HELMINTH PARASITES OF MAMMALS IN THRISSUR ZOO

By

VARADHARAJAN, A.

THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF VETERINARY SCIENCE

Faculty of Veterinary and Animal Sciences

Kerala Agricultural University

DEPARTMENT OF PARASITOLOGY

COLLEGE OF VETERINARY AND ANIMAL SCIENCES

MANNUTHY, THRISSUR, KERALA

1999

University

DECLARATION

I hereby declare that this thesis entitled "**HELMINTH PARASITES OF MAMMALS IN THRISSUR ZOO**" is a bonafide record of research work done by me during the course of research and that this 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

Mannuthy
7-7-99

VARADHARAJAN, A.

CERTIFICATE

Certified that this thesis entitled **"HELMINTH PARASITES OF MAMMALS IN THRISSUR ZOO"** is a record of research work done independently by Sri. Varadharajan, A., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Dr. C. Pythal
(Chairman, Advisory Committee)
Professor
Department of Parasitology
College of Veterinary &
Animal Sciences, Mannuthy

Mannuthy
7/7/'99

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Sri. Varadharajan, A.**, a candidate for the degree of Master of Veterinary Science in Parasitology, agree that this thesis entitled "**HELMINTH PARASITES OF MAMMALS IN THRISSUR ZOO**" may be submitted by Sri. Varadharajan, A., in partial fulfilment of the requirement for the degree.

7/7/99

Dr. C. Pythal
Professor
Department of Parasitology
(Chairman, Advisory Committee)

Dr. C. George Varghese
Professor and Head
Department of Parasitology
(Member)

7/7/99

Dr. H. Subramanian
Assistant Professor (Sel.Gr.)
Department of Parasitology
(Member)

7/7/99

Dr. M.R. Saseendranath
Associate Professor
Department of Preventive Medicine
(Member)

External Examiner
ASSOCIATE PROFESSOR
Dept of Path
Vet College
Bangalore 560 024

ACKNOWLEDGEMENT

With great devotion I would like to express my deep sense of gratitude and indebtedness to my guide Dr. C. Pythal, Professor, Department of Parasitology and Chairman of the Advisory Committee. I can not accord my own effort in a prime place but the timely guidance, motivation, urge, zeal feeling in me, by my guide, lending an air of self assurance and confidence during each phase of my Masters' Degree, stands out with clear distinction. Besides, his special care and concern for me is unforgettable.

I also wish to express my gratitude to Dr. C. George Varghese, Professor and Head i/c, Dr. H. Subramanian, Assistant Professor (Selection Grade), Department of Parasitology and Dr. M.R. Saseendranath, Associate Professor, Department of Preventive Medicine, Members of the Advisory Committee for their valuable suggestions, constructive criticism, consistent encouragement and timely help.

My sincere thanks to Dr. K. Madhavan Pillai, Professor (Rtd), Department of Parasitology for his intellectual support and help.

I am extremely grateful to Dr. S. Sulochana, Dean, College of Veterinary and Animal Sciences for the facilities provided for my research work.

I am forever fondly beholded to my mother and sisters for their boon and benevolence. I also express sincere gratitude to my uncle Shri. M. Subramanian and also to my brother Shri. A. Subramanian for their constant inspiration, financial support and motivation for the successful completion of my post-graduate studies.

Words fail to express my deep sense of gratitude to Dr. Latha K. Shiva for her constant inspiration, affectionate benevolence and meticulous motivation, to Dr. V. Ramesh for his glorious encouragement, incessant support and generous help and also to Dr. A. Arulmozhi for her mischievous criticism and sincere friendship during my entire course programme.

I am greatly indebted to Dr. K. Devada, and Dr. Lucy Sabu, Assistant Professors and Dr. Raghu Ravindran, Teaching Assistant, Department of Parasitology for their appropriate suggestions and amusing encouragements.

I wish to thank, Dr. N. Baskar, Dr. A. Kandasamy and Dr. N. Sreevidya, M.V.Sc scholars, Department of Parasitology, for their co-operation and help during my research work.

I am extremely thankful to Shri. K.V. Raveendran, Supdt., Shri. K. Sadasivan Pillai, Curator, Shri. Narayanakutty, Supervisor, Dr. Muraleedharan, Veterinary Officer i/c, all the keepers and the staffs of the Thrissur Zoo for their co-operation and help in collecting the materials for my research work.

I am sincerely thankful to Dr. K.V. Raghunandanan, Associate Professor, Department of Genetics for his timely and valuable help in taking microphotographs.

The boisterous support, lineal help and sincere friendship bestowed on me by Dr. P. Kanagaraju, Dr. S. Ramakrishnan, Dr. P. Thirumurugan, Dr. E. Sridharan, Dr. S. Mohan and Dr. D. Balasubramanian was memorable.

I extend my thanks to a Dr. R. Ramesh M.V.Sc. IVRI, Izatnagar and also to Dr. K. Senthilvel, Assistant Professor, LRS, Kattupakkam for their help in the collection of literatures.

My special thanks to Shri. O.K. Raveendran, M/s Peagles, Mannuthy for the perfect typing of this manuscript eventhough we faced certain unavoidable problems while doing the same.

Last but first, I bow my head before God Samayapuram Mariyamman for the blessings showered on me.

VARADHARAJAN, A.

Dedication

To

My late Father

Shri. R. APPAVU PADAYACHI

And

SHIVASAKTHI

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

Introduction

Chapter - I

INTRODUCTION

Wildlife are of tremendous importance as they are the ancestral sources of the domesticated animals and also valuable gene-pool resources for their upgradation. They also include species which may be potential domesticates. All organisms, whether animal or plant, which are not domesticated or farmed by man constitute wildlife, although the term conventionally relates to wild animals. Wild animals may be free-living, captive or feral and may also have substantial aesthetic, educational, recreational and economic values.

There are about 4,000 species of wild mammals present all over the world. Out of these about 380 species are present in India. This may include endemic species - species restricted to particular habitat in the country - as also non-endemic species-which are present in other countries as well.

Wildlife constitute precious natural resources seriously becoming depleted by various factors which accentuate the extinction of species; hence there is increasing realisation of the importance of preservation of wild animals. The zoological gardens have vital roles to play in the conservation of specific wild animals as they are serving as the sole breeding foci for certain highly endangered species of animals. Generally they exhibit free-living wild animals

destined to be in captivity. Historically these were the rather now-extinct cage- enclosure type outfit called "Closed Zoos" although the more desirable, habitat-simulating"Open Zoos" are being established either as new outfits or as replacements of the older "Closed Zoos" seen in almost all parts of the world, though this is very rarely seen in the developing countries like India. Even these so-called habitat-simulating and as such much more desirable "Open Zoos" are more than mostly not upto the mark because of certain fundamental laxities including the lack of correct perception and prompt as well as effective execution of adequate preventive measures with regard to the disease problems of the wild animals.

Captive rearing in zoos alters the environment and life of animals, causes stress, reduces resistance and may increase the incidence of diseases among them. In country-wide surveys on causes of mortality in free-living and captive felines as well as captive primates in India, Rathore and Khera (1981a, b) noted significant numbers of cases of worm infections. Mixed infections of *Fasciola* and amphistomes as well as haemonchosis and cestodiasis were among the causes of mortality in captive wild herbivores of Assam State Zoo during 1985-89 (Chakraborty and Chaudhury, 1996).

Rao and Acharjyo (1984) surveyed common diseases of captive wildlife at Nandankanan Zoo and found that helminth

parasitic diseases posed one of the major problems in different species. Chakraborty and Islam (1996) studied the prevalence of endo-parasitic infections in some free-living herbivores in Kaziranga National Park and found that 40.35% of the 171 faecal samples were positive for various species of helminth parasites. Maske *et al.* (1990) examined faecal samples of zoo animals of Maharaj Bag, Nagpur and based on morphology of eggs, found that helminths like strongyles and ascarid were present in mammals. Muraleedharan *et al.* (1990) surveyed the gastro-intestinal parasites of animals of Mysore Zoo and found that mammals has comparatively higher percentage of helminthic infection than birds.

Gaur *et al.* (1979) observed an apparent significance of helminthiasis in wild and zoo mammals in Uttar Pradesh and noted that a number of factors such as the variability of the moisture content of the faeces and the climatic conditions influence the incidence of infection. Faecal examination by Sarode *et al.* (1993) revealed that helminths such as ascarids, tapeworms and strongyles were present in carnivores in the Maharaj Bag Zoo and that the incidence was higher in winter, followed by summer and rainy seasons. Modi *et al.* (1997c) reported that age has significant influence on parasitic load only in the case of carnivores and not amongst herbivores.

Parasitic, particularly helminthic, infections are frequent under captive conditions (Rathore and Khera, 1981a) and is one of the major problem in wildlife health and management (Khan, 1979). However, Lall (1994) has stated that study of helminths in wildlife has not received due importance in our country and that such studies would help in providing information regarding helminthiasis in wildlife suggesting better means of control and also providing useful know-how for the control of the parasites in domestic animals, which in many cases share the parasites. Rajasekhariah *et al.* (1971) rightly pointed out that inadequate information with regard to diseases and parasites of zoo animals was a major limiting factor in preservation of the fast-disappearing game animals and development of zoological gardens.

