes	2	5	No	-	-
Striped Hyena (*Hyaena hyaena*)	No	-	-	*	*	*

* The species not present in the zoo

4.4.5 Bears

Breeding pairs of both Himalayan Black Bear (*Selenarctos thibetanus*) and Sloth Bear (*Melursus ursinus*) of Thiruvananthapuram Zoo though housed in pairs, were not successfully bred.

Thrissur Zoo had only one male each of the Himalayan Black Bear (*Selenarctos thibetanus*) and Sloth Bear (*Melursus ursinus*).

4.4.6 Felids

Four felid species were kept in Thiruvananthapuram Zoo of which all the four were in breeding pairs and successful breeding was noticed in three species.

Three species of this group were kept in Thrissur Zoo of which only one species were kept in pairs and breeding was noticed in them. The detailed breeding data of this group are given in Table 40.

Table 40. Breeding data of Felids in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo			Thrissur Zoo		
	Availability of breeding pairs	Total number of births	Total number of young ones	Availability of breeding pairs	Total number of births	Total number of young ones
Jungle Cat (*Felis chaus*)	Yes	-	-	No	-	-
Leopard (*Panthera pardus*)	Yes	1	2	No	-	-
Tiger (*Panthera tigris*	Yes	1	2	*	*	*
Lion (*Panthera leo*)	Yes	6	13	Yes	1	2

* The species not present in the zoo

4.4.7 Elephants

There was only one female elephant in Thiruvananthapuram Zoo and there was no elephant in Thrissur Zoo.

4.4.8 Perissodactyles

Two species of this group were housed in Thiruvananthapuram Zoo of which only one species *i.e.*, the Zebra (*Equus burchelli*) were in breeding pairs and breeding was observed in that species. The detailed breeding data of this group are given in Table 41.

Table 41. Breeding data of Perissodactyles in Thiruvananthapuram Zoo

Species	Availability of breeding pairs	Total number of births	Total number of young ones
Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)	No	-	-
Zebra (*Equus burchelli*)	Yes	1	1

4.4.9 Non-ruminant Artiodactyles

Two species of Non-ruminant Artiodactyles in Thiruvananthapuram Zoo which were in breeding pairs, gave birth to young ones.

Three species of this group of Thrissur Zoo were in breeding pairs of which two bred in the zoo. The detailed breeding data of this group are given in Table 42.

Table 42. Breeding data of Non-ruminant Artiodactyles in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo			Thrissur Zoo		
	Availability of breeding pairs	Total number of births	Total number of young ones	Availability of breeding pairs	Total number of births	Total number of young ones
Indian Wild Boar (*Sus scrofa*)	Yes	9	21	Yes	1	1
Camel (*Camelus dromedarius*)	*	*	*	Yes	-	-
Nile Hippopotamus (*Hippopotamus amphibius*)	Yes	5	5	Yes	3	3

* The species not present in the zoo

4.4.10 Ruminant Artiodactyles

Though ten species of this group are there in Thiruvananthapuram Zoo, only eight were in pairs and all of them were breeding successfully.

Out of the five species of Thrissur Zoo, four were in pairs and were breeding. The detailed breeding data of this group are given in Table 43.

Table 43. Breeding data of Ruminant Artiodactyles in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo			Thrissur Zoo		
	Availability of breeding pairs	Total number of births	Total number of young ones	Availability of breeding pairs	Total number of births	Total number of young ones
Barking Deer (*Muntiacus muntjak*)	Yes	11	11	No	-	-
Hog-Deer (*Axis porcinus*)	Yes	40	40	Yes	16	16
Spotted Deer (*Axis axis*)	Yes	80	80	Yes	191	191
Sambar Deer (*Cervus unicolor*)	Yes	54	54	Yes	38	38
Giraffe (*Giraffa camelopardalis*)	No	-	-	*	*	*
Blackbuck (*Antilope cervicapra*)	Yes	20	20	Yes	9	9
Nilgai (*Boselaphus tragocamelus*)	Yes	9	9	*	*	*
Mithun (*Bos frontalis*)	Yes	5	5	*	*	*
African Cape Buffalo (*Syncerus caffer*)	Yes	2	2	*	*	*
Nilgiri Tahr (*Hemitragus hylocrius*)	No	-	-	*	*	*

* The species not present in the zoo

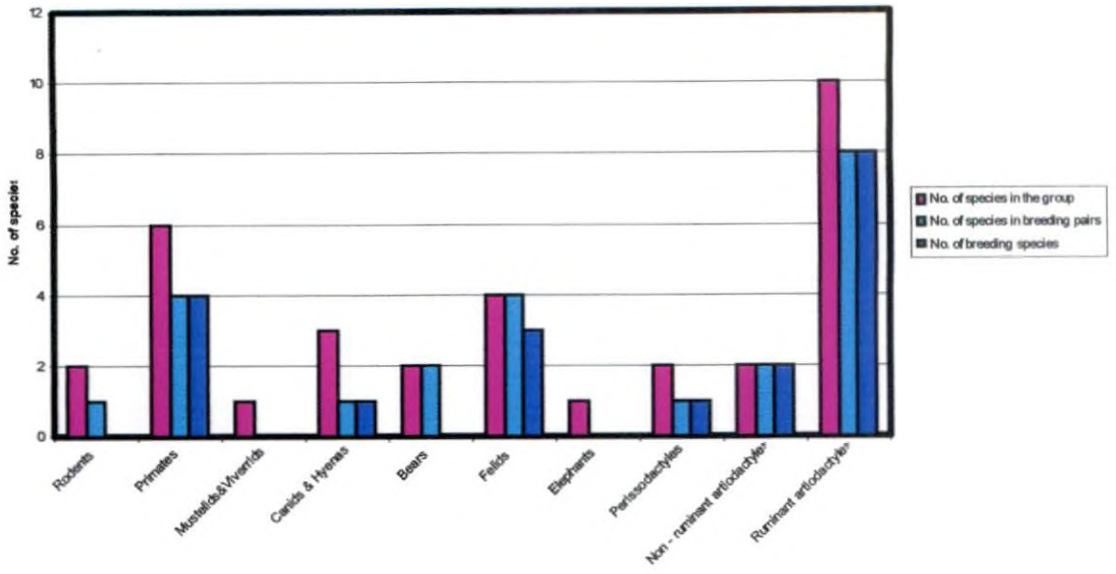

Fig.1. Breeding performance of captive mammals in Thiruvananthapuram Zoo

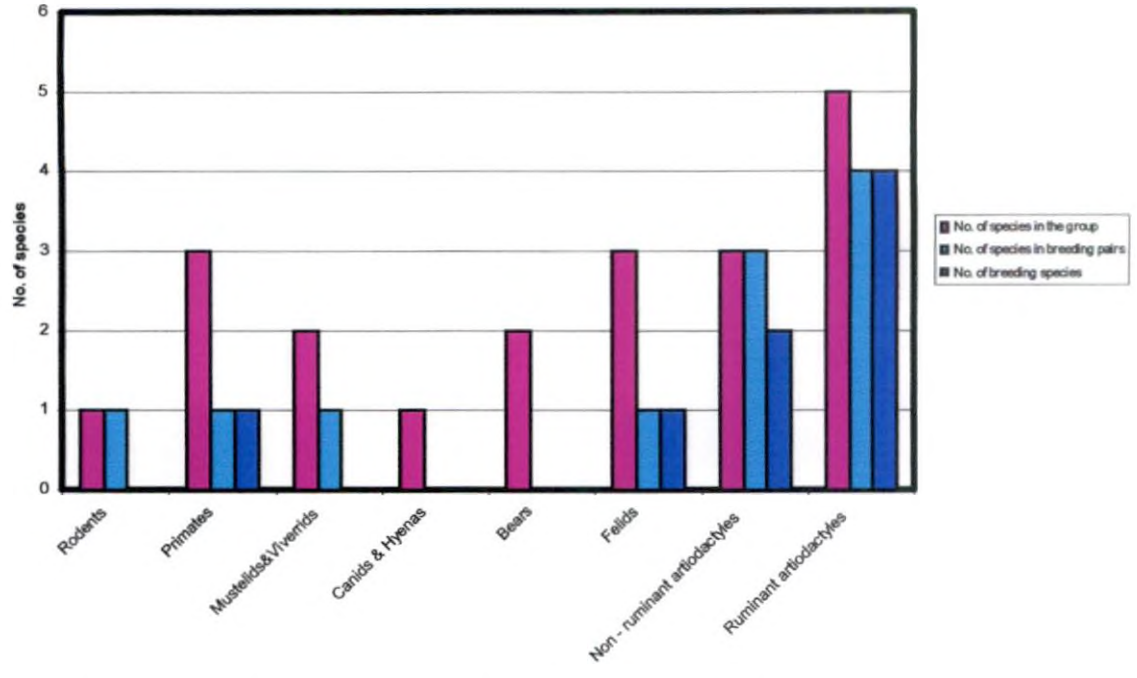

Fig.2. Breeding performance of captive mammals in Thrissur Zoo

4.5 Disease prevalence in zoo mammals

The diseases prevalence among the captive zoo mammals of Thiruvananthapuram and Thrissur Zoos in Kerala for a period of five years from 1996 to 2000 are presented in Tables 44 to 53.

Table 44. Diseases prevalent in Rodents in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Indian Giant Squirrel (*Ratufa indica*)	-	-	*	*
Indian Porcupine (*Hystrix indica*)	Peritonitis	1	-	-

* The species not present in the zoo

Table 45. Diseases prevalent in Primates in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Bonnet Macaque (*Macaca radiata*)	Pneumonia	3	Acute nephritis	2
			Hepatitis	1
			Lung carcinoma	3
Rhesus Macaque (*Macaca mulatta*)	-	-	Volvulus of intestine	1
			Lung carcinoma	1
Lion-tailed Macaque (*Macaca silenus*)	-	-	Peritonitis	1

Table 45 (Contd.)

Common Langur (*Presbytis entellus*)	Diarrhoea	1	*	*
	Trichuriasis	1		
Nilgiri Langur (*Trachypithecus johni*)	Diarrhoea	3	*	*
Capuchin Monkey (*Cebus capucinus*)	-	-	*	*

* The species not present in the zoo

Table 46. Diseases prevalent in Mustelids and Viverrids in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvanathapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Common Palm Civet (*Paradoxurus hermaphroditus*)	-	-	-	-
Small Indian Civet (*Viverricula indica*)	*	*	Dermatitis	1
			Dermato-mycoses	2
			Strongylosis	1

* The species not present in the zoo

Table 47. Diseases prevalent in Canids and Hyenas in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Indian Fox (*Vulpes bengalensis*)	-	-	*	*
Jackal (*Canis aureus*)	-	-	Ancylostomiasis	2
Striped Hyena (*Hyaena hyaena*)	Diarrhoea	1	*	*

*The species not present in the zoo

Table 48. Diseases prevalent in Bears in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Himalayan Black Bear (*Selenarctos thibetanus*)	Dermatitis	2	Enteritis	1
	Tick infestation	2	Ancylostomiasis	1
	Strongylosis	1		
Sloth Bear (*Melursus ursinus*)	-	-	Conjuncti-vitis	1
			Strongylosis	1

Table 49. Diseases prevalent among Felids in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Jungle Cat (*Felis chaus*)	-	-	Toxocariasis	1
Leopard (*Panthera pardus*)	Dermatitis	7	Suppurative myositis	1
			Pleurisy	1
			Dermato-mycoses	1
			Ancylostomiasis	1
Tiger (*Panthera tigris*)	Tick infestation	7	*	*
	Cestodosis	1		
	Gnathosto-miasis	1		

Table 49 (Contd.)

Lion (*Panthera leo*)	Tick infestation	9	Metritis	1
	Nematodosis	5	Peritonitis	1
	Ancylosto-miasis	2	Toxocariasis	1
	Toxocariasis	1		
	Pulmonary emphysema	1		
	Hepatic tumor	1		
	Histocytic cell sarcoma	1		
	Adeno carcinoma	1		

* The species not present in the zoo

Table 50. Diseases prevalent in Elephants in Thiruvananthapuram Zoo

Species	Disease	Number of cases
Indian Elephant (*Elephas maximus*)	Conjunctivitis	1

Table 51. Diseases prevalent among Perissodactyles in Thiruvananthapuram Zoo

Species	Disease	Number of cases
Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)	Fascioliasis	1
	Strongyloidosis	1
	Indigestion	1
Zebra (*Equus burchelli*)	-	-

Table 52. Diseases prevalent among Non-ruminant Artiodactyles in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Indian Wild Boar (*Sus scrofa*)	Fascioliasis	1	Nephritis	1
			Pleuropneumonia	1
			Lung carcinoma	1
Camel (*Camelus dromedarius*)	*	*	Conjunctivitis	1
Hippopotomus (*Hippopotamus amphibius*)	Diarrhoea	1	Ulcerative enteritis	1
	Intestinal torsion	1		

* The species not present in the zoo

Table 53. Diseases prevalent among Ruminant Artiodactyles in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo		Thrissur Zoo	
	Disease	Number of cases	Disease	Number of cases
Barking Deer (*Muntiacus muntjak*)	-	-	-	-
Hog-Deer (*Axis porcinus*)	Rabies	12	Peritonitis	1
	Hepatitis	1	Acute pneumonia	1
	Rumen impaction	1		
Spotted Deer (*Axis axis*)	Meningitis	1	Peritonitis	5
	Strongylosis	1	Chronic nephritis	1
			Acute pneumonia	6
			Acute tympany	1
			Cystic calculi	1
			Rumen impaction	3
			Lung carcinoma	4

Table 53 (Contd.)