The State Museum and Zoo, Thrissur (commonly called as Thrissur Zoo), was originally started in 1885 by Diwan Peshkar Sankarraiah at Viyyur near Thrissur as "Viyyur Park". Subsequently in 1912, the Museum was shifted to the now-existing place, Chembukkavu in Thrissur and modernised in 1914 with cages and enclosures in a total area of 4.5 hectares. At that time 7 species of mammals and one species of reptile were present. The number of visitors ranged at that time from 18000 to 22000 per annum. After the progressive establishment, now the zoo has 22 species of

mammals, 14 species of birds and 10 species of reptiles and the number of visitors exceeds 6 lakhs.

Information on parasites of wild animals in captivity in the Thrissur Zoo is meagre due to paucity of systematic investigations. So, a systematic study on the helminth parasites of mammals in the zoo was undertaken with the following objectives:

1. To elucidate the prevalence of helminth parasites among the different species of wild mammals in captivity.

2. To asses the influence of season and age as well as sex variations in the prevalence of helminthic infection.

3. To suggest measures for controlling the helminth parasites.

Review of Literature

Chapter - II

REVIEW OF LITERATURE

2.1 General health alterations in the zoo animals due to parasitic infections

In a survey on the prevalence of helminth parasites in wild and zoo animals in Uttar Pradesh, Gaur *et al.* (1979) reported that the clinical signs of parasitism were severe weakness, diarrhoea and dehydration in various wild animal species.

In country-wide wildlife surveys on causes of mortality in free-living and captive felines as well as captive primates, Rathore and Khera (1981a, b) noted significant numbers of worm infections.

Sleeman (1983) examined 57 deers (11 *Cervus elaphus*, 15 *Dama dama*, 3 *Cervus nippon* and 2 hybrids) in Ireland and recovered 9 species of helminths as also reported that *Spiculopteragia asymmetrica* was the most commonly occurring parasite in 4 species of deer but never in sufficient numbers to cause clinical disease.

Zuchowska (1988) reported that the most important nematodes in ruminants and camels at Lodz Zoo, Poland,

belonged to the families Trichostrongylidae, Trichuridae and Dictyocaulidae and that most infections were asymptomatic.

The prevalence and intensity of parasitic infections were investigated in 8 species of monkeys and 4 species of big feline predators (Pantherinae) kept in the Zoological Garden in Brno in the Czech Republic, during a 3 year period by Hartmannova (1989), who has reported that the important helminth parasites were *Trichuris trichiura* and *Enterobius vermicularis* in monkeys and *Toxascaris leonina* in the cats and has also stated that no deaths occurred due to parasitoses during the study period.

Maske *et al.* (1990) surveyed the helminth parasites of zoo animals of Maharaj Bag, Nagpur and reported that clinical symptoms like diarrhoea, dehydration as well as prostration were present in a variety of animals.

Muraleedharan *et al.* (1990) reported that the helminths and coccidia recovered from the wild animals of Mysore Zoo did not produce any alarming symptoms of disease but that a few animals such as tigers, lions and elephants had occasional diarrhoea. They also pointed out that though many helminthic or subclinical coccidial infections might not usually cause any immediate alarming signs, in the long run they might produce ill effects such as emaciation and weakness which would later be responsible for inviting other pathogens.

Heavy mortality among cervids (*Axis axis* and *Cervus unicolor*) due to *Paramphistomum cervi* was experienced during the hard summer of 1981 in Wildlife National Park, Ranthambore, Rajasthan, and the clinical signs were diarrhoea, anorexia and intense thirst. The inclement weather and inadequacy of natural feed were considered to be the main predisposing factors causing activation of the parasites leading to pathological effects (Arora, 1992).

Gogoi (1994) reported hookworm infestation in a tiger at Zoological Park, Itanagar and observed that the clinical signs comprised of lethargy, weakness and inappetance.

Clinical symptoms like diarrhoea, general malaise, lethargy, disinclination to move, dehydration, partial or complete anorexia and vomiting with or without expulsion of ascarids were observed by Maity *et al.* (1994) in a snow leopard (*Panthera uncia*) infested with *Toxocara cati*.

Thiruthalinathan *et al.* (1998) observed that wolves in Vandalur Zoo, Tamil Nadu showed symptoms like vomition, anorexia and debility due to *Spirometra* infections.

2.2 Prevalence of helminthic infections among zoo mammals

2.2.1 Determination by faecal examination

Raquib *et al.* (1972) examined 165 faecal samples belonging to 28 species of animals in the State Zoo, Guwahati, Assam, India and found that 18 genera of helminths were present in these animals.

Out of 31 species of mammals and 45 species of birds respectively in the Zoological Garden, Lucknow, Chauhan *et al.* (1973) examined fresh faecal samples of 25 mammals and 21 birds and found that the helminthic infections commonly encountered in mammals comprised of bursate worms in wild Bovidae and in species of Cervidae, toxascarids, hookworms and whipworms in species of carnivores and whipworms in species of primates. Subsequently, they also examined 21 mammals and 26 birds (out of 35 and 63 species respectively) at Delhi Zoo and found similar infections as present in Lucknow Zoo.

Hiregoudar (1976) reported that the faecal examination of *Cervus unicolor* and *Gazella gazella* in Gir Forest of India revealed the eggs of *Trichuris* sp. and *Trichuris* sp. as well as trichostrongylid respectively.

Lim and Lee (1977) reported that 36.1 per cent of 1,104 wild animals in Korean Zoo harboured parasites. They also

observed that *Toxocara* was found in lion, puma and leopard; *Toxascaris leonina* in lion and tiger; *Ancylostoma* in lion, puma, leopard and bear; *Trichuris* in leopard, fox and monkey; *T. ovis* in deer and camel; *Dibothriocephalus* in leopard, wolf and wild cat; *Physaloptera* in leopard and monkey; *Spirocerca* and *Capillaria aerophila* in fox; *C. contorta* and *C. caudinflata* in birds; *Paragonimus kellicotti* in fox, raccoon and raccoon dog; ascarids in jackals and bears; *Echinococcus granulosus* in jackals; *Metastrongylus apri* and *Oesophagostomum* sp. in bears; *O. radiatum* in deer; *O. venulosum* in goral and Barbary sheep; *Mecistocirrus digitatus*, *Paramphistomum*, *Bunostomum phlebotomum* and *Fasciola hepatica* in deer; *Marshallagia* and *Nematodirus* in bison; *Parascaris equorum* in Zebra; *Moniezia* in goral and Barbary sheep and ascarids, *Heterakis* and *Hymenolepis* in birds.

Baylisascaris transfuga eggs in the faeces of 59 of 92 bears and hookworm larvae in that of one have been reported by Manville (1978) in Wisconsin,USA.

Pandey (1978) studied 191 faecal samples from zoo animals in Lubumbashi, Zaire and reported that 58 (30.3%) samples contained helminth eggs. He also observed that ascarid eggs were present in one of 2 *Felis concolor*, one tiger and all of 5 lions and strongylid eggs in one of 3 *Vulpes vulpes*, 3 of 4 *Selenarctos tibetanus*, *Pan satyrus* and monkeys and that

Enterobius ova were found in 2 of the chimpanzees. *Trichuris* in 24 of the monkeys and *Strongyloides* in 4 of the monkeys.

Gaur *et al.* (1979) in a survey on the prevalence of helminth parasites in wild and zoo animals in Uttar Pradesh, examined faecal samples of 211 animals and reported that 96 (45.49%) animals were having helminths, the commonly prevalent species being *Haemonchus contortus*, *Oesophagostomum* sp., strongyles, *Toxascaris leonina*, *Fasciolopsis buski* and *Fasciola gigantica* in a variety of mammals.

Khan (1979) examined the faecal samples of wild animals of the Nehru Zoological Park, Hyderabad and found that the important helminths were strongyles, trichostrongyles, *Ascaris*, *Toxocara*, *Trichuris*, *Fasciola*, amphistome and *Moniezia* in herbivores; strongyle, *Trichuris*, *Ascaris*, *Oxyuris* and *Ancylostoma* in omnivores and *Toxascaris*, *Toxocara*, *Ascaris*, *Ancylostoma*, *Diphyllobothrium*, *Fasciola* and *Opisthorchis* in carnivores.

Hansel and Ruscher (1980) examined the faeces of 369 wild cats in Germany and observed that 72.6 per cent were infected with parasites, including *Toxocara* sp. (64.8%), hookworm (11.7%), *Capillaria* sp. (3.81%), *Trichuris vulpis* (1.4%) and *Taenia* sp. (3.0%).

Lakshmanan and Joseph (1980) reported the incidence of *Toxascaris leonina* and *Ancylostoma caninum* in circus lions in Madras by faecal examination.

The ova of helminth parasites from sick, moribund and a few healthy zoo animals (74) in Nigeria were identified and the genera *Ancylostoma*, *Bunostomum*, *Trichuris*, *Strongyloides*, *Echinococcus* and an unidentified cestode were observed (Bamidele and Ogunrinade, 1980).

Geraghty *et al.* (1982) studied 1822 fresh faecal samples from 48 mammals and 4 birds at the Zoological Gardens, Dublin, Irish Republic and found that helminth eggs were present in 171 samples (9.6%) and also that 95 per cent of the infected samples were from carnivores and herbivores. Persistent ascarid burdens were noticed in *Panthera uncia* and *P. pardus* and a high incidence of bursate worm eggs in herbivores.

Examination of a group of 125 animals from South West Africa, including various species of zebra antelopes, gazelles and monkeys destined for zoos and parks by Quesada and Maggio (1982) revealed infection with *Parascaris*, *Oxyuris* and *Strongylus* in zebras; *Haemonchus*, *Nematodirus*, *Trichuris* and *Paramphistomum* in antelopes and gazelles and *Strongyloides* in monkeys.