Sambar Deer (*Cervus unicolor*)	Pasteurellosis	2	Pertonitis	2
	Strongylosis	1	Myocarditis	1
	Pulmonary abscess	1	Rumen impaction	1
Giraffe (*Giraffa camelopardalis*)	-	-	*	*
Blackbuck (*Antilope cervicapra*)	Flea infestation	2	-	-
	Tick infestation	1		
Nilgai (*Boselaphus tragocamelus*)	Diarrhoea	1	*	*
Mithun (*Bos frontalis*)	Enteritis	2	*	*
	Coccidiosis	1		
	Hydatidosis	2		
	Ascites	2		
African Cape Buffalo (*Syncerus caffer*)	Strongylosis	1	*	*
	Diarrhoea	1		
Nilgiri Tahr (*Hemitragus hylocrius*)	Foot rot	1	*	*
	Bloat	1		

* The species not present in the zoo

4.5.1 Percentage of incidence of different classes of disease in zoo mammals

In Thiruvananthapuram Zoo a higher percentage of incidence of parasitic diseases (44.68 per cent) followed by infectious diseases (35.11 per cent), non-specific conditions (17.02 per cent) and neoplastic conditions (3.19 per cent) were found which is presented in Fig.3.

A higher percentage of incidence of infectious diseases (59.32 per cent) followed by neoplastic conditions (15.25 per cent), parasitic conditions (13.56 per cent) and non-specific conditions (11.87 per cent) were found in Thrissur Zoo which is presented in Fig.4.

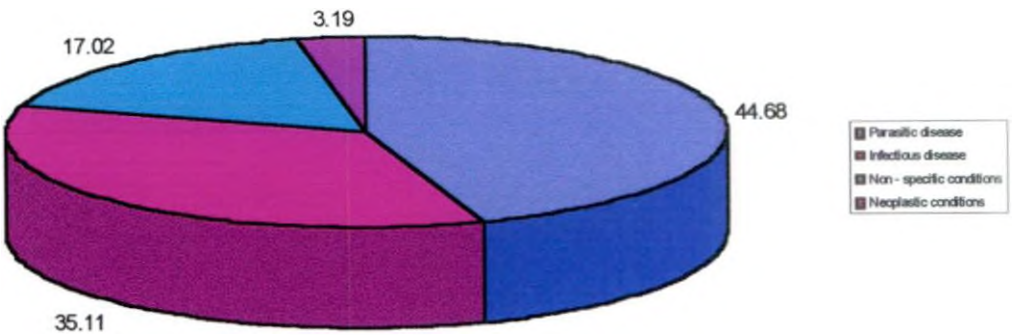

Fig. 3. Percentage of incidence of different classes of disease in captive mammals of Thiruvananthapuram Zoo

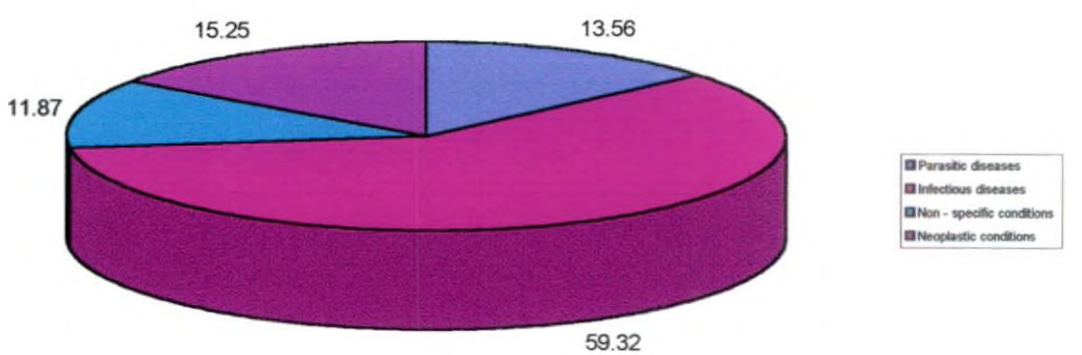

Fig. 4. Percentage of incidence of different classes of disease in captive mammals of Thrissur Zoo

4.6 Disease prevention measures in zoo mammals

4.6.1 *Thiruvananthapuram Zoo*

4.6.1.1 Vaccination programmes

Prophylatic anti-rabies vaccination with 'Rabisin' (manufactured by Serum Institute of India) was done in Camel, Nilgiri Tahr, Giraffe, Barking Deer, Hog-Deer, Mithun, Cape Buffalo, Bonnet Macaque and Jackals following the diagnosis of a case of rabies in a Hog-Deer at the zoo in the year 1996.

Vaccinations were done in all felines with Feligen (manufactured by Virbac) against feline panleukopenia, feline rhinotracheitis and feline calcivirus in the year 2000-2001. No other vaccination programmes were done during the study period of 1996-2000.

4.6.1.2 Deworming programmes

Deworming of all the mammals were done. The deworming programme followed in the zoo for the different mammals are given in Tables 54 to 63.

4.6.1.3 Cleaning and disinfection

The cleaning of all cages and animal enclosures in the zoo were done in the morning, before the feeding of the animals. In the monkey cages, they were shifted to an adjacent cage and the left over food and excreta were collected and disposed. The concrete floor of the cages were cleaned thoroughly with water under pressure and flushed out into the drainage channels. The closed carnivore

cages were not having shift facilities and the left over food and faecal matter were collected from outside and the concrete floor cleaned by spraying water under pressure. In herbivores which were kept in open runs, the left over twigs and leaves were collected and disposed off and the dung and faecal pellets around the feed and water troughs were also removed and cleaned. The small mammal cages with concrete flooring were also cleaned thoroughly with water after removing the excreta and food waste. In all open enclosures, the covered area in it were thoroughly cleaned and the feed and water troughs of all enclosures were cleaned and the water troughs refilled with fresh water. The pools provided in the enclosures of Hippopotamus, Great Indian One-horned Rhinoceros, Sloth Bear and the Himalayan Black Bears were emptied, cleaned and refilled twice in a week. Disinfection with 'benzalkonium chloride' solution (ITEOL-H manufactured by Astra-IDL Ltd.) were done occasionally in carnivore and primate cages.

4.6.2 Thrissur Zoo

4.6.2.1 Vaccination programmes

No vaccination was given in the zoo during the study period of 1996-2000.

4.6.2.2 Deworming programmes

Regular deworming was done for carnivorous species only, with the exception in camels. The deworming programme followed in the zoo for the different mammals are given in Tables 54 to 63.

4.6.2.3 Cleaning and disinfection

The cleaning of the entire cages and enclosures in the zoo were done in the morning, before feeding. The primates were shifted to adjacent cages and the left over food and excreta were collected and disposed off. The concrete floor was washed thoroughly with water under pressure. The carnivores were also shifted to adjacent facilities and the leftover food and excreta collected and disposed off. The concrete floors were cleaned thoroughly with water under pressure. The retiring cubicles of the bear enclosures were also cleaned with water under pressure. In the open runs of herbivores, the left over leaf twigs and grasses were collected and the faecal pellets around the feeding area were also collected and removed. The covered areas in the open runs were also cleaned and the feed and water troughs of all enclosures were cleaned and fresh water filled on the water troughs. The pools in Hippopotamus enclosures were emptied, cleaned and refilled twice in a week. Disinfection with 'benzalkonium chloride' solution (GERMIKLIN manufactured by Yuvaraj Chemicals Pvt. Ltd.) were done occasionally in carnivore and primate cages.

Table 54. Deworming programme followed in Rodents in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Indian Giant Squirrel (*Ratufa indica*)	Once in two years	*
Indian Porcupine (*Hystrix indica*)	Once in two years	Not dewormed regularly

* The species not present in the zoo

Table 55. Deworming programme followed in Primates in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Bonnet Macaque (*Macaca radiata*)	Once in an year	Not dewormed regularly
Rhesus Macaque (*Macaca mulatta*)	Once in an year	Not dewormed regularly
Lion-tailed Macaque (*Macaca silenus*)	Once in an year	Not dewormed regularly
Common Langur (*Presbytis entellus*)	Once in an year	*
Nilgiri Langur (*Trachypithecus johni*)	Once in an year	*
Capuchin Monkey (*Cebus capucinus*)	Once in an year	*

* The species not present in the zoo

Table 56. Deworming programme followed in Mustelids and Viverrids in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Common Palm Civet (*Paradoxurus hermaphroditus*)	Once in an year	Monthly
Small IndianCivet (*Viverricula indica*)	*	Monthly

* The species not present in the zoo

Table 57. Deworming programme followed in Canids and Hyenas in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Indian Fox (*Vulpes bengalensis*)	Once in an year	*
Jackal (*Canis aureus*)	Thrice in an year	Monthly
Striped Hyena (*Hyaena hyaena*)	Twice in an year	*

* The species not present in the zoo

Table 58. Deworming programme followed in Bears in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Himalayan Black Bear (*Selenarctos thibetanus*)	Once in an year	Regularly
Sloth Bear (*Melursus ursinus*)	Once in an year	Regularly

Table 59. Deworming programme followed in Felids in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Jungle Cat (*Felis chaus*)	Once in an year	Bimonthly
Leopard *(Panthera pardus*)	Twice in an year	Monthly
Tiger (*Panthera tigris*)	Thrice in an year	*
Lion (*Panthera leo*)	Thrice in an year	Monthly

* The species not present in the zoo

Table 60. Deworming programme followed in Elephants in Thiruvananthapuram Zoo

Species	Deworming frequency
Indian Elephant (*Elephas maximus*)	Once in an year

Table 61. Deworming programme followed in Perissodactyles in Thiruvananthapuram Zoo

Species	Deworming frequency
Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)	Once in an year
Zebra (*Equus burchelli*)	Twice in an year

Table 62. Deworming programme followed in Non-ruminant Artiodactyles in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Indian Wild Boar (*Sus scrofa*)	Once in an year	Not dewormed regularly
Camel (*Camelus dromedarius*)	*	Thrice in an year
Nile Hippopotamus (*Hippopotamus amphibius*)	Once in an year	Not dewormed regularly

* The species not present in the zoo

Table 63. Deworming programme followed in Ruminant Artiodactyles in Thiruvananthapuram and Thrissur Zoos

Species	Thiruvananthapuram Zoo	Thrissur Zoo
	Deworming frequency	Deworming frequency
Barking Deer (*Muntiacus muntjak*)	Once in an year	Not dewormed regularly
Hog-Deer (*Axis porcinus*)	Twice in an year	Not dewormed regularly
Spotted Deer (*Axis axis*)	Twice in an year	Not dewormed regularly
Sambar Deer (*Cervus unicolor*)	Twice in an year	Not dewormed regularly
Giraffe (*Giraffa camelopardalis*)	Twice in an year	*
Blackbuck (*Antilope cervicapra*)	Twice in an year	Not dewormed regularly
Nilgai (*Boselaphus tragocamelus*)	Twice in an year	*
Mithun (*Bos frontalis*)	Twice in an year	*
African Cape Buffalo (*Syncerus caffer*)	Twice in an year	*
Nilgiri Tahr (*Hemitragus hylocrius*)	Twice in an year	*

* The species not present in the zoo

Discussion

5. DISCUSSION

5.1 Classification of zoo mammals

Considering the taxonomic classification and their food habits, the ten captive mammal groups in the present study, are in tune with the classification of mammals by Prater (1971) and Agarwal (1996a).

The order Artiodactyla is subdivided into Non-ruminant Artiodactyles and Ruminant Artiodactyles based on food habits. The sub-orders of Artiodactyles *viz.* suiformes and tylopoda are included in Non-ruminant Artiodactyles having two or three chambered stomach, and the sub-order 'Rumenatia' which are true ruminants are placed in the group of ruminant Artiodactyles. Prater (1971) had classed the seventeen orders of placental mammals and noted that an order can be divided into sub-orders and families. Agarwal (1996a) classified mammals into orders. According to him, the animals are divided into Artiodactyles and again into groups of Bovidae, Cervidae and, a third group of pigs, hippos and tylopoda. Kotpal (2000) classified mammals based on the mode of life and their adaptations and placed all carnivores in one group, and all hoofed animals together. In the present classification, only the taxonomic position and food habits of zoo mammals were considered and hence are not in agreement with the reports by Kotpal (2000).

5.2 Feeding of zoo mammals

5.2.1 Rodents

5.2.1.1 Indian Giant Squirrel (*Ratufa indica*)

The ration for Indian Giant Squirrel in Thiruvananthapuram Zoo which is primarily of fruits with some nuts and greens added to it, is akin to the reports by Xavier *et al.*, (1996) in Small Travancore Flying Squirrels in the wild. According to them, their diet consisted of fruits, leaves, buds and seeds. On the other hand, Karsten (1987) stated that squirrels need animal protein in the diet. The suggestion of Kranz (1999) to provide omnivore dog food to squirrels is not adopted in Thiruvananthapuram Zoo though the other supplements mentioned are provided. Commercial dog foods are not very popular in our markets and commercial dog foods are not commonly used to feed the zoo animals in Indian zoos and that may be the reason for not feeding such items in Thiruvananthapuram Zoo. The diet in Thiruvananthapuram Zoo may have been formulated taking the frugivorous food habits of the animal (Prater, 1971).

Dry matter in the diet provided is about 2.6 per cent of the body weight of the animal with a crude protein of 21 per cent. The crude protein content of the diet of Giant Squirrel observed in the present study is in agreement with that of the diet schedule at Basle Zoological Gardens (Clark *et al.*, 1978) and higher crude fat and crude fibre content in the Thiruvananthapuram Zoo diet does not agree with the reports from Basle Zoological Gardens.

5.2.1.2 Indian Porcupine (*Hystrix indica*)

The porcupine ration in Thiruvananthapuram and Thrissur Zoos consisted of roots, tubers and vegetables, with the exception of bread that is included in Thiruvananthapuram Zoo diet and the quantity of tapioca provided varied greatly between the two zoos. The ration in Nandankanan Zoo differed as they provided fruits, milk, cooked rice, grams and maize, in addition to tubers and vegetables (Acharjyo and Patnaik, 1990b). The diet ingredients in Thiruvananthapuram and Thrissur Zoos may be selected based on the food habits of porcupines in wild.

The dry matter provided was about 2.1 per cent of the body weight of porcupines in Thiruvananthapuram Zoo and was only 0.32 per cent of body weight in Thrissur Zoo, and the crude protein percentage of the diet was more in Thrissur (11.9%) when compared to Thiruvananthapuram (7.2%). The crude protein and crude fat content of the diet of both zoos were much less on comparison with that of omnivore diet at the Basle Zoological Gardens (Clark *et al.*, 1978). Traditional diets are fed to animals in Indian zoos based on their food items in wild. Concentrated commercial foods are not usually included in the ration in the two zoos.

5.2.2 Primates

5.2.2.1 Bonnet Macaque (*Macaca radiata*), Rhesus Macaque (*Macaca mulatta*), Lion-tailed Macaque (*Macaca silenus*), Common Langur (*Presbytis entellus*), Nilgiri Langur (*Trachypithecus johni*), Capuchin Monkey (*Cebus capucinus*)

The ingredients of primate ration in both zoos were almost similar, except milk that is included in Thrissur Zoo and Bengal gram and orange were common for all primates in Thiruvananthapuram Zoo. The rations mainly consisted of fruits, vegetables, nuts, bread and cooked rice. The diet of Lion-tailed Macaques in Nandankanan Biological Park (Acharjyo and Patnaik, 1994) and Stump-tailed Macaques in Sri Venkateswara Zoological Park (Kumar and Raghavaiah, 1996c) agrees with the present observation. The primate diets in Indian zoos may be formulated considering the frugivorous (Prater, 1971) and foliage eating food habits of monkeys in the wild, and cooked rice and bread may be acting as rich carbohydrate sources.

The dry matter content of the diet of Rhesus Macaque in Thiruvananthapuram Zoo was almost double that of Bonnet Macaque. The crude protein content in the primate ration of Thiruvananthapuram Zoo varied from 8.25 per cent for Rhesus Macaque to 16.66 per cent for Common Langur. Martin (1978) has recommended 15 per cent crude protein for Old World monkeys. In Thiruvananthapuram Zoo this was met only in Common Langur and Lion-tailed Macaque rations. For New World monkeys the recommendations is 25 per cent crude protein (Martin, 1978) and for the

Capuchin Monkey in Thiruvananthapuram Zoo, the crude protein content (11.9 per cent) is far below that level. The energy requirement for Rhesus Macaque recommended in the above report is in agreement with the ration of Thiruvananthapuram and Thrissur Zoos. The crude protein content is also much less compared to the diet suggested by Manjramkar (1994) for monkeys. The ether extract of the different diets in Thiruvananthapuram Zoo also varied greatly.

The primate ration in Thrissur Zoo is agreeable to that mentioned by Martin (1978) regarding crude protein percentage. The energy available in the primate diet in Thrissur Zoo is much higher when compared to the diet schedule in Thiruvananthapuram Zoo. But the crude protein content as compared to diet suggested by Manjramkar (1994) is much less and the fat content in the Thrissur diet is more. The dry matter provided for Bonnet Macaque in Thrissur is almost four times as that provided in Thiruvananthapuram Zoo.

5.2.3 Mustelids and Viverrids

5.2.3.1 Common Palm Civet (*Paradoxurus hermaphroditus*), Small Indian Civet (*Viverricula indica*)

The ration of Common Palm Civet in Thiruvananthapuram and Thrissur Zoos were comparable, with the exception that cooked rice is included in Thrissur Zoo. Beef formed the main item of viverrid rations in Kerala zoos. Rettig and Divers (1978) also made similar reports of traditional viverrid diets consisting of chopped meat, fruits, vegetables and eggs. Similar diets are also

reported by Xavier and Balakrishnan (1993) and Iyer (1997) in Small Indian Civets. The above diets may be formulated considering the omnivorous feeding habit of these animals (Prater, 1971). The dry matter provided for Common Palm Civet in Thrissur was almost double as that of Thiruvananthapuram Zoo and also varied between the two viverrid diets in Thrissur. The crude protein content of the diet was more for the Small Indian Civet. The energy of the ration is also much higher in viverrid ration of Thrissur Zoo, when compared with that of Thiruvananthapuram Zoo. This may be due to inclusion of cooked rice in the ration of Thrissur Zoo. This variation between the zoos may be due to non-availability of any scientific studies on the diet of these animals and it may be a common practice to add and delete ingredients in the diet.

5.2.4 Canids and Hyenas

5.2.4.1 Indian Fox (*Vulpes bengalensis*), Jackal (*Canis aureus*), Striped Hyena (*Hyaena hyaena*)

Beef formed the major ingredient of this group in Thiruvananthapuram and Thrissur Zoos and only the quantity provided varied between species. In Thrissur Zoo much higher amount of beef is provided for Jackals compared to that of Thiruvananthapuram Zoo. Mathen (1994) has suggested to feed jackals with one kilogram of beef in zoos. This is in agreement to the quantity of beef provided in Thrissur Zoo and not agreeing with that in Thiruvananthapuram Zoo and the suggestion to supplement cooked rice is not followed in either zoos. Contrary to this diet, Heller (1978) suggested commercial dog food.

Commercial products are not much popular in Indian markets and so are not included in the diets in Indian zoos. The administrative difficulty in incorporating such feedstuffs may be a reason for the non -inclusion of such diets. It should have been better if the two zoos followed the same pattern of feeding.

Mathen (1994) mentioned that canids need 80 to 90 kilo calories of energy per kg body weight and this is met only in the Jackal diet in Thrissur Zoo with a much high energy content and is not met in the diets provided in Thiruvananthapuram. On comparison with the diet suggested for carnivores by Manjramkar (1994), the ration in Thiruvananthapuram and Thrissur Zoo is having much higher crude protein and ether extract content. This difference may be due to the difference in nutrient content of commercial balanced diet and that of a whole meat diet.

5.2.5 Bears

5.2.5.1 Himalayan Black Bear (*Selenarctos thibetanus*), Sloth Bear (*Melursus ursinus*)

The diets of the two species of bears differed in providing cooked beef to Himalayan Black Bear, and green grass to Sloth Bear in Thiruvananthapuram Zoo. On the other hand, the diet in Thrissur Zoo included vegetables, cooked rice, bread and milk. Honey is provided only to Sloth Bear. Chakraborty *et al.*, (1998) reported an almost similar diet for Himalayan Black Bear at Jawaharlal Nehru Zoological Park. The diet of Sloth Bear in Amsterdam Zoo, as reported

by Jacobi (1975) consisted mainly of meat and fish and is not similar to the diet schedule in Thiruvananthapuram and Thrissur Zoos. Mathen (1994) suggested to feed commercial dog food to bears which is contrary to the present report though fruits, vegetables and honey are supplemented in Thrissur and Thiruvananthapuram Zoos. The omnivorous feeding habit and the liking for honey (Prater, 1971) might have been considered for formulating their feeds in the zoos.. Besides bread and cooked rice may be added as rich carbohydrate sources in the diet of these animals. Black Bear being the most carnivorous of all bears received cooked beef in their diet in Thiruvananthapuram Zoo.

The dry matter content of the diet offered in Thiruvananthapuram and Thrissur Zoos varied greatly in both species and the crude protein content in Himalayan Black Bear diet in Thiruvananthapuram was higher compared to the other bear diets in Thiruvananthapuram and Thrissur Zoos, with almost similar crude protein contents. Johnson (1999) mentioned that bears should consume 1.5 to 2 per cent of their body weight as food per day in dry matter basis which is not in agreement with the present observations.

5.2.6 Felids

5.2.6.1 Jungle Cat (*Felis chaus*), Leopard (*Panthera pardus*), Tiger (*Panthera tigris*), Lion (*Panthera leo*)

The felid diets in both zoos consisted primarily of beef varying in quantity between species depending upon their body size. Chicken was included in the diets of Tigers in Thiruvananthapuram Zoo once in a week and

milk was provided to all except Jungle Cat. The quantity of beef provided in Thiruvananthapuram and Thrissur Zoo for the same species are almost similar and in Thrissur Zoo milk is provided only for Black Panther and Lion.

In Nandankanan Zoo, 650 g of beef daily and chicken once in a month were provided for Jungle Cats (Acharjyo and Patnaik, 1990a). This observation is not in agreement with the diet schedule adopted in Kerala zoos for small felids. The report of Theobald (1978) on the amounts of meat fed to adult cats were low when compared to the diets in Kerala zoos except for Leopards. In contrary, the diet given to Asiatic Lions at Arignar Anna Zoological Park (Basavaraju *et al.*, 1994) is much higher when compared to that of Thiruvananthapuram and Thrissur Zoos. Shoemaker *et al.* (1993) suggested providing whole animal carcasses occasionally and this was followed in tiger feeding in Thiruvananthapuram Zoo at times and for other felids, only meat chunks were given. The observations of Mathen (1994) agreed with the present observations of Leopard diets in Kerala zoos. The energy requirements mentioned in the above report are met with in the meat diets of both zoos in Kerala. The energy requirement mentioned by Phillips (1994) is much higher for lions and is not in agreement with the present finding. The felids are obligate carnivores and so the cheapest source of meat *i.e.* beef, is included as the major part of felid diets in Kerala zoos. Tigers are provided with additional chicken, as whole carcasses. This may be due to the higher status they enjoy as an endangered animal in the zoos of Kerala.

5.2.7 Elephants

5.2.7.1 Indian Elephant (*Elephas maximus*)

Fodder grass, coconut-palm leaves and *Caryota* leaves formed the roughage portion of the elephant's ration in Thiruvananthapuram Zoo. It was supplemented with cooked rice, banana, plantain, sugarcane and jaggery. The total roughage provided came around 90 kg and is akin to the report of Bist (1996). The recommendation of Poole and Taylor (1999) is to include a variety of species of food plants ideally 25 or more in elephant diet and to provide sodium in the form of salt lick. The diet provided for elephants in the forest department of Kerala (Das, 1996) differed from the diet in the zoo, except for the roughage portion. *'Timothy hay'* is included as the roughage in Portland Zoological Garden (Schmidt, 1978) and this may be due to the different roughage availability in the two places. The present diet is similar to that mentioned by Krishnamurthy (1998). The elephants are provided with grain rations in cooked form, twice a day in Southern states of India as per the above report.

Crude fiber content of the elephant diet is highest making about 30 per cent of the diet. Palm leaves and *Caryota* leaves with high fiber increase the crude fiber content of elephant ration. Traditionally the captive elephants owned by individuals in Kerala were fed *'Caryota'* leaves (Krishnamurthy, 1998) as roughage and that maintained by forest department were let out for natural grazing (Das, 1996). As an energy source, cooked rice, jaggery and

sugarcane were offered to elephants. In the present observation of the feeding system in the zoos, the above considerations are adopted.

5.2.8 Perissodactyles

5.2.8.1 Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)

The Rhinoceros ration in Thiruvananthapuram Zoo consisted of about 150 kg roughage supplemented with broiler starter mixed with wheat bran as concentrate. Besides this, vegetables, cooked rice, grams and plantain are also included. The diet of rhinoceros at Delhi Zoological Park reported by Bhatia and Desai (1975) are in agreement with the present observation. Contrary to this, at Nehru Zoological Park, Hyderabad the concentrate part of the ration is increased to eight kg and the roughage part reduced to 50 kg (Khan and Choudhury, 1987). Kanpur Zoo also provided eight kg of concentrate though 100 kg of roughage are given (Sabharwal, 1989).