Saad *et al.* (1983) examined 184 faecal samples from 44 species of wild animals and birds kept at Khartoum Zoo, Sudan, for helminth and protozoan parasites and observed that 20 of the 44 species (45%) harboured parasites. They also reported the presence of 4 genera of helminths in *Panthera leo*, 2 in *Cercopithecus aethiops* as also *Panthera tigris* and *Diphyllobothrium* sp. in *Panthera leo* and *Hyaena hyaena*.

Faecal sample examination of 11 felid species such as *Panthera*, *Felis* etc. in the Madrid Zoo revealed the helminth infections to be *Toxascaris leonina* and *Strongyloides* sp. (Diego *et al.*, 1984).

In a case of parasitic gastritis in an Asian lion, Tanwar *et al.* (1984) observed the eggs of *Toxascaris leonina* and *Toxocara cati* by faecal examination and also reported that the eggs of *Toxascaris leonina* were slightly oval, with smooth shells and measured 75.35 to 90.43 μ in length and 60.28 to 75.35 μ in width while the eggs of *Toxocara cati* measured 75.35 μ in diameter.

Mandal and Choudhury (1985) have examined faecal samples from *Panthera tigris* in the Sundarbans Forest India and observed ova of *Toxocara cati*, *Gnathostoma spinigerum* and *Troglotrema* sp.

Faecal examination of 63 ponies in the Island of Skyros revealed *Strongylus* sp. eggs in 60 and *Triodontophorus* as well as *Trichonema* sp. eggs in 3 animals (Kinis *et al* 1985).

Ramasamy *et al.* (1985) studied the faecal samples of 197 *Axis axis* from 3 National Parks (Dudwa and Corbett in Uttar Pradesh and Tadoba in Maharastra) in India and reported that 61 animals (30.96%) were positive for *Muellerius* infection.

During the year 1969-1973 an extensive investigation for the parasites of wild mammals and birds was carried out by testing blood and stool samples in the clinical laboratory of Delhi Zoological Park and the identifications of the parasites were mostly done upto the level of genus (Adkoli *et al.*, 1986). It was observed that strongyle, *Strongyloides* and *Trichuris* were present in Artiodactyla; *Strongyloides* in Perrissodactyla and Proboscidea; *Strongyloides* and *Trichuris* in Primates and *Strongyloides*, *Ascaris* and hookworms in Carnivora.

Khan (1987) examined 143 wild cats (*Felis chaus*) and 24 domestic cats in Lucknow and reported that all the animals were infected with helminths; trematodes were present in 13.3 per cent of wild cats and 8.3 per cent of domestic cats; nematodes in 44 per cent and 25 per cent and cestodes in 97.2 and 66.7 per cent respectively. *Dipylidium*, *Joyeuxiella* and

Ancylostoma were the most prevalent parasites and multiple infections were common.

Endoparasites were present in 39.6 per cent of faecal samples from deer from Taiwan. *Haemonchus contortus, Trichostrongylus colubriformis, Strongyloides papillosus* and *Oesophagostomum* sp. were the most common gastro-intestinal nematodes found; 4 other species of nematodes, 2 species of trematodes and one species of cestode were also found. Prevalence was significantly higher in winter and in young deer than in older as also in red and axis deer than in sambar (Su and Lee, 1987).

Arora and Das (1988) observed the eggs of *Trichuris* sp. and *Paragonimus westermanii* in the intestinal contents of a tigress at Corbett National Park.

A monthly study of the prevalence of helminths in some mammals and birds was carried out between January to December 1988 at the AOC Zoological Garden, Ankara, Turkey, by examining faecal samples of 45 carnivores, 38 herbivores and 14 omnivores. Omnivores had the highest infection rate with 50% being parasitized, while herbivores and carnivores had infection rate of 39.4 per cent and 28.8 per cent respectively. The main helminths detected among carnivores were *Toxocara canis, T. cati, Toxascaris leonina, Uncinaria* sp., *Strongyloides* sp., *Taenia* sp. and *Dipylidium caninum;*

among herbivores Trichostrongylidae species *Muellerius capillaris*, *Cystocaulus ocreatus*, *Protostrongylus* sp. and *Passalurus ambiguus* and among omnivores *Trichuris* sp., *Strongyloides* sp. and *Enterobius* sp. (Tigin *et al.*, 1989).

Salman and Shah (1989) have studied the prevalence of gastrointestinal nematodes in large cats kept at the Lucky Irani Circus and the Lahore as well as Bahavalpur Zoos in Pakistan by examining faecal samples from 61 animals including lions, leopards and tigers and observed that 56 animals (91.80%) were positive for helminthic infection with overall prevalences of 87.5 per cent, 83.7 per cent and 27.9 per cent for *Toxascaris leonina*, *Toxocara canis* and *Ancylostoma braziliense* respectively.

In a survey of parasitic infections in Bombay zoo, Niphadkar *et al.* (1989) reported that 36.79 per cent of carnivores and 15.2 per cent of herbivores were infected and also that the tigers, cats, leopards, jackals, hyaenas and foxes were infested mainly with *Toxocara*, hookworms and *Spirometra* sp. and the ruminants with strongyle infections predominantly, followed by amphistome and *Trichuris* sp.

Muraleedharan *et al.* (1990) surveyed the gastrointestinal parasites of animals of Mysore Zoo and found that mammals had comparatively higher percentage of helminthic infection (31.10%) than birds (25%). They also reported that the

prevalence and the intensity of ascarid infection was high in tigers and lions and that strongylids, *Trichuris*, *Ancylostoma*, amphistome, *Fasciola*, *Enterobius* and cestodes were also observed in a variety of mammals.

Maske *et al.* (1990) examined faecal samples of 28 zoo animals of Maharaj Bag, Nagpur and reported that 17 animals were found positive for parasitic infections. Based on the morphology of eggs, they also found that toxascarids, *Ancylostoma*, *Paragonimus* and *Taenia pisiformis* occurred in lions and tigers, *Ancylostoma* in leopard and ascarid sp. in lion cubs.

Hasslinger *et al.* (1992) examined faecal samples from carnivores kept in Zoological Gardens in Egypt and Germany. At Giza, 27 of 52 (51.9%) animals were infected with endoparasites and only 8 of 36 (22.2%) animals were infected at Munich.

Lu *et al.* (1992) surveyed the helminths of 21 carnivorous animals of 11 species in the Hefei City Zoo, Anhui, China during April and May, 1989 by examining fresh faecal samples and observed that the overall prevalence of infection was 95.2 per cent. They also found that the highest prevalence of infection was caused by hook worms (76.2%) followed by *Paragonimus westermanii* (66.7%) and *Spirometra mansonoides* (47.6%).

The results of faecal examination of primates, herbivores and carnivores representing mammals of Bannerghatta National Park, Bangalore revealed that *Ascaris*, strongyle and *Trichuris* sp. representing the nematode infection (75.1%) was predominant followed by mixed infection of nematodes and coccidia (16.6%) and coccidia (8.3%). Infections in the order of prevalence were ascarids (33.4%), ascarids and strongyle (22.3%), strongyle (11.1%), ascarids and coccidia (11.1%), *Trichuris* sp. (8.3%), coccidia (8.3%) and strongyle and coccidia (5.5%). It was also observed that 41.66 per cent of primates, 43.39 per cent of herbivores and 40.00 per cent of carnivores had helminthic infections (Reddy *et al.*, 1992).

Faecal examination detected *Neoascaris vitulorum*, *Cooperia* and *Haemonchus contortus* in 8 bison, *Strongyloides*, *Camelostrongylus mentalis* and *Moniezia expansa* in a bactrian camel, the latter 3 species and *Oesophagostomum columbianum* in 6 dromedaries and *Fasciola gigantica*, *Trichostrongylus axei* and *Strongyloides* in llamas (Pavlovic *et al.*, 1992).

Periodical stool examination of 8 lions and 4 leopards during the period 1985-1990 and of 2 tigers during 1988-1990 maintained at Maharaj Bag Zoo, Nagpur, revealed that in lion 97 (61%) of 159 stool samples, in leopards 54 (60%) of 90 samples, and in tiger 7 (33.3%) of 21 samples were positive for helminthiasis, caused mainly due to ascarids, *Ancylostoma*

and mixed infections of *ascarids*, *Ancylostoma*, tape worms and *Strongylus* (Sarode *et al.*, 1993).

During routine clinical examination of lesser cats at Nandankanan Biological Park, Orissa, Rao and Acharjyo (1994) found various species of *Ancylostoma*, *Spirometra*, *Toxascaris*, *Toxocara*, *Taenia*, *Euparyphium* and *Oncicola*.

Microscopic examination of faecal samples from 81 different species of carnivores at the Giza Zoological Gardens, Egypt revealed among other things *Toxascaris leonina* eggs in 8.64 per cent (Siam *et al.*, 1994).

Gogoi (1994) detected hookworm eggs in a tiger at Itanagar Zoological Park, which revealed clinical signs of hook worm infection.

Maity *et al.* (1994) have reported that eggs of *Toxocara cati* were found in the faeces of 5 captive snow leopards maintained at Padmaja Naidu Himalayan Zoological Park, Darjeeling with clinical signs including diarrhoea, lethargy, dehydration and vomition.