The dry matter content of the diet provided to rhinoceros at Thiruvananthapuram Zoo is 48.52 kg and this is in agreement with the report of Nelson (1978). Jones (1979) pointed out that rhinoceros are used to diet with high fiber content and the range of protein in the diet is 10 to 25 per cent of the dry weight of the diet and this is found akin to the practices in Thiruvananthapuram Zoo. As the Rhinoceros are browsers, much roughage is included in the zoo diet and this simple stomached animal is provided with broiler starter as the concentrate ration.

5.2.8.2 Zebra (*Equus burchelli*)

Green grass formed the roughage portion and grams mixed to wheat bran, the concentrate part. The diet provided at Arignar Anna Zoological Park as reported by Rao and Asaithambi (1995) also agree with this, though the roughage provided is double the quantity. Haque (1996) suggested providing pelleted horse feed and hay to Zebra. The non-availability and difficulty in the procurement of both these items under the government controlled administrative set up may be a major factor causing this difference and the traditional diets of equines including horse gram and wheat bran are provided in these zoos.

5.2.9 Non-ruminant Artiodactyles

5.2.9.1 Indian Wild Boar (*Sus scrofa*)

In Thiruvananthapuram Zoo, broiler starter with cooked rice added to it, formed the concentrate. Tapioca and bread was also supplemented. Whereas in Thrissur Zoo, wheat bran and cooked rice formed the major portion with tapioca, cucumber and pumpkin supplemented. Contrary to this Boever (1978) recommended commercial swine ration to wild boars, supplemented with carrots, potatoes, greens, apple, bread, meat and hay. Some of the supplements mentioned in the above report were added in the diet in Kerala zoos and alternate concentrates are also provided. Cooked rice was added as an energy source and since the diets of these animals in the wild consisted of roots and tubers; tapioca was added in the ration in both the zoos.

5.2.9.2 Camel (*Camelus dromedarius*)

The camel ration in Thrissur Zoo included Jack leaves forming the roughage portion and four varieties of grams; the concentrate portion. Similar ration is followed at the army camel corps, though legume straw is provided as the roughage (Rathore, 1986). Mathen (1994) and Sahoo (1996) recommended concentrates with 12 to 14 per cent crude protein and salt licks to supplement trace minerals at all times of the year. A dry matter of 11.88 kg with 17 per cent crude protein was available for Camels in Thrissur Zoo.

5.2.9.3 Nile Hippopotamus (*Hippopotamus amphibius*)

In Thiruvananthapuram Zoo, compounded cattle feed mixed with wheat bran and cooked rice formed the major diet and 22.5 kg green grass was added as roughage. In Thrissur Zoo the quantity of green grass provided was higher (40 kg) and wheat bran mixed with cooked rice was also provided. Boever (1978) suggested a similar diet with hay as the roughage part. Similar rations are also provided in Nehru Zoological Park, Hyderabad though the quantity provided varied (Benerji and Pillai, 2000). The roughage portion provided in Thiruvananthapuram Zoo may be an insufficient one when compared to the rations in other zoos.

5.2.10 Ruminant Artiodactyles

5.2.10.1 Barking Deer (*Muntiacus muntjak*), Hog-Deer (*Axis porcinus*), Spotted Deer (*Axis axis*), Sambar Deer (*Cervus unicolor*)

The deer ration in Thiruvananthapuram Zoo consisted mainly of compounded cattle feed as the concentrate part and fodder grass and leaves as roughage portion. The quantity of both roughage and concentrate provided, varied between species. Grams and wheat bran were included in the ration except for Hog-Deer and extra cotton seed was added for Spotted and Sambar Deers.

In Thrissur Zoo, compounded cattle feed and green grass and jack leaves are provided to all deers except for Barking Deer. Cotton seed and grams are provided as supplements. The present finding is akin to the diet for ungulates at Oklahoma City Zoo (Grisham and Savage, 1990). The diets of both zoos agree with the recommendations of Mathen (1994) and Sahoo (1996) who suggested concentrates at the rate of 0.5 to 1 per cent of body weight. The mineral salt block as mentioned by them is not provided in Kerala zoos.

The dry matter provided in the ration for Barking Deer in Thiruvananthapuram Zoo was higher compared to the large sized Hog-Deer. The crude protein content of all diets was almost similar. The dry matter provided for Spotted Deer in Thrissur Zoo is much higher and is almost similar

to that of a Sambar Deer having much higher body weight. Here also the dry matter provided for Hog-Deer was much less and Barking Deer was provided with the lowest dry matter. It differed greatly from that in Thiruvananthapuram Zoo. The crude protein content of the diet was much higher for Barking Deers, compared to others, having almost similar crude protein percentage. Higginbottom (1996) suggested a crude protein level of 14 to 17 percentages and is found agreeable in all deers except for little less in the Spotted Deer ration in Thiruvananthapuram Zoo and a much higher crude protein available for Barking Deer in Thrissur Zoo. The diet of Philadelphia Zoo also had similar crude protein and crude fat in ration (Snyder and Moore, 1968) compared to diets in Kerala zoos. The dry matter recommended (Mathen, 1994) is provided for all deers except for Hog-Deer in Thiruvananthapuram Zoo. Spotted Deer in Thrissur Zoo and Barking Deer in Thiruvananthapuram Zoo were provided with a much higher dry matter than needed. This may be due to the absence of a scientific feeding schedule in these zoos.

5.2.10.2 Giraffe (*Giraffa camelopardalis*)

The giraffe ration in Thiruvananthapuram Zoo consisted of compounded cattle feed with Bengal gram mixed to it and fodder leaves as roughage. Besides, vegetables and fruits are also included. In Mysore Zoo an almost similar ration is provided as reported by Gowda (1986). In Dvurkralove Zoo (Fundova, 1974) the concentrate provided is more compared to Thiruvananthapuram Zoo diet.

A dry matter of 10.3 kg having 14.36 per cent crude protein was provided to Giraffe in Thiruvananthapuram Zoo. This is in agreement with the dry matter provided in Dvurkralove Zoo (Fundova, 1974) and the crude protein percentage provided in Thiruvananthapuram Zoo diet is little more than that in Dvurkralove Zoo. The crude protein level suggested by Higginbottom (1996) is found satisfied in the Giraffe diet of Thiruvananthapuram Zoo.

5.2.10.3 Blackbuck (*Antilope cervicapra*)

Blackbuck at Thiruvananthapuram Zoos were fed compounded cattle feed with wheat bran and grams added to it and green grass and leaves as roughage. In Thrissur Zoo also, an almost similar ration with compounded feed, grams, green grass and jack leaves, with exception of wheat bran is provided. In Oklahoma City Zoo, Blackbucks were given 0.3 to 0.5 kg of mixed grain sweet feed and hay as roughage (Grisham and Savage, 1990). The recommendation of Kewalramani (1996) is found agreeable in the present observation also.

The dry matter provided for Blackbucks in both zoos are comparable and with almost similar crude protein contents. The crude protein level recommended by Higginbottom (1996) is akin to the present system existing in Kerala zoos.

5.2.10.4 Nilgai (*Boselaphus tragocamelus*), Mithun (*Bos frontalis*), African Cape Buffalo (*Syncerus caffer*), Nilgiri Tahr (*Hemitragus hylocrius*)

In Thiruvananthapuram Zoo the ration consisted of compounded feed with wheat bran and grams added to it and fodder grass and leaves as roughage. Vegetables were also provided for Cape Buffalo and Nilgiri Tahr. In Stanley Zoo, 2.7 kg of ungulate mix and hay are provided for Nilgais (Lacey, 1969). This is in tune with the present observations. In Dvurkralove Zoo a ration with hay as roughage is provided for Cape Buffaloes (Fundova, 1974) which is akin to the present observation. Contrary to the Nilgiri Tahr diet in Thiruvananthapuram Zoo, the Tahrs at Memphis Zoo are provided with commercially prepared calf chow, hay and mineral salt blocks (Wilson, 1980).

The dry matter provided for Mithun (7.73 kg) was comparable to that of Nilgai (7.21 kg) in Thiruvananthapuram Zoo, though they differ much in their body weight. The crude protein content of all diets is similar ranging from 13-15 per cent and having crude fat around 3.5 per cent. This is in agreement with the modified diets of herbivores in Philadelphia Zoo as reported by Snyder and Moore (1968). The dry matter provided for Cape Buffaloes in Thiruvananthapuram Zoo is much higher than that of the diet given in Dvurkralove Zoo (Fundova, 1974). The recommendation of Higginbottom (1996) is also akin to the present observations.

5.3 Housing of zoo mammals

5.3.1 Rodents

5.3.1.1 Indian Giant Squirrel (*Ratufa indica*)

Kranz (1999) suggested enclosures measuring 1.8 x 1.8 x 1.8 m for Oriental Giant Squirrels with branches in it for locomotion. The present housing system agrees with this, though concrete nest boxes at the floor level were provided in Thiruvananthapuram Zoo as against the suggestion of wooden nest boxes in the above report. Malabar Giant Squirrel at Arignar Anna Zoological Park were housed in an enclosure with a height of 6 m (Paulraj and Naidu, 1988) and the present report is not agreeing to it. Enclosure height is important as they are arboreal creatures and will be utilizing the aerial space if provided with tree trunks. The provision of horizontal bars in the enclosure in Thiruvananthapuram Zoo as an enrichment tool is similar to the reports by Ashraf *et al.* (1993). The squirrels in Thiruvananthapuram Zoo were housed in the traditional small mammal cages which were designed commonly for viverrids, pangolins, lagomorphs and small felids. So the nest boxes were placed on the floor level for easy use of the ground dwelling small mammals and the arboreal habitat of the squirrel is not considered in the designing.

5.3.1.2 Indian Porcupine (*Hystrix indica*)

The Porcupines in Thiruvananthapuram Zoo were housed in a spacious concrete floored enclosure with retiring den on the rear part, and an enclosure

with natural flooring and a small covered area was provided in Thrissur Zoo. Porcupine enclosures at Nandankanan Zoo (Acharjyo and Patnaik, 1990b) and Bombay Zoo (Wani, 1994) were provided with retiring dens and is akin to the present report in Thiruvananthapuram Zoo. But the above two reports observed lesser floor space in the porcupine enclosures compared to Kerala zoos.Thrissur Zoo lacked secluded retiring dens for these animals. But the natural flooring provided, satisfied the fossorial nature of porcupines and the wooden logs provided in both zoos helped gnawing of porcupines, as their continuously growing incisors demand that. Natural flooring was not provided in Thiruvananthapuram Zoo and this may be to avoid chances of animal escapes by digging tunnels through the floor of the enclosure.

5.3.2 Primates

5.3.2.1 Bonnet Macaque (*Macaca radiata*), Rhesus Macaque (*Macaca mulatta*), Lion-tailed Macaque (*Macaca silenus*), Common Langur (*Presbytis entellus*), Nilgiri Langur (*Trachypithecus johni*) and Capuchin Monkey (*Cebus capucinus*)

Primates were housed in closed cages in Thiruvananthapuram and Thrissur Zoo with swings provided for enrichment in Thiruvananthapuram Zoo and wooden logs in Thrissur Zoo. Retiring platforms provided in Thiruvananthapuram Zoo and RCC (Reinforced cement concrete) slabs in Thrissur Zoo offered shelter to animals which were low in hierarchical structure. Tempel (1972) reported similar cages at Dresden Zoo for primates. Though the height of the enclosures in Thiruvananthapuram Zoo and those for

Bonnet Macaques and Rhesus Macaques in Thrissur Zoo seemed sufficient, the arboreal Lion-tailed Macaques in Thrissur Zoo were provided with an enclosure height of 2.15 m, which is not ideal. The cages of Bonnet Macaques in Thrissur Zoo are also over crowded. Open island enclosures with trees and shrubs were provided for monkeys in other Indian zoos (Ponnuswamy and Paulraj, 1990; Manimozhi and Basavaraju, 1992; Acharjyo and Patnaik, 1994; Kumar and Raghavaiah, 1996c). Even though provision of swings and tree trunks for enrichment is advantageous in closed cages, an enclosure simulating natural habitat will be more ideal for monkeys with inquisitive nature and offer added protection to the subordinate animals. This may also permit breeding of females by lower males, thus reducing the chances of inbreeding in the troop by the superior male alone.

The monkey cages in Thiruvananthapuram Zoo were constructed earlier; when the concept of open enclosures and environmental enrichment were not in vogue and so traditional closed cages were constructed. But now open enclosures are under construction for primates as part of the modernization of the zoo. Thrissur Zoo is also having old cages and due to unavailability of land for further expansion, is unable to design open enclosures. The zoo due to lack of new cages are not able to transfer the overcrowded Bonnet Macaque population which are prolific. The stress due to overcrowding may be seen in these monkeys and this may affect the welfare of these animals. Animals should be housed with a goal of maximizing species-specific behaviors and minimizing stress-induced behaviors. For social species, this normally requires

housing in compatible pairs or groups. A strategy for achieving desired housing should be developed in these zoos. The minimum space suggested by the Central Zoo Authority for the family Cercopithecidae is 2 m length,1 m breadth and 1.5 m height(Central Zoo Authority,1992).

5.3.3 Mustelids and Viverrids

5.3.3.1 Common Palm Civet (*Paradoxurus hermaphroditus*), Small Indian Civet (*Viverricula indica*)

In both zoos viverrids were housed in closed cages and nest boxes were provided in Thiruvananthapuram Zoo. In Thrissur Zoo wooden platforms were provided for viverrids and a tree trunk is provided for Palm Civet. The space provided in the Palm Civet enclosure of both the zoos satisfy the American Association of Zoos and Aquaria guidelines of 6 m^2 floor area and 1.8 m height (Carnio, 1999). But it is not agreeable to the present finding with regard to the Small Indian Civet enclosure in Thrissur Zoo. Nest boxes were available for each animal in Thiruvananthapuram Zoo, so that the weak and smaller animals seek protection easily. This facility is lacking in Thrissur Zoo for viverrids, which need a secluded retiring place. The wooden log provided for Palm Civet in Thrissur was advantageous for this tree dwelling species. Wooden cages to house civets were reported by Xavier and Balakrishnan (1993) as seen in civet oil producing units of South India. Thrissur Zoo with its limited facilities are lacking spacious cages, and attempts to furnish the cage are also limited.

5.3.4 Canids and Hyenas

5.3.4.1 Indian Fox (*Vulpes bengalensis*), Jackal (*Canis aureus*)

The open enclosure with natural flooring and retiring den for Jackals in Thiruvananthapuram Zoo was comparable with that of enclosure for Indian Wild Dog at Arignar Anna Zoological Park (Rao *et al.*, 1996). The retiring den provides hiding places for the animals and the natural substrate floor enable the animals to dig holes. The Jackal enclosure in Thrissur Zoo and the Indian Fox enclosure in Thiruvananthapuram Zoo were closed cages, without such facility. Contrary to this, open-island enclosures were used for housing canids in West Berlin Zoo (Klos, 1974) and in Sri Venkateswara Zoological Park (Kumar and Raghavaiah, 1996b).

The Indian Fox in Thiruvananthapuram Zoo and the Jackal in Thrissur Zoo were housed without pairs and so did not demand spacious open enclosure for them, whereas the jackal pack in Thiruvananthapuram Zoo was having the scope for breeding and were housed in spacious open enclosure, with settings to favour captive breeding.

5.3.4.2 Striped Hyena (*Hyaena hyaena*)

The hyena enclosure in Thiruvananthapuram Zoo had a floor area of 6.8 x 4.7 m and is similar to that reported by Rieger (1979), but lacked the den and visual barriers suggested by him for the natural breeding of the animals. The concrete floor of the enclosure was also a drawback which prevented the

digging behaviour of the animals. Only a single hyena is available in Thiruvananthapuram Zoo and this does not demand a naturalized habitat to aid the breeding of the animal.

5.3.5 Bears

5.3.5.1 Himalayan Black Bear (*Selenarctos thibetanus*), Sloth Bear (*Melursus ursinus*)

The bear houses in Thiruvananthapuram Zoo and the Sloth Bear cage in Thrissur Zoo were open enclosures with fencing around and having water pools and retiring facilities. In West Berlin Zoo (Klos, 1974) and Jawaharlal Nehru Biological Park (Chakraborty *et al.*, 1998), similar enclosures were provided. Thrissur Zoo housed the Himalayan Black Bear in an open enclosure with dry moat barrier. Enclosed breeding dens were provided for the bear exhibits in Thiruvananthapuram Zoo and Jacobi (1975) reported a similar enclosure in Amsterdam Zoo, which facilitated breeding. Johnson (1999) described enrichment options for bear enclosures and this is in agreement with the present observation in Thiruvananthapuram Zoo for bears and Himalayan Black Bear at Thrissur Zoo. The Sloth Bear enclosure in Thrissur Zoo lacked a natural setting and was deficient in enrichment. This may be because, Thrissur Zoo housed single animal and Thiruvananthapuram Zoo had breeding pairs in a natural environment. Also cage modifications may not be easily taken up in government zoos due to administrative constraints.

5.3.6 Felids

5.3.6.1 Jungle Cat (*Felis chaus*)

The small felids were housed in closed cages in both zoos and retiring dens were provided in Thiruvananthapuram Zoo. Thrissur Zoo provided a wooden platform for enrichment. These enclosures were also similar to that in Nandankanan Zoo (Acharjyo and Patnaik, 1990a), but the retiring dens were not available in Thrissur Zoo. The small felid cages of both zoos are agreeable to the enclosure size recommended by Mellen (1999), though the enclosure heights were little less in Kerala zoos. The enclosure enrichment facilities described by him is not practiced in both zoos in the present observation. The facility for utilizing the vertical component of the cage were not provided and secure dens are available only in Thiruvananthapuram Zoo. Though the wooden platform in Thrissur Zoo helps in sharpening claws, similar facility was not there in Thiruvananthapuram Zoo.

Smaller mammals are often neglected in Indian zoos with regard to the breeding and propagation.. The enrichment options that can be met by the limited resources available for these zoos, is also not provided.

5.3.6.2 Leopard (*Panthera pardus*)

The dome shaped enclosure of Leopards in Thiruvananthapuram and Thrissur Zoo were in agreement with the enclosure dimensions suggested by Shoemaker *et al.* (1993). Wooden log was provided in Thiruvananthapuram

Zoo enclosure. A closed enclosure resembling the natural habitat is provided in SriVenkateswara Zoological Park (Kumar and Raghavaiah, 1996a), which is contrary to the present report. Traditional carnivore cages were utilized in both zoos for housing the animals and open enclosures available in the zoo were not covered properly. This flaw in the enclosure design may lead to serious dangerous situations, as these animals are good climbers and leapers.

5.3.6.3 Tiger (*Panthera tigris*)

They were stationed in an enclosure simulating natural abode with a water pool in it. This is in agreement with Bemmel (1968) that tigers will not mate in traditional carnivore cages, even though lions mated freely in small cages. The Tiger enclosure in Thiruvananthapuram Zoo is also in accordance with the suggestions of Phillips (1994). The secretive and solitary nature of tigers is demanding an enclosure with natural visual barriers aiding separation of mates as and when they need.

5.3.6.4 Lion (*Panthera leo*)

In Thiruvananthapuram Zoo the animals were kept in closed dome shaped traditional carnivore cages without any enrichment provisions. In Thrissur Zoo, a closed cage was connected to an open enclosure with an artificial earthen mound and wooden log in it. The space requirements mentioned by Shoemaker *et al.* (1993), is not met with, in these closed cages. Since this zoo is constructed very early, the old cages are still in use. The

enrichment options were to some extent found agreeable in the open enclosure attached to Thrissur Zoo. Shift cage facilities were also available only in Thrissur Zoo. In Arignar Anna Zoological Park, Asiatic Lions are displayed in dry moated enclosures with concrete houses attached to it (Basavaraju *et al.*, 1994). The Thiruvananthapuram Zoo was having a sizeable population of lions and also breeding of hybrid lions was not of priority. They were also found to breed in the traditional cages and now are kept in the closed cages separated from their mates.

5.3.7 Elephants

5.3.7.1 Indian Elephant (*Elephas maximus*)

The open enclosure having trees and shrubs provided an adequate environment to the animal in Thiruvananthapuram Zoo, protected with dry moat barriers. Cast steel rings were provided on the floor of the stable in Thiruvananthapuram Zoo and similar reports are there from Topeka Zoo (Clarke, 1968). The retiring stable provided was akin to the recommendations by Bist (1996). Krishnamurthy (1998) reviewed that most zoos were keeping elephants in stables and only very few zoos provided open enclosures with moats around them, similar to that in Thiruvananthapuram Zoo.

5.3.8 Perissodactyles

5.3.8.1 Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)

The rhinoceros enclosure in Thiruvananthapuram Zoo was with dry moat barrier having mud wallows and large water pools. Jones (1979) and Miller and Foose (1996) also suggested similar type of enclosures for rhinoceros. Similar reports are there from other Indian zoos (Bhatia and Desai, 1975; Khan and Choudhury, 1987 and Anon, 1994). The provision of wallowing facilities as observed in Thiruvananthapuram Zoo is also good for rhinoceros as Venugopal *et al.* (1994) reported that wallowing is the most frequent activity in rhinoceros.

5.3.8.2 Zebra (*Equus burchelli*)

The enclosure was a fenced paddock with a covered shelter at the corner. More spacious enclosure with dry moat around are provided in Arignar Anna Zoological Park (Rao and Asaithambi, 1995). The zoos in Kerala were established years back and this may be a reason for the old systems of housing prevailing in the two zoos and under the government administrative set up, changes may not be that easy. The dimension of the covered area was also less in Thiruvananthapuram Zoo. Breeding was observed in zebras at

Thiruvananthapuram Zoo with these facilities and these open paddocks were designed earlier for the ungulates.

5.3.9 Non-ruminant Artiodactyles

5.3.9.1 Indian Wild Boar (*Sus scrofa*)

Thiruvananthapuram Zoo provided a congenial atmosphere to the animal with natural flooring, compared to the concrete flooring in Thrissur. The rooting behaviour is taken care of and also the mud wallow in Thiruvananthapuram Zoo was an added enrichment. A water pool was provided for this purpose in Thrissur Zoo. These observations are similar to the reports by Boever (1978). Not much sophisticated enclosure is demanded by wild boars and as they are prolific breeders, and captive breeding is not of priority.

5.3.9.2 Camel (*Camelus dromedarius*)

Housed in fenced open paddock with a covered area provided in the zoos. Boever (1978) reported that camels were kept in fenced enclosures, moated exhibits or in barns or stalls. This domestic animal is housed for the sake of exhibition only as they are not common in Kerala.

5.3.9.3 Nile Hippopotamus (*Hippopotamus amphibius*)

Boever (1978) reported that hippopotamuses need access to water regularly and in the both zoos, water pools are provided for the purpose. Naidu

(1986) also suggested the need of a sizeable pool for hippopotamus. The Kerala zoos provided a more natural enclosure to the animals as against that described for hippopotamus at Topeka Zoo (Clarke, 1968).

5.3.10 Ruminant Artiodactyles

5.3.10.1 Barking Deer (*Muntiacus muntjak*)

The Barking Deer enclosure in Thiruvananthapuram Zoo was an open run with undulating terrain and is similar to enclosures reported by Maloney (1968) for deers in Washington Zoo and Grisham and Savage (1990) in Oklahoma City Zoo. Thrissur Zoo housed the animal in a concrete floored closed cage, and this finding disagrees with the above reports. Deers are provided open runs in most zoos and Thrissur Zoo with only a single animal of the species, housed it in the closed cage, as the zoo was having shortage of open runs. Being a socially living animal this type of captivity affects the welfare of the animal. The Central Zoo Authority of India insists that keeping of animals singly and without considering their social structure, should be stopped at the earliest (Central Zoo Authority, 1992). The government owned zoo of Thrissur still lacks the stipulated facilities for many of its animals. The animal welfare suggestions put forth by the Central Zoo Authority, that every zoo shall keep animals in viable, social group, may be practiced at the earliest in the government owned zoos of Kerala.

5.3.10.2 Hog-Deer (*Axis porcinus*)

Housed in open runs with moat barrier in Thiruvananthapuram, and fenced area in Thrissur Zoo and is similar to the observation of deer enclosures in Washington Zoo by Maloney (1968) and in Oklahoma City Zoo by Grisham and Savage (1990). Housing of deer in open runs is followed in zoos all over the world and they are seen to breed well under these conditions.

5.3.10.3 Spotted Deer (*Axis axis*)

These deer are housed in open runs with fencing around in Thiruvananthapuram and Thrissur Zoos. Similar reports are there from different countries (Maloney, 1968; Grisham and Savage, 1990). The increasing captive population of these deer in both zoos are a problem and unless controlled breeding is adopted, the housing facilities provided will become insufficient for the animals in future.

5.3.10.4 Sambar Deer (*Cervus unicolor*)

They are also housed in enclosures with moat barriers in both zoos. In Thiruvananthapuram Zoo water pool and a concrete floored feeding area are provided for them. The present observation agrees with the reports of Maloney (1968) and Grisham and Savage (1990). The covered area provided in Thiruvananthapuram Zoo is inadequate for such a large population. These animals are breeding prolifically, demanding control in breeding to suit the existing housing conditions.

5.3.10.5 Giraffe (*Giraffa camelopardalis*)

The open paddock for giraffe with the large covered area is found adequate. This is comparable to the exhibit enclosure at Topeka Zoo (Clarke, 1968). These tall animals are offered feed and water at raised levels in most zoos and this is followed in Thiruvananthapuram Zoo also.

5.3.10.6 Blackbuck (*Antilope cervicapra)*

Open runs are provided for blackbucks in both zoos. Blackbucks in Arignar Anna Zoological Park were kept in enclosures with undulating terrain, sparse tree cover and large open area (Ponnuswamy and Paulraj, 1990) which is not in agreement with the present report. These animals in wild are inhabiting the plains and so may be comfortable in a terrain with few shrubs and trees.