Chakraborty and Islam (1996) surveyed the gastrointestinal parasitic infections in some free-living herbivores in Kaziranga National Park, Assam by examining 171 faecal samples and found that 40.35 per cent of the animals were positive for parasitic infections and also observed that

the helminth ova comprised of *Paramphistomum Fasciola*, strongyle, *Trichuris*, *Oesophagostomum*, *Strongyloides*, *Ascaris* and cestodes.

Panda and Pal (1996) have examined the faecal samples of 53 monkeys (*Macaca radiata*) at monthly interval over a period of one year at zoological garden, Alipore, Calcutta and observed that the maximum association of *Balantidium coli* was with *Entomoeba coli* and *Trichuris trichuris* followed by other parasitic infections like *Ancylostoma duodenale*, *Ascaris lumbricoides* and *Entomoeba histolytica*.

Gupta and Yadav (1997) studied the amplitude of parasitic infections in pony mares in Tarai Area of Uttar Pradesh by examination of faecal samples and blood smears. They reported that *Strongylus* sp. dominated in the rate of infection with 64.52 per cent followed by *Gastrodiscus aegyptiacus* with 30.90 per cent and *Trichonema* with 17.74 per cent. They also recorded helminths such as *Trichostrongylus*, *Strongyloides westeri*, *Dictyocaulus arnfieldi*, *Parascaris equorum* and *Oxyuris equi* as well as the larvae of *Strongylus equinus*, *S. edentatus*, *S. vulgaris*, *Gyalocephalus*, *Triodontophorus* and *Oesophagostomum*.

During a survey of gastrointestinal parasites of dromedary camels in Gassim Region, Saudi Arabia, Magzoub *et al.* (1997) found the presence of strongyle-type,

Nematodirus and *Strongyloides* eggs, trophozoites and cysts of *Balantidium* and oocysts of *Eimeria* and also reported that the general incidence of infection ranged from 62 to 90 per cent.

Faecal examination of 8 carnivorous animals from Sanjay Gandhi Zoological Park, Patna, and Jawaharlal Nehru Biological Park, Bokaro Steel City revealed nine species of endoparasites from lion, tiger, leopard, clouded leopard, golden cat, fishing cat, leopard cat, jungle cat, khikhir, khatash, wolf, hyaena and bear with the prevalence rate of 33.33 per cent, 62.50 per cent, 53.85 per cent, 75.00 per cent, 100.00 per cent, 50.00 per cent, 50.00 per cent, 0.00 per cent, 33.33 per cent, 0.00 per cent, 100.00 per cent, 25.00 per cent and 70.00 per cent respectively. The parasites identified were *Ascaris* sp., *Ancylostoma* sp., *Trichuris* sp., *Strongyloides* sp., *Taenia* sp. and *Fasciola* sp. in the percentages of 33.75, 18.75, 1.25, 2.50, 2.50 and 1.25 respectively (Modi *et al.*, 1997a).

Incidence of *Spirometra* was detected in certain wild carnovores in Arignar Anna Zoological Park, Madras, during routine faecal examination; the ova of the parasites were detected in one out of 6 lion samples, one of 3 tiger samples, one of 2 wolf samples and 2 of 8 panther samples (Thiruthalinathan *et al.*, 1998).

Varadharajan and Pythal (1999) studied the incidence of gastro-intestinal parasitism in free living, feral Bonnet

Macaques (*Macaca radiata* L.) in Tamil Nadu and found that 90 per cent of 32 animals had helminthic infections. It was also observed that strongylids, *Strongyloides* and ascarids were the major infections.

2.2.2 Determination by post-mortem examination

Ramanujachari and Alwar (1955) conducted a post-mortem of 5 monkeys (*Macacus* sp.) in Madras and collected a few number of *Oesophagostomum apiostomum* from nodules in the large intestines especially the caecum and colon besides a fair collection of *Trichuris*. One of the monkeys revealed gross lesions in the liver, spleen and lungs with multiple hydatids of the size of a gooseberry.

Patnaik (1964) recovered *Haemonchus contortus* from the abomasum of a blackbuck in Baranga Zoo, Orissa, India.

Rao and Acharjyo (1972) reported that the incidence of fascioliasis was about 50 per cent and 60 per cent in spotted deer and blackbuck respectively at Nandankanan Zoo but the other wild ungulates like sambar, barking deer, four-horned antelope and nilgai were not affected although they were housed within same fencing adjacent to a canal and the source of grass supply remained the same, which was apparently the source of infection.

Chauhan *et al.* (1973) have reported the helminths like *Gastrothylax* and *Ancylostoma braziliense* in a spotted deer and wolves respectively at Lucknow Zoo.

Examination of whole carcasses of 12 wild cats in Slovenia, Yugoslavia revealed *Toxascaris leonina* in 2, *Toxocara cati* in 8, *Ollulanus tricuspis* in 2, *Taenia taeniaeformis* in 10 and *Mesocestoides lineatus* in 2 animals (Brglez and Zeleznik, 1976).

In a zoo in the German Democratic Republic, no helminths were found in *Loxodonta africana* but *Fasciola jacksoni* and *Pfenderius* sp. were found in *Elephas maximus*, *Ostertagia mentulata*, *Haemonchus contortus* and *Nematodirus spathiger* in *Antelope cervicapra* and *Ostertagia* sp. and *Oesophagostomum* sp. in *Cervus canadensis* (Petersen, 1977).

Addison *et al.* (1978) examined 148 *Ursus americanus* in Canada for helminth parasites and found that 83 animals were infected with helminths of which 2 contained *Taenia krabbei*, 1 *Alaria americana*, 20 *Baylisascaris transfuga*, 21 *Crenosoma* sp. and 1 *Trichinella* sp.

Dies (1979) reported that helminths were found in 69 of 91 *Ursus americanus* from North-Western Alberta, Canada; *Baylisascaris transfuga* was present in the large and small intestines of 56 animals and gravid *Taenia krabbei* and

T. hydatigena in small intestine of 10 and 3 animals respectively.

Ashizawa *et al.* (1979) recovered the lung fluke, *Paragonimus ohirai* from cysts in the lungs of *Sus scrofa leucomystax* in Miyazaki Prefecture, confirming that the wild boar was a natural host for *P. ohirai*.

Examination of 238 wild boars shot in Belorussian SSR revealed *Metastrongylus*, *Ascaris*, *Trichinella*, *Physocephalus*, *Macrocanthorhynchus*, *Dicrocoelium*, *Alaria*, *Cysticercus teunicollis* and *Echinococcus* (Litvinov and Zen'-Kov, 1979); it was concluded that wild boars could act as reservoirs of these parasites for domestic swine.

Agrawal and Ahluwalia (1980) have reported *Gastrothylax crumenifer* in a sambar (*Cervus unicolor*) died at Zoological Garden, Jaipur.

Pillai *et al.* (1981) reported the nematode *Cylicospirura subaequalis* from 2 tumour-like growths on the stomach wall of a dead *Felis chaus* in Kerala.

Hafeez *et al.* (1983) reported the amphistome, *Gastrothylax crumenifer* in a spotted deer for the first time in Andra Pradesh, India.

Presidente (1984) has listed the helminths like *Fasciola hepatica*, *Orthocoelium streptocoelium*, *Oesophagostomum venulosum*, *Trichostrongylus axei*, *Ostertagia* sp. and *Spiculopteragia asymmetrica* from *Cervus unicolor* in Australia and NewZealand.

Agrawal *et al.* (1986) have reported the occurrence of aortic lesions due to *Spirocerca lupi* infection in jackals at Mathura, Uttar Pradesh.

Somvanshi *et al.* (1987) reported adult *Toxocara* sp. from the stomach of a leopard from Ramgarh, India.

Padhi *et al.* (1987) reported large number of amphistomes like *Paramphistomum cervi*, *Gastrothylax crumenifer* and *Fischoederius elongatus* in the rumen of an *Axis axis* which died at Nandankanan Zoo, Orissa.

Large number of *Camelostrongylus mentulatus* and some specimens of *Nematodirus spathiger* as well as *Haemonchus contortus* were collected from the abdomen and small intestine during post-mortem of a male blackbuck that died at the Edinburgh Zoo (Flach and Sewell, 1987).

Five species of lung nematodes (*Metastrongylus asymmetricus*, *M. confusus*, *M. elongatus*, *M. pudendotectus* and *M. salmi*) and 2 species of stomach nematodes (*Ascarops*

strongylina and *Physocephalus sexulatus*) were found in wild boars (*Sus scrofa*) in France (Humbert and Henry 1989).

Cheema *et al.* (1992) examined 96 wild boars hunted near Faisalabad, Pakistan and reported that 66 (69%) were infested with endoparasites. These included *Ascaris suum* in 11 animals, *Metastrongylus apri* in 12, *Paragonimus westermanii* in 10, *Necator* sp. in 3, *Bourgelatia diducta* in 6, *Ascarops strongylina* in 4 and *Fasciolopsis buski* in 10; 3ρ animals had mixed infections with nematodes and trematodes.

Pythal *et al.* (1993) had reported the death of a wild Indian leopard in Kerala due to heavy infections with the lung fluke *Paragonimus westermanii* and the hook worm *Galonchus perniciosus.*

Lall (1994) reported that helminthic infections in hippos were apparently not uncommon but the records were few and perhaps none in India where hippos were found only in zoological gardens. He also found helminths like *Fasciola gigantica, F. hepatica* and paramphistomes in a hippo shot dead in Kimma, Keffa, Ethiopia.