5.3.10.7 Nilgai (*Boselaphus tragocamelus*)

Housed in an open run in Thiruvananthapuram Zoo. A similar enclosure is provided for Nilgais at Stanley Zoo (Lacey, 1969). Nilgais inhabiting the plains of the country also demand scattered vegetation in their enclosures and will breed well under these conditions.

5.3.10.8 Mithun (*Bos frontalis*)

The open grass land with fencing around is found adequate, but lacking in sufficient shade trees. Being semi-domestic, they will breed well in captivity

even with the limited enrichment provided. Reports are meager on housing of Mithun in zoos.

5.3.10.9 African Cape Buffalo (*Syncerus caffer*)

In Thiruvananthapuram Zoo an enclosure with dry moat barrier having shade trees and water pool in it is provided. This open enclosure is found adequate as the animal is breeding. Reports on the housing of Cape Buffaloes in other zoos are meager.

5.3.10.10 Nilgiri Tahr (*Hemitragus hylocrius*)

The open run provided with rock paved paths and rocky mounds in it may help to reduce hoof problems. This is in agreement with the observations of Wilson (1980) at Memphis Zoo. In contrast, the enclosure in Arignar Anna Zoological Park, as reported by Ponnuswamy and Paulraj (1990) is an open island, with dry moat around. Rocky patches were provided in this enclosure, similar to that in Thiruvananthapuram. A single animal is housed in Thiruvananthapuram Zoo and the added enrichment of the enclosure has no role in the captive breeding of the animal and so it may be adequate. Central Zoo Authority has recommended a minimum space requirement of 2.5 x 1.5 m space for each animal.(Central Zoo Authority,1992).

5.4 Breeding of zoo mammals

5.4.1 Rodents

5.4.1.1 Indian Giant Squirrel (*Ratufa indica*)

A single Indian Giant Squirrel is housed in the Thiruvananthapuram Zoo. Successful breeding of Indian Giant Squirrels were reported at Arignar Anna Zoological Park with sufficient enclosure enrichment (Paulraj and Naidu, 1988). The Kerala zoos are not having a scientifically planned captive breeding programme and often the lower mammals are neglected and they are not in pairs.

5.4.1.2 Indian Porcupine (*Hystrix indica*)

Though the porcupines are housed in pairs in Thiruvananthapuram and Thrissur Zoo, no breeding is reported. Contrary to this, good breeding history were reported by Acharjyo and Patnaik (1990b) in Nandankanan Biological Park. Lack of areas for sufficient seclusion in the enclosure in Thrissur Zoo, may be hindering the breeding of animals. Since these animals pair for caring their young ones in wild, the presence of other con-specifics in the enclosure and the ratio of males to females may be affecting the breeding in Thiruvananthapuram Zoo.

5.4.2 Primates

5.4.2.1 Bonnet Macaque (*Macaca radiata*), Rhesus Macaque (*Macaca mulatta*), Lion-tailed Macaque (*Macaca silenus*), Common Langur (*Presbytis entellus*), Nilgiri Langur (*Trachypithecus johni*), Capuchin Monkey (*Cebus capucinus*)

Breeding was observed in the primates which were in pairs. In Thiruvananthapuram Zoo the Nilgiri Langur and Rhesus Macaque is not having a mate and so is for Lion-tailed Macaque and Rhesus Macaque in Thrissur Zoo. This is against the stipulations of Central Zoo Authority (Central Zoo Authority,1992).The Lion-tailed Macaque, in Thiruvananthapuram Zoo, though bred gave birth to only one offspring during the study period. Successful breeding of Lion-tailed Macaques, were reported by Ponnuswamy and Paulraj (1990) at Arignar Anna Zoological Park and at the National Zoological Park, New Delhi (Acharjyo and Patnaik, 1994). Providing a natural environment, other than the closed enclosures for shy creatures like Lion-tailed Macaques may be the reason for better captive breeding in the above zoos. Breeding of Nilgiri Langurs are also reported from Arignar Anna Zoological Park (Manimozhi and Basavaraju, 1992) and so providing pair to the animal in a natural habitat may favour breeding. Capuchin and Rhesus Macaque births were registered at San Francisco Zoo by Reuther and Doherty (1968) and Rhesus Macaque births at Bucharest Zoo was observed by Cociu and Cociu (1976). Provision of breeding pairs is needed for captive breeding in this

group. Bonnet Macaques are breeding without any control in Thrissur Zoo as against Thiruvananthapuram, and is due to the larger population housed there. Uncontrolled breeding may lead to space problems and stress in these animals. This is against the stipulations of the Central Zoo Authority (Central Zoo Authority,1992)

5.4.3 Mustelids and Viverrids

5.4.3.1 Common Palm Civet (*Paradoxurus hermaphroditus*), Small Indian Civet (*Viverricula indica*)

Common Palm Civets are not in breeding pairs in Thiruvananthapuram and Thrissur Zoos. Seager and Demorest (1978) mentioned that Palm Civets breed well in captivity and so non-availability of mates may be the only factor hindering the breeding of these animals. These lesser mammals are not given much attention for breeding in kerala zoos. The Small Indian Civet are housed in breeding pairs in Thrissur Zoo but not bred so far. The non-availability of sufficient space and absence of nocturnal houses in the zoos may be the contributing factors for this, as the females need ample hiding space and are very stress prone (Seager and Demorest,1978).

5.4.4 Canids and Hyenas

5.4.4.1 Indian Fox (*Vulpes bengalensis*), Jackal (*Canis aureus*), Striped Hyena (*Hyaena hyaena*)

The Indian Fox and hyena in Thiruvananthapuram Zoo and the jackal in Thrissur Zoo are not in pairs and so was not breeding. This is against the zoo

rules prescribed by the Central Zoo Authority (Central Zoo Authority,1992). The Jackals housed in pairs, in Thiruvananthapuram Zoo, were breeding and the open enclosure with natural flooring and retiring dens provided may be a contributing factor. Jackal births were also reported at San Francisco Zoo (Reuther and Doherty, 1968) and at Bucharest Zoo (Cociu and Cociu, 1976). Breeding of Striped Hyena in captivity was observed by Rieger (1979) and suggested proper denning facilities in the enclosure for success in breeding. So the pre-requisite of providing an adequate enclosure need to be satisfied besides a potential mate, in Thiruvananthapuram Zoo for hyena. Reports of breeding of Indian Fox in captivity is not available. Though the animal is shy and less social, compared to jackals, providing adequate housing with retiring dens and a potential mate can favour their breeding. As these animals are common around our villages, zoos do not consider breeding the animals important, and so no planned breeding is adopted. Though the Central Zoo Authority has instructed to keep animals in breeding pairs, the Kerala zoos are not following it .

5.4.5 Bears

5.4.5.1 Himalayan Black Bear (*Selenarctos thibetanus*), Sloth Bear (*Melursus ursinus*)

No breeding is observed in the pairs of both Himalayan Black Bear and Sloth Bear in Thiruvananthapuram Zoo and in Thrissur Zoo due to absence of breeding pairs, though Central Zoo Authority has suggested to keep animals in pairs (Central Zoo Authority,1992). Sloth Bear births are reported by Reuther

and Doherty (1968) at San Francisco Zoo, and in Amsterdam Zoo by Jacobi (1975). Himalayan Black Bear breeding was reported at Bucharest Zoo (Cociu and Cociu, 1976) and Jawaharlal Nehru Biological Park (Chakraborty *et al.*, 1998). The Thiruvananthapuram Zoo had housed the two bear species in an open enriched enclosure with denning facilities, only recently and they will have to settle down and breeding can be expected in future which is found otherwise adequate. Thrissur Zoo though had a good open enclosure for Black Bear lacks proper denning area and breeding can be expected only by introducing potential mates to this enclosure after providing the necessary seclusion areas. The Sloth Bear in Thrissur is also housed in an inadequate quarter.

5.4.6 Felids

5.4.6.1 Jungle Cat (*Felis chaus*), Leopard (*Panthera pardus*), Tiger (*Panthera tigris*), Lion (*Panthera leo*)

The lion is observed to be the most successful breeder among felids in both Thiruvananthapuram and Thrissur Zoo. The gregarious habit of the lion aiding a more social life compared to other fields may be a contributing factor in this, whereas the other felids are solitary animals. Leopards and tigers breed in Thiruvananthapuram Zoo. In Thrissur Zoo, Leopards and Jungle Cats are not in pairs and though Jungle Cats in Thiruvananthapuram Zoo were in pairs, no breeding is reported. Breeding of Leopards, Bengal Tigers and Lions were also reported at San Francisco Zoo by Reuther and Doherty (1968) and lion and leopard births were reported by Cociu and Cociu (1976) at Bucharest Zoo.

Lion breeding was also reported from Arignar Anna Zoological Park (Basavaraju *et al.*, 1994). Tiger births are reported in Rotterdam Zoo (Bemmel, 1968) and Mysore Zoo (Raju *et al.*, 1997). Contrary to the present report, Jungle Cat breeding was noticed at Nandankanan Zoo (Acharjyo and Patnaik, 1990a). The Jungle Cat enclosures in both zoos are lacking enough enrichment and *i.e.* to be provided for proper breeding. Also the zoos are not having any planned breeding programme for these animals and they are often brought to zoos by local procurement. Their population and availability of pairs were often dwindling in the zoos during the study period. Tigers and leopards; demand a more natural environment than closed enclosures for mating and caring young ones and in Thiruvananthapuram Zoo an open enclosure is provided for tigers. Leopards though found to mate in closed cages, their breeding performance may be improved by providing a natural setting.

5.4.7 Elephants

5.4.7.1 Indian Elephant (*Elephas maximus*)

The Thiruvananthapuram Zoo houses only an old female elephant provided with a natural open enclosure. Only few zoos were successful in breeding elephants in captivity (Krishnamurthy, 1998). Poole and Taylor (1999) also mentioned that elephants breed only in natural or semi natural conditions. Elephants with elaborate courtship, need a natural setting for their mating which is provided in Thiruvananthapuram Zoo and introduction of potential mates into the enclosure is needed.

5.4.8 Perissodactyles

5.4.8.1 Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*)

Though provided with a natural open enclosure, the Thiruvananthapuram Zoo is having two male rhinoceros. The acquisition of a female on transfer of one male may be tried and the spacious enclosure with pool and natural settings seem otherwise sufficient. The need for spacious enclosure for breeding rhinoceros is also suggested by Jones (1979). Rhinoceros breeding is also reported in Mysore Zoo (Gowda, 1986), Nehru Zoological Park of Hyderabad (Khan and Choudhury, 1987) and in Kanpur Zoo (Sabharwal, 1989). Indian Rhinoceros have received much attention in the name of its captive breeding and re-introduction programmes and most Indian zoos have tried on that line.

5.4.8.2 Zebra (*Equus burchelli*)

A pair of Zebra is kept in Thiruvananthapuram Zoo and a birth is reported. Similar reports are also from Arignar Anna Zoological Park (Rao and Asaithambi, 1995). Zebras may not need elaborate natural settings for their breeding and an open enclosure will suffice if potential mates are present. Being an exotic animal they may not be given breeding priority

5.4.9 Non-ruminant Artiodactyles

5.4.9.1 Indian Wild Boar (*Sus scrofa*)

Successful breeding with good fecundity was noticed in Thiruvananthapuram Zoo and low breeding was observed in Thrissur Zoo. The natural enclosure in Thiruvananthapuram Zoo and a much larger population may be contributing to better breeding in Thiruvananthapuram Zoo. Wild Boar births are also reported by Cociu and Cociu (1976) at Bucharest Zoo. They are gregarious and prolific animals and its captive propagation need not be of priority in Indian zoos as their increase in population in the wild is a problem.

5.4.9.2 Camel (*Camelus dromedarius*)

Though they maintain breeding pair in Thrissur Zoo, no successful breeding was noticed. Since they are domestic animals, their breeding was not of much concern to zoos. Though the enclosure was found adequate for their breeding, there may be other factors that prevent successful breeding in these animals.

5.4.9.3 Nile Hippopotamus (*Hippopotamus amphibius*)

Successful breeding of this exotic animals are observed in both zoos. Breeding also have been reported in Kanpur Zoo (Ahsan, 1986) and Nehru Zoological Park, Hyderabad (Benerji and Pillai, 2000). Provision of adequate spacious enclosure and a large water pool may be the factors favouring the breeding of hippopotamus. This is also akin to the report of Gowda (1986).

5.4.10 Ruminant Artiodactyles

5.4.10.1 Barking Deer (*Muntiacus muntjak*), Hog-Deer (*Axis porcinus*), Spotted Deer (*Axis axis*), Sambar Deer (*Cervus unicolor*), Giraffe (*Giraffa camelopardalis*), Blackbuck (*Antilope cervicapra*), Nilgai (*Boselaphus tragocamelus*), Mithun (*Bos frontalis*), African Cape Buffalo (*Syncerus caffer*), Nilgiri Tahr (*Hemitragus hylocrius*)

Successful breeding is noticed in all the Ruminant Artiodactyles housed as breeding pairs. Giraffe and Nilgiri Tahr in Thiruvananthapuram Zoo and Barking Deer in Thrissur Zoo are not in breeding pairs. Successful breeding was also reported in San Francisco Zoo in case of Spotted Deers, Blackbucks, Reticulated Giraffes and Nilgais (Reuther and Doherty, 1968). Nilgai births were also reported in Stanley Zoo (Lacey, 1969) and Bucharest Zoo (Cociu and Cociu, 1976). Birth of Giraffe calves in Mysore Zoo was reported by Gowda (1986) and Nilgiri Tahrs were bred in captivity at Memphis Zoo and Minneapolis Zoo (Wilson,1980). Maradia (1995) reported Blackbuck fawning at Rajkot Zoo. These are gregarious animals leading a social life in the wild and when they are placed in herds in captive conditions, successful breeding is ensured. The deers are very prolific also. Nilgiri Tahrs need an enriched enclosure with rocky patches, grass and shrubs for captive breeding (Ponnuswamy and Paulraj, 1990).