Chakraborty *et al.* (1994) reported the parasites found at post-mortem in 214 captive wild herbivores of 3 orders (Artiodactyla, Perrissodactyla and Proboscidea) in Assam State Zoo, India and also observed that the common nematodes

recovered were *Haemonchus*, *Ascaris*, *Gongylonema*, *Trichostrongylus*, *Oesophagostomum*, *Setaria*, *Dioctophyma*, *Cooperia*, *Onchocerca*, *Trichuris*, *Kiruloma*, *Chabertia*, *Necator*, *Bunostomum*, *Dictyocaulus*, *Habronema*, *Choniangium* and *Grammocephalus*; the trematodes were *Fasciola*, *Paramphistomum*, *Gastrothylax*, *Fischoederius*, *Carmyerius*, *Cotylophoron*, *Gigantocotyle*, *Homologaster*, *Pseudodiscus*, *Pfenderius* and *Brumptia* while the cestodes were *Moniezia*, *Anoplocephala*, *Echinococcus* and *Taenia*.

Varma *et al.* (1996) have collected the helminth parasites *Gigantocotyle explanatum*, *Moniezia expansa* and *Trichuris ovis* from the digestive tract of a blackbuck which died in Van Prani Udyan, Wildlife Conservation Management and Surveillance Unit at Indian Veterinary Research Institute, Izatnagar.

Magzoub *et al.* (1997) observed the gastro-intestinal tracts, liver, lungs and kidneys of 240 young and adult Najdi camels slaughtered in different abattoirs in Gassim Region, Saudi Arabia and recovered the helminths like *Haemonchus longistipes*, *Nematodirus spathiger*, *N. dromedarii* *Parabronema skrjabini*, *Camelostrongylus mentulatus*, *Trichostrongylus probolurus*, *Trichuris globulosa*, *Physocephalus sexulatus*, *P. cristatus*, *Moniezia expansa* and *Stilesia vittata*.

During post-mortem examination of a tiger at Nehru Zoological Park, Hyderabad, Rao and Singh (1998) observed the

tape worm, *Diphyllobothrium latum* in the deodenum and jejunum and in addition, also noted a taeniid species which possessed rostellum with hooks.

Amrithraj *et al.* (1999) recovered 58 mature and nearly mature echinostomes, *Artyfechinostomum malayanum* from the intestine of a small Indian civet (*Viverricula indica*) in Trichur, Kerala.

2.3 Variation in the prevalence of helminthic infections

2.3.1 Seasonal variation

During a survey of parasitic infections among wild mammals and birds at Lucknow Zoo, Chauhan *et al.* (1973) found that many mammals were having helminth infections and also observed that the highest incidence of these infections was generally present during rainy and winter seasons.

Mirck (1978) reported that in Utrecht, The Netherlands, strongylid eggs in horses and ponies were found in 52.4 per cent in April, 65.2 per cent in August and 50.7 per cent in October.

Pandey (1978) had examined 191 faecal samples from zoo animals in Lubumbashi, Zaire in 1974 and 1975 and found that

the level of helminthic infections was higher in July than January of both years.

Su and Lee (1987) had examined faecal samples from deer in Taiwan and observed that the prevalence of infection with endoparasites was significantly higher in winter than in summer and autumn.

In a survey of parasitic infections in Bombay Zoo, Niphadkar *et al.* (1989) reported that 36.79 per cent of carnivores and 15.2 per cent of herbivores were infected and also that the seasonal variation of the incidene of *Toxocara* sp. and hook worms in March was 45.8 per cent; in July, 12.5 per cent; in August, 20 per cent and in other months 4.8 per cent.

Maske *et al.* (1990) reported that in Maharaj Bag Zoo, toxascarids and *Ancylostoma* infections were commonly encountered in lions and tigers in rainy and winter seasons, followed by *Paragonimus westermanii* and *Taenia pisiformis* seen during winter season.

Sarode *et al.* (1993) examined faecal samples of 8 lions, 4 leopards and 2 tigers of Maharaj Bag Zoo, Nagpur and found that in lions and tigers incidence of parasitism was higher in winter (October-January) followed by summer (February-May) and rainy seasons (June-September) but that in leopards, the

infection rate was higher in summer season followed by winter and rainy seasons.

Gupta and Yadav (1997) studied the seasonal incidence of parasites in pony mares at Tarai Area of Uttar Pradesh and found that *Strongylus* sp. dominated in the rate of infection with highest of 64.52 per cent in winter followed by *Gastrodiscus aegyptiacus* with 30.90 per cent in summer and *Trichonema* sp. with 17.74 per cent in winter.

Season-wise prevalence of parasitic infection in various species of herbivorous animals in the Sanjay Gandhi Zoological Park, Patna and the Jawaharlal Nehru Biological Park, Bokaro Steel City was higher in all the seasons i.e., monsoon, winter, spring and summer seasons as compared to carnivorous animals. Statistical analysis revealed no significant effect of season on the prevalence of parasites both in carnivorous and herbivorous animals. Cent per cent parasitic infection was observed in elephant, capped langur, golden cat and wolf. All the other animals showed infection rates varying from 12.5 to 75 per cent. The infection rate was found to be constant throughout the year in both herbivorous and carnivorous animals. However, the highest percentage of infection in rhinoceros, mithun, blackbuck, spotted deer, tiger and bear was found more in monsoon, whereas in sambar, golden langur, clouded leopard and leopard it was in winter and in monkey in summer. There was no specific period during the year when the

infection rate in a particular species of wild animals became abnormally high which might be due to the fact that most of the herbivorous and carnivorous animals maintained under captivity were stall fed and once they acquire infection through food and water they remain infected for most part of the year irrespective of seasonal variation (Modi *et al.*, 1997b).

Magzoub *et al.* (1997) examined 1200 fresh faecal samples obtained from Najdi camels in Gassim Region of Saudi Arabia and observed that the incidence of infection ranged from 62 per cent to 90 per cent. They also reported that high incidence of infection with strongyle-type and low incidence with *Nematodirus* were observed during rainy season and that the reverse during the dry season.

Bhat and Manickam (1998a) studied the intensity of gastro-intestinal nematode infections in sambar (*Cervus unicolor*) during different seasons at J. Jayalalitha Wildlife Sanctuary, Mudumalai, Guindy Childrens' Park and Arignar Anna Zoological Park, Madras and found that the means of egg per gram of nematode infections were not significant between seasons and parks. The season-wise mean eggs per gram in sambar during different seasons in different study area varied from 4 ± 1.63 in summer to 22 ± 3.27 in winter in Arignar Anna Zoological Park, from 11 ± 2.78 in summer to 27 ± 5.39 in winter in Guidy Childrens' Park and from 4 ± 2.22 in summer to

24 ± 4.76 in south west monsoon in J. Jayalalitha Wildlife Sanctuary.

Bhat and Manickam (1998b) studied the seasonal variation in parasitic burden in spotted deer (*Axis axis*) in different sanctuaries in Tamil Nadu and reported that the mean eggs per gram of gastro-intestinal nematodes varied from 2 ± 1.33 to 32 ± 4.42 during different seasons in different study areas. It was also observed that the egg counts were generally high in free-living animals at J. Jayalalitha Wildlife Sanctuary, Mudumalai and Guindy National Park, Madras as compared to captive animals at Arignar Anna Zoological Park and Guindy Children's Park, Madras where regular deworming was followed.

2.3.2 Age variation

Mirck (1978) has examined 3791 faecal samples of horses and ponies in Utrecht, The Netherlands and reported that *Strongyloides westeri* eggs were found in 56.4 per cent of foals aged less than 6 months and in 12.3 per cent of those aged 6-12 months. He also observed that the eggs of *Oxyuris equi* or larvae of *Dictyocaulus arnfieldi* were not found in animals over 10 years and that the eggs of *Parascaris equorum* were found in animals upto 15 years old.

Humbert and Henry (1989) studied the prevalence of lung and stomach nematodes in wild boars and observed 92 per cent

and 97 per cent rates respectively. They also reported that in both cases, intensity of infection was significantly greater in young wild boars less than one year age than in the older animals.

Salman and Shah (1989) stated that the severity of gastro-intestinal nematode infections was more in the Lucky Irani Circus than in the Lahore and Bahawalpur Zoos in Pakistan, probably due to more conducive conditions for parasitic infections in lion cubs than in adults, reflecting an age-dependant prevalence.

The influence of age on the parasitic load in both herbivorous and carnivorous zoo animals in Sanjay Gandhi Zoological Park and Jawaharlal Nehru Biological Park in Bihar was studied by Modi *et al.* (1997c); the adult animals were found to carry higher infection (47.89% in herbivorous and 57.81% in carnivorous animals) as compared to their young counterparts (44.12% in herbivorous and 18.75% in carnivorous animals). It was also observed that age had significant influence on the parasitic load only in the case of carnivores and not amongst herbivores.

2.3.3 Sex variation

Conti *et al.* (1983) have reported that among black bears in Florida, USA the intensities of helminthic infections were significantly higher in male animals.

Delahay *et al.* (1998) reported that the prevalence of infection with *Toxocara cati* was significantly higher in female cats of wild type.

Influence of sex on the prevalence of parasitic infections among zoo animals of Bihar revealed that the average infection rate was higher in males in both herbivorous (50.00%) and carnivorous animals (58.54%) as compared to that of females of both groups of animals i.e., 44.26 per cent and 41.03 per cent respectively. But on statistical analysis this difference was found to be non-significant. Males of rhinoceros, mithun, nilgai, spotted deer and golden langur were found to be infected more than their relevant female counterparts. However, in case of blackbuck sambar and monkey, females were more infected as compared to males (Modi *et al.*, 1998).