5.4.11 Breeding performance of zoo mammals

Good breeding performance is noted in Ruminant Artiodactyles, primates, Non-ruminant Artiodactyles, Perissodactyles and canids when kept in

breeding pairs. Better breeding is observed in gregarious animals. On the other hand, solitary animals demand separation of mates and reunion at the mating season. In Thrissur Zoo, better performance was noted in Ruminant Artiodactyles, primates, and in lions among felids and Non-ruminant Artiodactyles, with the exception of Camels. The reason may be attributed to their gregarious nature aiding breeding.

5.5 Disease prevalence in zoo mammals

5.5.1 Rodents

Only a case of peritonitis was reported among rodents in Thiruvananthapuram Zoo and no cases were reported in Thrissur Zoo. Parasitic diseases were reported in Common Giant Flying Squirrels at Nandankanan Zoo (Rao and Acharjyo, 1984) and in Porcupines at Coimbatore Mini Zoo (Varadharajan and Kandasamy, 2000). Regular stool examinations of rodents may not be taken up in Thiruvananthapuram and Thrissur Zoos.

5.5.2 Primates

Neoplasms and pneumonia were reported in primates of Assam State Zoo (Goswami and Chakraborty, 1996). Vellayan (1998) also has observed pneumonia as a common disease in primates in Asia. Reports of pneumonia were also recorded in the present study in Thiruvananthapuram Zoo. The other reports were of parasitic diseases in Rhesus Macaques and Nilgiri Langurs at Assam State Zoo (Gaur *et al.*, 1979) and in Bonnet Macaque and Rhesus

Macaque at Coimbatore Mini Zoo (Varadharajan and Kandasamy, 2000). The above two reports were based on the screening of faecal samples of primates in zoos. Diarrhoea was a major disease noticed in Thiruvananthapuram Zoo with a report of trichuriasis in Common Langur. Neoplasms formed the major disease in Thrissur and also infectious diseases and non-specific conditions were found. Absence of regular screening may be the reason for meager reports from the zoos of Kerala.

5.5.3 Mustelids and Viverrids

In this group, only the Small Indian Civet in Thrissur Zoo were observed to be having dermatitis, dermatomycoses and strongylosis. The other reports available were of parasitic diseases in both Civet Cats and Palm Civets (Gaur *et al.*, 1979; Varadharajan and Kandasamy, 2000). Also prevalence of tuberculosis in Assam State Zoo was reported by Thakuria (1996). The report of strongylosis in civets warrants regular screening of their faecal samples for parasites in Thrissur Zoo. Strongyles are also having a direct life cycle and so chances of reinfection are more in the closed quarters.

5.5.4 Canids and Hyenas

Two cases of ancylostomiasis are reported in jackals in Thrissur Zoo and a case of diarrhoea in Striped Hyena in Thiruvananthapuram Zoo. Many reports are there on the prevalence of ancylostomiasis as a major parasitic disease in canids and also dirofilariasis and toxascariasis were reported (Rao

and Acharjyo, 1984; Chauhan *et al.*, 1973 and Varadharajan and Kandasamy, 2000). Even with the monthly deworming programme in Thrissur Zoo, ancylostomiasis is frequent. This may be due to the fecundity and short development time of larva of ancylostomes, with a direct life cycle. Proper hygiene has to be ensured by scrubbing and cleaning the enclosure to reduce the chance of reinfection. Metabolic bone disease in Striped Hyena are reported by Jayathangaraj *et al.* (1998) at Vandalur Zoological Park and tuberculosis in Assam State Zoo (Thakuria, 1996) and chances of a metabolic bone disease are less in Thiruvananthapuram Zoo as feeding hyenas on bones with meat attached to it, is the practice followed .

5.5.5 Bears

Ecto and endo parasitic conditions are observed in bears besides infectious conditions. *Ancylostoma* are also listed by Vellayan (1998) in the common parasites of ursids and this is akin to the present report. Trichurid infection was reported by Chauhan *et al.* (1973) at Lucknow zoo and the other reports were of Ring worm (Pal, 1997) and pasteurellosis (Mehrotra *et al.*, 1999b). The open enclosure with natural settings may be a contributing factor for ectoparasitic condition in Thiruvananthapuram Zoo. The deworming programmes are also taken up less frequently in both the zoos.

5.5.6 Felids

Parasitic diseases were the common disease in felids and more neoplasms are reported among lions in Thiruvananthapuram Zoo. Reports on the neoplasms in felids were meager in other zoos. Toxocariasis and ancylostomiasis were the more frequently reported diseases besides *Toxocara*, which agree with the present finding (Gaur *et al.*, 1979; Rao and Acharjyo, 1984; Tanwar *et al.*, 1984 and Varadharajan and Kandasamy, 2000). These are parasites having a direct life cycle and inspite of frequent deworming in the Thiruvananthapuram and Thrissur Zoo chances of reinfection exist. Cestodosis and gnathostomosis are reported in tigers in Thiruvananthapuram Zoo and Varadharajan and Kandasamy (2000) has noted spirurid infection in Jungle Cats. Dermatomycoses as reported in a leopard in Thrissur Zoo was also found in lions of Sanjay Gandhi Biological Park (Singh *et al.*, 1997b). Tick infestations are reported in tigers and lions of Thiruvananthapuram Zoo. Kumari and Choudhuri (1999) also reported similar case in leopards at S.V. Zoological Park. The open enclosures with vegetation for tigers, may be contributing to tick infestation. Many reports were there of blood protozoan diseases (Ahmed *et al.*, 1990; Singh *et al.*, 1997a and Upadhye and Dhoot, 2000). Frequent screening of blood samples of felids for these parasites may be taken up as a regular practice.

5.5.7 Elephants

A case of conjunctivitis was reported in the female elephant at Thiruvananthapuram Zoo. Parasitic conditions were reported in elephants in captivity (Gaur *et al.*, 1979; Lakhar and Das, 1988; Roy and Mazumdar, 1988 and Modi *et al.*, 1997). The elephant is dewormed only once in an year in Thiruvananthapuram Zoo and regular dung examinations if carried out may reveal parasitic conditions.

5.5.8 Perissodactyles

Two cases of parasitism and a case of indigestion were reported in rhinoceros in Thiruvananthapuram Zoo. Higher parasitic infections in rhinoceroses are also reported by Dutta *et al.* (1990) and Modi *et al.* (1997) and the former reported fascioliasis and strongyloidosis at Assam State Zoo. Fascioliasis may have contracted through the herbages supplied to rhinoceros brought from infected areas harbouring the intermediate snails. They are dewormed only once in an year. Rabies was reported in Lucknow Zoo (Arora, 1986) and infectious diseases were reported from Assam State Zoo by Chakraborty and Choudhury (1996).

5.5.9 Non-ruminant Artiodactyles

A case of fascioliasis was reported in Wild Boar in Thiruvananthapuram Zoo and infectious conditions and neoplasms were observed in Thrissur Zoo. Only conjunctivitis in camel was reported from Thrissur Zoo and infectious

conditions and non-specific conditions were noted in hippopotamus of the zoos. Fascioliasis in Wild Boars were also reported by Gaur *et al.* (1979) at Kanpur Zoo and Cheema *et al.* (1992) in Wild Boars in Punjab along with other endoparasites. Similarly parasites in Wild Boars were also reported by Rao and Acharjyo (1984). Lall (1994) reported fascioliasis in a hippopotamus at Ethiopia. In Thiruvananthapuram Zoo, Wild Boars are dewormed only once in a year and this may be a contributing factor. Parasitic diseases in Camels were reported at Coimbatore Mini Zoo (Varadharajan and Kandasamy, 2000). The frequent deworming followed in Thrissur Zoo may have reduced the chances of infection in this group.

5.5.10 Ruminant Artiodactyles

Infectious conditions, neoplasms and non-specific conditions were present among this group in Thrissur Zoo with no reports of parasitic diseases. In spite of absence of regular deworming, this may be due to lack of diagnostic facilities for faecal matter screening in Thrissur Zoo. Twelve cases of rabies were reported in Hog-Deers and two case of pasteurellosis in Sambar Deer at Thiruvananthapuram Zoo. Pasteurellosis were also reported in a male Chital Deer at Maharajbagh Zoo (Dhoot and Upadhye, 2001). Septicaemic pasteurellosis can occur at times of environmental stress. The Hog-Deers may have contracted rabies from stray dogs or other carnivorous vermins entering the zoo premises. Parasitic diseases were also reported in Thiruvananthapuram Zoo in ruminants, mainly strongylosis, coccidiosis and hydatidosis. Similar

reports were also from Kanpur Zoological Park (Gaur *et al.*, 1979) and in zoo animals of Bihar (Modi *et al.*, 1997) and in Coimbatore Mini Zoo (Varadharajan and Kandasamy, 2000). The mass deworming programme in the large population of ungulates may not be so effective and chances of re-infection are also higher. Non-specific and infectious conditions are also found in the zoo besides cases of ectoparasitic infestation in Blackbucks. Contrary to this, specific infectious condition like tuberculosis were reported at Kamla Nehru Park (Garg *et al.*, 1990) and at Assam State Zoo (Thakuria, 1996) and these reports were based on detailed diagnostic tests. Literature on ectoparasitic infestation in deers are scanty.

5.5.11 Percentage of incidence different classes of disease in zoo mammals

The higher percentage of incidence of parasitic conditions in Thiruvananthapuram Zoo compared to Thrissur Zoo may be due to the availability of diagnostic facilities for screening of faecal samples in the Veterinary hospital, attached to Thiruvananthapuram Zoo. Thrissur Zoo lacked such a facility and hence no proper diagnosis of parasitic diseases were possible and hence the scanty reports. Infectious diseases and neoplastic conditions ranked higher in Thrissur Zoo, as detailed post-mortem examinations and further histopathological diagnostic methods could be conducted at the Veterinary College in Thrissur near to the zoo.

5.6 Disease prevention measures in zoo mammals

5.6.1 Vaccination programmes

Vaccination is regularly performed only in felines at Thiruvananthapuram Zoo and no vaccination programmes are conducted in Thrissur Zoo. In Kanpur Zoo vaccination of the susceptible zoo animals were carried out in case of prevalence of infectious diseases in surrounding areas (Gairola, 1986) and this is also not done in Kerala zoos as observed in the present study. Snyder and Moore (1968) mentioned vaccinations against panleukopenia in felids at Philadelphia Zoo. Poliomyelitis in primates and distemper and hepatitis vaccinations in canids were also provided in Philadelphia Zoo.

Vellayan (1998) suggested polio, rabies and tetanus vaccination in primates and immunoprophylaxis for canine distemper, feline panleukopenia canine adeno-virus, canine parvo-virus, feline viral rhinotracheitis, feline calici virus and also rabies in carnivores. Carnio (1999) reported these vaccinations in civets also.

In zoos of Thiruvananthapuram and Thrissur, vaccination of felids and canids against common diseases may have to be taken up as squeeze cage facilities are available. Though outbreaks of foot and mouth disease are reported in Kerala, enough facilities are not available in both zoos for vaccinating such as a large hoof stock population. Feeding of deer by visitors has to be totally discouraged as these feeding materials can transmit the disease

from the domestic stock. Thiruvananthapuram Zoo is having a Veterinary hospital with adequate facilities, with a fulltime Veterinarian and this may be the factor for better prophylactic measures adopted in this zoo compared to Thrissur Zoo which lacks the above facilities. Reports on the preventive methods adopted in the zoos of India, are meagre.

5.6.2 Deworming programmes

Regular and frequent deworming are adopted only for carnivores and camels in Thrissur Zoo. In Thiruvananthapuram Zoo, though regular deworming are done in all mammals, the deworming frequency is very low in rodents, primates, viverrids, bears, elephants, rhinoceros and Non-ruminant Artiodactyles. Besides them the Indian Fox, Jungle Cat and Barking Deer were also less frequently dewormed in Thiruvananthapuram Zoo.

Thrissur Zoo provides greater priority to carnivore deworming, as they are housed in closed cages, as chances of reinfection are more. Thiruvananthapuram Zoo also had given such a priority, though with some exceptions. In the hoofed stock at Thiruvananthapuram Zoo, mass deworming was done along with the concentrate ration supplied, and the rodents are the most neglected group as far as deworming practice is concerned.. For all other species yearly deworming were done.