2.4 Treatment for helminthic infections in zoo mammals

Kageruka and Puijenbroeck (1967) reported that a single oral or parenteral dose of Tetramisole (1.5 mg/kg body weight) was effective in lions, tigers, leopards, jaguars, pumas and foxes against *Toxascaris* sp., *Toxocara* sp. and *Ancylostoma* sp. but not effective against *Trichuris* sp.

Chandrasekharan *et al.* (1970) reported that Thiabendazole at 50 mg/kg body weight orally was 100 per cent effective in treating camels which had *Trichostrongylus* infection but was not effective in *Trichuris* infection.

Chandrasekharan *et al.* (1971) reported that Helmatac Premix at a dose rate of 20 mg Parbendazole per kg body weight was 100 per cent effective against natural infection of *Trichostrongylus* sp. in camel, *Haemonchus contortus* and *Strongyloides* sp. in Nilgiri Tahr kids and about 50 per cent effective against *Trichuris* sp. in Nilgiri Tahr kids. It was observed that the drug was ineffective against *Moniezia* and amphistomes in Nilgiri Tahr.

Nilverm at a dose rate of 15 mg Tetramisole per kg body weight was 100 per cent effective against *Trichostrongylus colubriformis* as well as *Impalaia* sp. in camel and *Haemonchus contortus* in Nilgiri Tahr and ineffective against amphistomes of Nilgiri Tahr (Chandrasekharan *et al.*, 1972).

Chandrasekharan *et al.* (1973) conducted clinical trials with Banminth II at a dose rate of 10 mg of Morantel tartrate per kg body weight against naturally occurring infections of gastro-intestinal nematodes of two Nilgiri Tahr kids, one nilgai calf, one wild pig, one camel, one lion cub and one zebra and reported that the drug was 100 per cent effective against *Trichostrongylus colubriformis* of Nilgiri Tahr kids,

camel and nilgai calf and *Toxascaris leonina* of lion cub; 96.77 per cent effective against *Oesophagostomum* sp. of wild pig and 40 per cent and 48 per cent respectively against *Trichuris* sp. of male Nilgiri Tahr kid and *Trichuris globulosa* of camel.

Dollinger and Ruedi (1974) reported that Mebendazole at 40 mg/kg body weight for 5 successive days was 97-100 per cent effective against *Trichuris* infections in monkeys and also that Levamisole by mouth was highly effective against *Strongyloides stercoralis* as well as *S. fuelleborni* and satisfactory against *Trichuris* infections.

Movchan and Veselova (1975) listed the antihelmintics used at the Sukhumi Primate Centre, Moscow, USSR and reported that Diethylcarbamazine phosphate at 1, 5 or 20 mg/kg body weight were effective for microfilariae, *Oesophagostomum*, *Strongyloides* and *Ancylostoma*; Thiabendazole at 25 or 100 mg/kg for *Strongyloides*, *Ancylostoma* and *Oesophagostomum* and Tetramisole (Nilverm) at 1, 5 or 15 mg/kg for the nematodes already mentioned as also *Acanthocephalus*.

Forstner *et al.* (1976) studied the efficacy and safety of Mebendazole in zoo ruminants at the Hellabrunn Zoo, Munich for 3 years and reported that a daily dose of 5 mg/kg body weight for 14 days for ruminants was effective against *Trichuris*, *Capillaria*, *Protostrongylus* and strongyles.

Krait *et al.* (1977) reported that Tetramisole at 10-15 mg/kg body weight was highly effective against nematodes (Trichocephalidae, Capillariidae, Trichstrongylidae and Strongylidae) in deer in Voronezh National Park, USSR.

Methyridine 90% injectable solution (1 ml/4.5 kg body weight) subcutaneously and Morantel Tartrate 4% (1 ml/4 kg body weight) orally were highly effective against mixed infection of *Trichuris*, *Haemonchus*, *Nematodirus* and *Strongyloides* as also against single infection of *Trichuris* in camels. Tetramisole Hydrochloride 3% (0.5 ml/kg body weight) orally was next in the order of merit but Thiabendazole (90 mg/kg body weight) did not give encouraging results (Lodha *et al.*, 1977).

Enigk and Dey-Hazra (1978) tested Febantel (Rintal) against gastro-intestinal nematodes in various wild even-toed ungulates, solipeds and carnivores and reported that adult strongylids (except hook worms) were eliminated from wild ruminants by a single dose of 5.0 mg/kg body weight and from dromedaries by 7.5 mg/kg; adult hook worms in wild felids by 3x10 mg/kg on 3 successive days and *Toxascaris* as well as *Toxocara* infections of wild felids by 10 mg/kg.

Eriksen (1978) reported that recommended doses of Mebendazole against cestodes in zoo animals in Denmark were 5-10 mg/kg body weight over 5 successive days for primates; 15

mg/kg body weight over 2 successive days for carnivores and 15 mg/kg on 2 successive days for Artiodactyla.

Ramisz *et al.* (1978) reported that Fenbendazole at 25 mg/kg body weight (two doses at 6-7 days apart) was highly effective against *Trichocephalus* sp. and *Ancylostoma* sp. in monkeys in a zoo in Poland.

Bockeler and Lindau (1978) reported that Fenbendazole, as Panacur pellets 1.5 per cent, at 7.5 mg/kg body weight was highly effective against trichostrongyle and strongyle infections in wild ruminants at Cologne Zoo, German Federal Republic and also that carnivores were completely cured of trichurids, ascarids and *Capillaria* by 50 mg/kg body weight of Fenbendazole.

Thiophanate at a dose rate of 50 mg/kg body weight was found to be 100 per cent effective against *Oesophagostomum dentatum* of two wild boars and 85.72 to 100 per cent against *Toxascaris leonina* of five lion cubs (Chandrasekharan *et al.*, 1979).

Litvinov and Zen'-Kov (1979) have encountered *Metastrongylus* in upto 100 per cent of young wild boars in the Belorussian SSR and successfully treated the infection with Nilverm or Tetramisole granules.

Lakshmanan and Joseph (1980) reported that Helmacid and Neobidermin were effective in the treatment of *Toxascaris leonina* and *Ancylostoma* spp. infections in lions.

Goltenboth (1981) reported that a Febantel preparation was used to treat parasitic infections of zoo animals including 20 different species comprising monkeys, various felids, bears, giant pandas, wild boars, armadillos, camels and kangaroos and that good results were obtained.

Kumar *et al.* (1981) reported that 7 *Ateles* monkeys (4 *A. belzebuth* and 3 *A. paniscus*) were unsuccessfully treated for spirurid infection daily for 5 days (days 0 to 4) with Mebendazole at a dosage increasing from 20 to 40 mg/kg, the course being repeated on days 15 to 19 and that finally successfully treated with Levamisole at 8 mg/kg on day 30 and again, where necessary, on days 35 to 38 at 10 mg/kg.

A suspected case of dictyocauliasis in a pony was successfully treated with Mebendazole 20 mg/kg body weight daily for 4 days (Church, 1983).

Tanwar *et al.* (1984) reported that Piperazine adipate was highly effective for the treatment of the nematodes *Toxocara cati* and *Toxascaris leonina* in an Asian lion at the dose rate of 100 mg/kg body weight.

Flach and Sewell (1987) reported that monthly treatment was necessary to eliminate parasitic infections from black buck and also that Oxfendazole was highly effective against *Camelostrongylus mentulatus* infection in blackbuck but ineffective against *Nematodirus spathiger*.

Bansal *et al*. (1989) reported that Albendazole at 5 mg/kg body weight was 100 per cent effective against *Trichostrongylus*, *Haemonchus*, *Bunostomum*, *Oesophagostomum*, *Strongyloides* and *Nematodirus* infections in camels but was ineffective against *Trichuris*.

Knottenbelt (1989) suggested a list of drugs for treatment of parasitic infections in wild animals. For nematodes, Fenbendazole - 10% (1 ml/20 kg), Ivermectin (2 ml/50 kg) and Piperazine hydrochloride - 64.5% (30 g/100 kg) orally in food; Levamisole - 2.5% (3 ml/10 kg) orally in water and Ivermectin - 1% injectable (1 ml/50 kg body weight sub-cutaneously) were highly effective. For cestodes, Niclosamide - 20% (1 ml/4 kg) orally in water and for trematodes, Rafoxanide - 3% (2.5 ml/10 kg) orally in water as well as Nitroxynil - 34% injectable (1.5 ml/150 kg) were effective.

Jones (1989) suggested that Fenbendazole (5 mg/kg), Thiabendazole (50 mg/kg), Oxfendazole (5 mg/kg), Levamisole granules (7.5 mg/kg), Levamisole + Oxyclozanide (1.5 mg/kg and

15 mg/kg respectively) as well as Albendazole (5 mg/kg) orally in food and Levamisole (7.5 mg/kg) subcutaneously were effective against helminthic infections in deer.

Maity *et al.* (1994) reported that Nemocid at 1.5 tablets (375 mg of Pyrantel Pamoate/animal) orally was effective against clinical toxocariasis in snow leopards.

Fenbendazole at 10-15 mg/kg body weight was more effective than Albendazole and Mebendazole for the treatment of hook worm infections in tigers (Gogoi, 1994).