The detailed deworming programme adopted in mammals at Kanpur Zoological Park (Gairola, 1986) is not adopted in the zoos of Kerala as evidenced from the present observations. The Rhinoceros at Nehru Zoological

Park were screened once a month for worms and dewormed once in three months (Khan and Choudhary, 1987) and also in Allen Forest Zoo (Anon, 1994). Better deworming programmes were also reported by Grisham and Savage (1990) at Oklahoma City Zoo. Though faecal examinations for parasites are not routinely carried out in Thiruvananthapuram and Thrissur Zoo, for felids, deworming as suggested by Mellen (1999) is followed. Reports on similar activities in other zoos are meagre.

5.6.3 Cleaning and disinfection

Cleaning of cages were done daily before the morning feeding in both zoos. The large felids and other carnivores in Thrissur Zoo have shift cages which ensured thorough cleaning of the floor of the cages. Primates are having such facility in both zoos and ensured better cleaning. The cleaning operations are found in agreement with the suggestions of Fowler (1978). The suggestions by Martin (1978) are also true in the present observation, concerning primate houses. The recommendation of cleaning cage walls of large cat houses (Calgary Zoo-keeper Training Lecture, 1989) is not practiced in Thiruvananthapuram and Thrissur Zoo. The feeding practices in both zoos are not in agreement with the suggestions of Phillips (1994), as meat chunks are offered on enclosure floors in both zoos. In Thiruvananthapuram Zoo chances of faecal contamination of the meat may be there. Phenolic disinfectant are not used in felid cages in both zoo, which is in accordance with the Felid Veterinary Guidelines (1996).

Summary

6. SUMMARY

A detailed study on the existing husbandry and managemental practices were taken up in the Government owned zoos of Kerala. The captive mammals in the zoos were classified into ten groups, based on the taxonomic position and food habits. The existing feeding practices and cleaning measures were observed and the nutrient content of the present ration was worked out. The housing systems adopted for the captive mammals were also documented. The details pertaining to breeding, disease prevalence and disease prevention were codified.

The ration for Indian Giant Squirrel in Thiruvananthapuram Zoo consisting of fruits, nuts and greens provided a dry matter of 0.0605 kg. The Indian Porcupine ration in both zoos consisted of roots, tubers and vegetables and provided a dry matter of 0.304 kg and 0.0467 kg in Thiruvananthapuram and Thrissur Zoos respectively. The primate ration in Kerala zoos consisted mainly of fruits, vegetables, nuts, bread and cooked rice. The dry matter available in the diet for different species ranged from 0.128 kg to 0.259 kg in Thiruvananthapuram Zoo and it was 0.507 kg in the primate diet in Thrissur Zoo.

The Viverrid diets in Kerala zoos included beef, plantain, bread and milk and the dry matter content varied from 0.076 kg to 0.113 kg for different species. Beef formed the diet of Canids and Hyenas in Kerala zoos, with dry

matter availability ranging from 0.257 kg to 0.514 kg for the different species. The ration for bears in the zoos included vegetables, fruits, cooked rice, bread and milk. The dry matter content of the diet for Himalayan Black Bear were 1.354 kg and 0.725 kg and for Sloth Bear were 1.433 kg and 0.805 kg in Thiruvananthapuram and Thrissur Zoos respectively. The Felids in the zoos were provided with beef, and whole chicken were included in Tiger diet. Milk was supplemented to some felids in both zoos. The dry matter content available for the different species varied from 0.0257 kg to 2.2 kg.

Elephants in Thiruvananthapuram Zoo were provided with *Caryota* leaves, coconut-palm leaves and fodder grass as roughage. Cooked rice and other supplements were also fed. A total dry matter of 28.09 kg was available for the animal. The Rhinoceros in Thiruvananthapuram Zoo were provided with 150 kg of roughage, along with broiler starter, cooked rice, wheat bran and grams, providing a total dry matter of 48.52 kg. A total dry matter of 8.81 kg was provided for Zebra in Thiruvananthapuram Zoo with a ration of green grass, and grams mixed to wheat bran. Indian Wild Boar in Thiruvananthapuram Zoo was fed broiler starter, cooked rice and tapioca. In Thrissur Zoo they were given wheat bran, cooked rice, tapioca and vegetables. The dry matter content of the diets was 1.28 kg and 1.49 kg in Thiruvananthapuram and Thrissur Zoos respectively. Camels in Thrissur Zoo were provided with a total dry matter of 11.88 kg with jack leaves and grams as the ingredients of the ration. Nile Hippopotamus in Thiruvananthapuram Zoo were given green grass and compounded feed mixed with wheat bran and

cooked rice, providing a dry matter of 16.23 kg. In Thrissur Zoo, green grass, and wheat bran mixed to cooked rice were fed to them and it had a total dry matter of 21.78 kg.

The ruminant artiodactyles in the two zoos were provided rations consisting of compounded feed, green grass and fodder leaves. Grams, cotton seed and wheat bran were also supplemented in certain rations. An exception to this is the Barking Deer ration in Thrissur Zoo consisting of grams and vegetables. The dry matter content of the ration for different species in Thiruvananthapuram Zoo ranged from 1.067 kg in Hog-Deer to 19.31 kg in African Cape Buffalo. In Thrissur Zoo it ranged from 0.5 kg in Barking Deer to 4.8 kg in Sambar Deer.

The Indian Giant Squirrel kept in Thiruvananthapuram Zoo were housed in a closed cage with nest boxes, tree trunks and horizontal bars for environment enrichment. Indian Porcupines in Thiruvananthapuram Zoo were housed in concrete floored open enclosure having retiring dens. In Thrissur Zoo, they were housed in a natural floored open enclosure. The primates in Kerala zoos were housed in closed cages and retiring platforms and swings were provided in Thiruvananthapuram Zoo, and wooden logs and cemented concrete slabs as fittings in Thrissur Zoo.

The Viverrids were accommodated in closed cages. Nest boxes were provided only in Thiruvananthapuram Zoo. Wooden platforms and logs were provided for them in cages of Thrissur Zoo. Indian Fox in Thiruvananthapuram

Zoo and Jackal in Thrissur Zoo were kept in closed concrete floored cages. An open enclosure with natural flooring and retiring den was provided for Jackals in Thiruvananthapuram Zoo. The Bear enclosures in Thiruvananthapuram Zoo and the Himalayan Black Bear enclosure in Thrissur Zoo were with an undulating terrain having water pools and other natural fittings as environment enrichment. Artificial retiring dens were available in Thiruvananthapuram Zoo. Jungle Cats were kept in closed cages in both zoos and wooden platforms were available in Thrissur Zoo. Leopards and Lions in the zoos were accommodated in traditional closed cages and wooden logs were provided as fittings in the Leopard cage in Thiruvananthapuram Zoo.

In Thiruvananthapuram Zoo both Elephants and Rhinoceros were kept in large open enclosures with dry moat barriers. Water pool and mud wallows were provided in Rhinoceros enclosures. Indian Wild Boar in Thiruvananthapuram Zoo was accommodated in an enclosure with mud wallows and in Thrissur Zoo a concrete floored enclosure is provided with a wallowing pool in it. The Hippopotamuses in the zoos were housed in large open enclosures having large water pools. The other ungulates were housed in open runs or paddocks with covered shelter area in it in both zoos. Water pools were available in Sambar Deer and Cape Buffalo enclosures in Thiruvananthapuram Zoo, and artificial rocky mounds and rock paved paths were provided for Nilgiri Tahr.

Twenty-three different mammalian species were maintained as breeding pairs in Thiruvananthapuram Zoo. Successful breeding were recorded in 19

species. The animals which were not breeding, even when kept in pairs were the Indian Porcupine, the Himalayan Black Bear, the Sloth Bear and the Jungle Cat.

Eleven mammalian species were in breeding pairs in Thrissur Zoo and breeding was noticed in eight species. The Indian Porcupine, the Small Indian Civet and the Camels were not breeding, even when kept in pairs.

About the disease incidence among rodents, only a case of peritonitis was reported in Indian Porcupine at Thiruvananthapuram Zoo. Infectious and parasitic conditions were reported in primates of Thiruvananthapuram Zoo, and non-specific and neoplastic conditions were observed in addition to infectious conditions in Thrissur Zoo. Parasitic and infectious conditions were registered in Small Indian Civet in Thrissur Zoo. In Canids and Hyenas group, a case of diarrhoea was reported in Striped Hyena in Thiruvananthapuram Zoo and parasitism were reported from Jackals in Thrissur Zoo. Both parasitic and infectious conditions were observed in Bears kept in Kerala zoos. Parasitic, infectious and non-specific conditions were observed in the Felids of the two zoos and also neoplastic conditions were reported in Lions of Thiruvananthapuram Zoo. Only a case of conjunctivitis was reported in Elephants in Thiruvananthapuram Zoo. In Perissodactyles group, parasitic conditions and indigestion were observed in Rhinoceros in Thiruvananthapuram Zoo. Non-ruminant Artiodactyles in Thiruvananthapuram Zoo showed parasitic, non-specific and infectious conditions, and infectious and neoplastic conditions was observed in Thrissur Zoo. Infectious and non-

specific conditions were observed in Ruminant Artiodactyles of both the zoos and neoplasms were observed in Spotted Deer of Thrissur Zoo. Parasitic conditions were also reported from this group in Thiruvananthapuram Zoo.

Vaccinations were regularly performed only in Felids in Thiruvananthapuram Zoo and no vaccinations were done in Thrissur Zoo. Regular dewormings were done for all mammals in Thiruvananthapuram Zoo. The Rodents in the zoo were dewormed once in two years and all Primates, Viverrids, Bears, Elephant and Non-ruminant Artiodactyles were dewormed once in an year. The Indian Fox, Jungle Cat, Rhinoceros and Barking Deer were also dewormed once in an year, and the Hyena, Leopard, Zebra and all other Ruminant Artiodactyles were dewormed twice an year. Thrice an year deworming were performed in Jackals, Tigers and Lions. In Thrissur Zoo regular deworming were done only in Carnivores and in Camels. Jungle Cats were dewormed bimonthly, and monthly deworming done in other Carnivores. The Camels were dewormed thrice a year.

The enclosures and cages in the zoos were cleaned daily in the morning, before the feeding. The feed and water troughs were also cleaned daily and the water pools in the enclosures were emptied, cleaned and refilled twice a week. 'Benzalkonium chloride' solution was the disinfectant used in the zoos and that was used only in Carnivore and Primate cages, occasionally.

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EVALUATION OF HUSBANDRY PRACTICES IN CAPTIVE ZOO MAMMALS IN KERALA

By

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ABSTRACT OF A THESIS

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ABSTRACT

Husbandry practices adopted for captive zoo mammals, were studied in the Government owned zoological gardens located at Thiruvananthapuram and Thrissur districts of Kerala State. The mammals in the zoos were classified into ten groups, based on the taxonomic position and food habits. In the feeding management studies, the different feed ingredients used to formulate the ration for these ten groups of mammals were recorded. The dry matter content of the ration was worked out. A comparative study was taken up between Thiruvananthapuram and Thrissur Zoos, in the feed ingredients as well as in the dry matter content of the ration in all the above ten groups of mammals.

The management practices with regard to housing of animals were also observed. Cages and enclosures were provided for the animals and in most of the cases the floor was made of cement concrete. A comparison between the two zoos with regard to the substrate and the type of cage for the ten groups of mammals were also made. The environment enrichment methods adopted as well as the provisions for wallowing and perching were also observed and compared in the two zoos among the ten groups of mammals.

Under the captive breeding observations in Thiruvananthapuram Zoo it was found that 23 different mammalian species were kept in breeding pairs though successful breeding were noticed in 19 of them. The animals which do not breed in captivity even when kept in pairs, were the Indian Porcupine, the

Himalayan Black Bear, the Sloth Bear and the Jungle Cat. Whereas in Thrissur Zoo, 11 mammalian species were in breeding pairs and out of that eight species were successfully breeding. The Indian Porcupine, Small Indian Civet and the Camels in the zoos were not breeding, eventhough they were in pairs.

Disease prevalence was another management practice studied. Parasitic diseases (44.68 per cent), infectious diseases (35.11 per cent), non-specific conditions (17.02 per cent) and neoplastic conditions (3.19 per cent) were observed in captive mammals in Thiruvananthapuram Zoo; and infectious conditions (59.32 per cent), neoplastic conditions (15.25 per cent), parasitic diseases (13.56 per cent) and non-specific conditions (11.87 per cent) were observed in Thrissur Zoo.

Vaccinations were regularly done only in felids in Thiruvananthapuram Zoo and no vaccinations were done in Thrissur Zoo. Regular dewormings were done for all mammals in Thiruvananthapuram Zoo, but only in carnivores and Camels in Thrissur Zoo. The frequency of deworming varied between the species and did not conform to any scientific suggestions.

Hygiene and sanitation showed that the enclosures in the zoos were cleaned daily in the morning, before the feeding of the animals. Along with that the feed and water troughs were also cleaned. The water pools were emptied, cleaned and refilled twice in a week. 'Benzalkonium chloride' solution was the disinfectant used in the zoos, and were occasionally used only in the carnivore and primate cages.