Partani *et al.* (1995) conducted an experiment in camels naturally infected with mixed infections of gastro-intestinal nematodes and treated them with Albendazole, Fenbendazole, Levamisole, Tetramisole and Ivermectin and also observed a suspected resistance of *Strongyloides papillosus* to Fenbendazole and of *Haemonchus longistipes* to Tetramisole. It was also found that all the anthelmintics had an efficacy of greater than 95 per cent and that the lower confidence limit of Albendazole, Levamisole and Ivermectin was higher than 95 per cent whereas it was less than 90 per cent in the case of Fenbendazole and Tetramisole.

Materials and Methods

Chapter - III

MATERIALS AND METHODS

3.1 Prevalence of helminthic infection in the zoo mammals

Investigation on the prevalence of helminthic infections in the zoo mammals was carried out by recognising faecal eggs and identification of worms collected after faecal examination and post-mortem examination respectively over a period of one year from May,`98 to April,`99.

3.1.1 Faecal examination

The details regarding the mammals present in the zoo is given in the Table 1. Fresh faecal samples were collected in separate polythene sachets of 5"x6" in size for each animal and labelled with proper indentification of species, age, sex etc. of the animals. Then the sachets were stapled and brought to the laboratory for the examination. The samples were processed with the concentration method of centrifugation-cum-sedimentation technique.

Sedimentation Technique

A small quantity of the sample, of about the size of pea, was thoroughly emulsified in a mortar and pestle, with about 10 ml of water. This emulsion was then strained through a

Table 1. Showing the details regarding wild mammals present in the Thrissur Zoo (as on May, 1998)

Sl No.	Species	Category of animals			Total
		Male	Female	Young (Below 1 yr)	
		Herbivores			
1.	Spotted Deer *Axis axis* (Erxleben)	45	51	9*	105
2.	Sambar *Cervus unicolor* (Kerr)	11	6	-	17
3.	Hog-Deer *Axis porcinus* (Zimmermann)	4	4	2*	10
4.	Barking deer *Muntiacus muntjak* (Zimmermann)	1	-	-	1
5.	Blackbuck *Antelope cervicapra* (Linnaeus)	4	1	1*	6
6.	Kashmere Goat *Capra sibirica* (Pallas)	2	-	-	2
7.	Camel *Camelus dromedarius* (Linnaeus)	1	1	-	2
8.	Hippopotamus *Hippopotamus amphibius* (Linnaeus)	1	2	-	3
9.	Pony *Equus caballus* (Linnaeus)	1	-	-	1
		Omnivores			
10.	Bonnet Macaque *Macaca radiata* (Geoffroy)	19	15	2	36
11.	Liontailed Macaque *Macaca silenus* (Linnaeus)	3	1	-	4
12.	Rhesus Macaque *Macaca mulatta* (Zimmermann)	-	1	-	1

(Contd.)

* Sexes were not determined

Table 1 (Contd.)

13.	Himalayan Black Bear *Selenarctos thibetanus* (G. Cuvier)	1	-	-	1
14.	Sloth Bear *Melursus ursinus* (Shaw)	1	-	-	1
15.	Indian Porcupine *Hystrix indica* (Kerr)	2	-	-	2
16.	Indian Wild Boar *Sus scrofa cristatus* (Wagner)	3	3	-	6
17.	Small Indian Civet *Viverricula Indica* (Desmarest)	2	2	-	4
18.	Common Palm Civet *Paradoxurus hermaphroditus* (Pallas)	2	2	-	4
		Carnivores			
19.	Asiatic Lion *Panthera leo persica* (Meyer)	3	3	-	6
20.	Indian Leopard *Panthera pardus fusca* (Meyer)	3	-	-	3
21.	Jackal *Canis aureus* (Linnaeus)	1	-	-	1
22.	Jungle Cat *Felis chaus* (Guldenstaedt)	1	-	-	1
	Total	111	92	14	217

seive into a suitable container to remove all the coarser particles. The filtrate was then poured into a centrifuge tube just upto an inch below the brim and centrifuged at 1,000 rpm for 1-2 minutes. The supernatant fluid was then thrown off retaining only a small quantity required to re-emulsify the sediment. A drop of the re-emulsified material was transferred to a slide, covered with a 22 mm square coverslip and examined for any ova of helminth parasites.

The ova of the helminth parasites were identified on morphological basis and the infections were graded as light (+), medium (++ to +++) and heavy (++++ and above), each plus representing an ovum per field under low power.

After the examination, the processed faecal samples were preserved in 7 ml and 10 ml plastic vials with 10% formalin.

Microphotographs of the ova of different helminth parasites encountered in the various species of wild mammals were taken from the preserved faecal samples.

3.1.2. Post-mortem examination

The worms collected if any from the animals during post-mortem examination, usually conducted at the zoo, were identified on morphological basis after staining with carmine solution in case of trematodes as well as cestodes and clearing with lactophenol or creosote in case of nematodes.

Results

Chapter - IV

RESULTS

4.1 General health alterations in the zoo animals due to parasitic infections

The wild mammals in the zoo did not show considerable specific clinical symptoms due to parasitic infections during the study period. However, general weakness and debility were seen in a number of animals such as bonnet macaques, Indian wild boars, Indian porcupines, Kashmere goat, blackbuck and jungle cat which were positive for infections. Occasional diarrhoea and dehydration were also seen in Asiatic lions, jackal, jungle cat, Indian leopards and bonnet macaques due to consistent ascarid and hook worm burdens. In an Indian leopard, which was infected with *Paragonimus*, respiratory distress along with consistent cough was seen. Alopecia was seen in camels and bonnet macaques which were positive for helminthic infections.

4.2 Prevalence of helminthic infections among zoo mammals

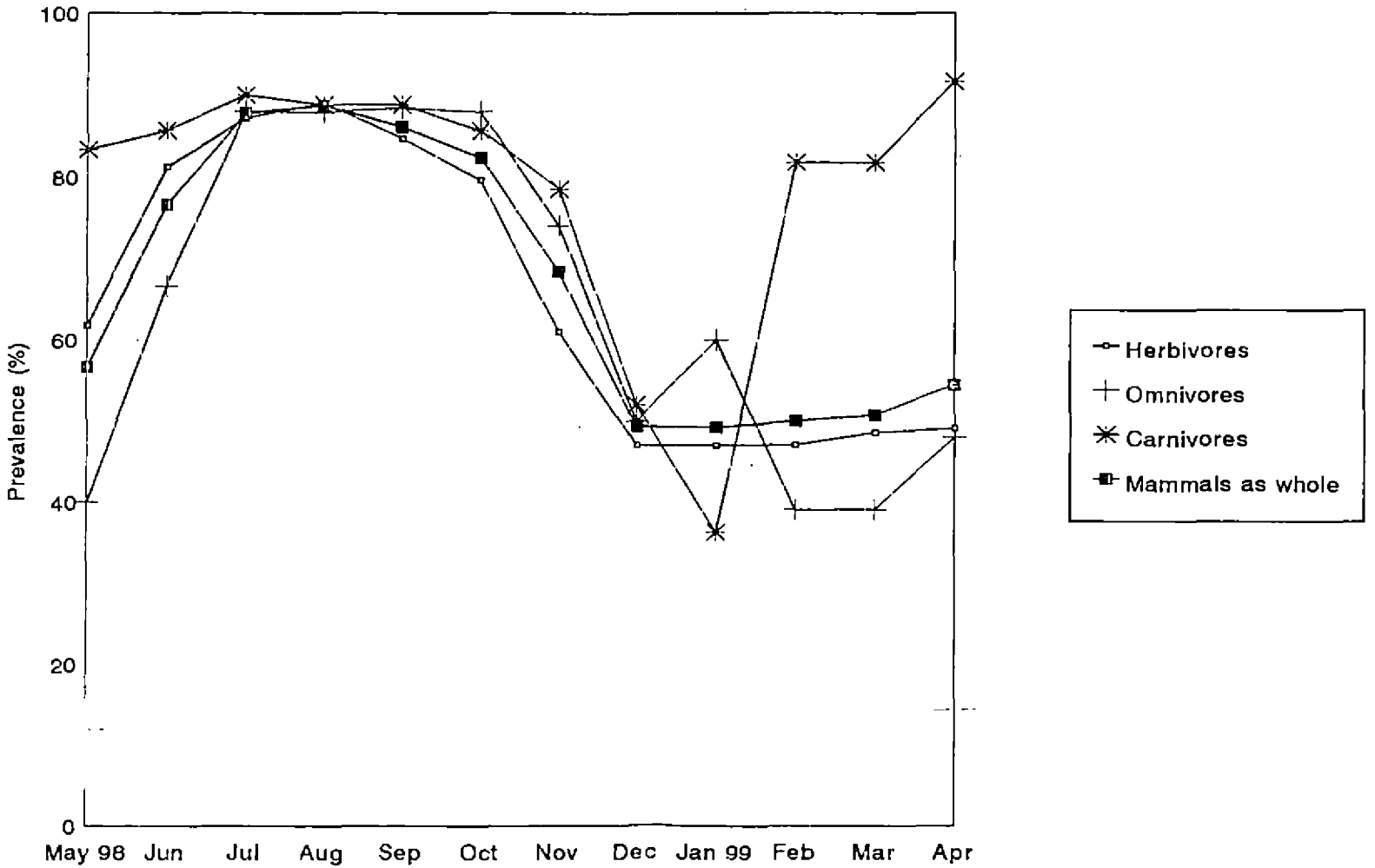
4.2.1 Determination by faecal examination

The month-war prevalence of helminthic infections among the mammals of the zoo is presented in Table2 and Graph 1. It was observed that the highest prevalence was found during the

Table 2. Month-war prevalence of helminthic infections among mammals

Month	Herbivores			Omnivores			Carnivores			Mammals as whole		
	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
May-'98	34	21	61.76	20	8	40.00	6	5	83.33	60	34	56.66
Jun-'98	32	26	81.25	21	14	66.66	7	6	85.71	60	46	76.66
Jul-'98	47	41	87.23	25	22	88.00	10	9	90.00	82	72	87.80
Aug-'98	55	49	89.09	25	22	88.00	9	8	88.88	89	79	88.76
Sep-'98	59	50	84.74	26	23	88.46	9	8	88.88	94	81	86.17
Oct-'98	59	47	79.66	25	22	88.00	7	6	85.71	91	75	82.41
Nov-'98	59	36	61.01	27	20	74.07	28	22	78.57	114	78	68.42
Dec-'98	34	16	47.05	22	11	50.00	25	13	52.00	81	40	49.38
Jan-'99	34	16	47.05	20	12	60.00	11	4	36.36	65	32	49.23
Feb-'99	34	16	47.05	21	8	39.09	11	9	81.81	66	33	50.00
Mar-'99	35	17	48.57	23	9	39.13	11	9	81.81	69	35	50.72
Apr-'99	53	26	49.07	25	12	48.00	12	11	91.66	90	49	54.44
Whole year	535	361	67.47	280	183	65.35	146	110	75.34	961	654	68.05

Graph 1. Month-war prevalence of helminthic infections among mammals



months of July, August, September and October, the rates being 87.8 per cent, 88.76 per cent, 86.17 per cent and 82.41 per cent respectively and that moderate prevalence was encountered during the months of June (76.66%) and November (68.42%). During the other months of the study period the prevalence was comparatively lower, being only 49.38 per cent in December, 49.23 per cent in January, 50 per cent in February, 50.72 per cent in March, 54.44 per cent in April and 56.66 per cent in May. The overall prevalence of the infection was 68.05 per cent. Carnivores had the highest prevalence (75.34%) when compared to herbivores (67.47%) and omnivores (65.35%).

Herbivores

The species-wise monthly prevalence and the type of helminthic infections among herbivores are presented in Table 3 and 4.

In Spotted Deer, out of 252 samples (84 males, 96 females, 6 from below 1 month and 66 from 1 month to 1 year) examined, 161 (61 males, 66 females and 34 from 1 month to 1 year) samples(63.88%) were positive; strongyle (Fig.1-3) and amphistome infections were present throughout the study period; *Strongyloides* present except in May and March; spirurid (Fig.4) except in May, February and April and ascarid present only in May. The overall intensity of infection varies from + to +++ during the period. Multiple infections were present in 53 samples examined.

In the case of Sambar, out of 75 samples (31 males, 33 females, 2 from below 1 month and 9 from 1 month to 1 year) examined, 47 (20 males, 25 females and 2 from 1 month to 1 year) samples (62.66%) were positive for helminthic infections; strongyle and amphistome infections were present in May, June, July, August, September, October, November, January and April and in July, August, september, October, February, March and April respectively. Spirurid and ascarid infections were also present in July, August, September, October, November, December and January and in May, June, August, September and October respectively. Mixed infections were seen in 23 samples studied. The overall intensity of infection in Sambar varied from + to +++ during the period.

Out of 54 Hog-Deer samples (24 males, 25 females and 5 from 1 month to 1 year) examined, 34 (15 males, 15 females and 4 from 1 month to 1 year) samples (62.96%) were positive for helminthic infections; strongyle infection was present in all the months except in March; amphistome infection in July, September, October, March and April; spirurid infection except in May, June and July and *Strongyloides* and ascarid infections in June and in August and October respectively. The overall intensity of infection varied from + to ++ during the study period. Twelve samples were positive for mixed infections.

Among Barking Deer, 12 samples (males) were examined of which 3 (25%) were positive; spirurid and strongyle were found in the months of July, August and of October respectively.

Mixed infections were present in one sample. The overall intensity of infections varied from + to ++ during the entire study period.

In Blackbuck, out of 45 samples (40 males, 2 females and 3 from 1 month to 1 year) examined, 38 (33 males, 2 females and 3 from 1 month to 1 year) samples (84.44%) were positive for helminthic infections; strongyle (Fig.5) was present throughout the study period. Spirurid, *Strongyloides* and ascarid infections were present during the months of January, February and March, of August and of June respectively. Mixed infections were present in 11 samples and the overall intensity of infection varied from + to ++++ during the entire period.

Out of 24 faecal samples from Kashmere Goat (males) examined, 23 (95.83%) were positive; strongyle (Fig.6) infection was present throughout the study period. *Strongyloides* and spirurid infections in the months of May, June, August and September and of October, November, January and February respectively; *Fasciola* in June and August and *Trichuris* only in May and September. The overall intensity of infection varied from + to ++++. Multiple infections were present in 14 samples examined during the entire study period.

In the case of Camel, out of 35 samples (17 males and 18 females) examined, 28 (16 males and 12 females) samples (80%) were positive; strongyle infection was present in the months

of May to November and *Trichuris* (Fig.7) in the months of September to February as well as April; *Strongyloides* infection was present in June, September and February; ascarid in June and July and spirurid only in October. Multiple infections were present in 14 samples examined and the overall intensity of infection varied from + to +++ during the study period.

Among 26 Hippopotamus samples (12 males and 14 females) examined, 22 (10 males and 12 females) samples (84.61%) were positive for helminthic infections; strongyle infection was present during the entire study period except in June, July, and January; ascarid present in July, August, September and December and spirurid in June, July, August and October. Multiple infections were present in 9 samples and the overall intensity of infection varied from + to ++ during the study period.

In Pony, out of 12 samples (males) examined 5 (41.66%) were positive for helminthic infections; *Strongyloides* infection was present in the months of June and August; *Parascaris* in July and October and spirurid in August and September. Multiple infection was present in one sample and the overall intensity ranged from + to ++ during the study period.

Table 3. Species-wise monthly prevalence of helminthic infections among herbivores:

3.1 Spotted Deer

Month	Number of samples examined					Number of samples found positive					Prevalence (%)
	Male	Female	1 month-1 year	Below 1 month	Total	Male	Female	1 month-1 year	Below 1 month	Total	
May-'98	3	3	5	-	11	2	2	2	-	6	54.54
Jun-'98	3	4	3	-	10	2	3	3	-	8	80.00
Jul-'98	9	9	8	-	26	8	8	5	-	21	80.76
Aug-'98	12	12	7	-	31	11	10	5	-	26	83.87
Sep-'98	10	14	9	2	35	10	13	6	-	29	82.85
Oct-'98	9	12	7	3	31	8	9	5	-	22	70.96
Nov-'98	13	13	6	-	32	5	6	2	-	13	40.62
Dec-'98	4	4	3	-	11	3	3	-	-	6	54.54
Jan-'99	4	5	3	-	12	3	4	-	-	7	58.33
Feb-'99	4	4	2	1	11	3	1	1	-	5	45.45
Mar-'99	4	4	4	-	12	2	3	-	-	5	41.66
Apr-'99	9	12	9	-	30	4	4	5	-	13	43.33
Whole year	84	96	66	6	252	61	66	34	-	161	63.88

Table 3.2 Sambar

Month	Number of samples examined					Number of samples found positive					Prevalence (%)
	Male	Female	1 month-1 year	Below 1 month	Total	Male	Female	1 month-1 year	Below 1 month	Total	
May-'98	4	4	-	-	8	2	2	-	-	4	50.00
Jun-'98	2	3	-	-	5	2	3	-	-	5	100.00
Jul-'98	3	3	-	-	6	2	3	-	-	5	83.33
Aug-'98	2	4	1	-	7	2	4	-	-	6	85.71
Sep-'98	3	3	-	-	6	3	2	-	-	5	83.33
Oct-'98	4	3	1	-	8	2	3	1	-	6	75.00
Nov-'98	3	1	-	-	4	2	1	-	-	3	75.00
Dec-'98	2	2	-	1	5	1	-	-	-	1	20.00
Jan-'99	2	2	1	1	6	1	2	-	-	3	50.00
Feb-'99	2	2	2	-	6	-	2	-	-	2	33.33
Mar-'99	2	3	2	-	7	2	1	-	-	3	42.85
Apr-'99	2	3	2	-	7	1	2	1	-	4	57.14
Whole year	31	33	9	2	75	20	25	2	-	47	62.66

3.3 Hog-Deer

Month	Number of samples examined				Number of samples found positive				Prevalence (%)
	Male	Female	1 month-1 year	Total	Male	Female	1 month-1 year	Total	
May-'98	1	2	-	3	-	1	1	1	33.33
Jun-'98	2	2	-	4	1	-	-	1	25.00
Jul-'98	2	2	-	4	2	2	-	4	100.00
Aug-'98	1	2	2	5	1	2	2	5	100.00
Sep-'98	2	2	1	5	2	2	-	4	80.00
Oct-'98	3	2	1	6	3	2	1	6	100.00
Nov-'98	2	2	1	5	2	2	1	5	100.00
Dec-'98	2	2	-	4	2	-	-	2	50.00
Jan-'99	2	2	-	4	-	1	-	1	25.00
Feb-'99	3	3	-	6	1	-	-	1	16.66
Mar-'99	2	2	-	4	1	1	-	2	50.00
Apr-'99	2	2	-	4	-	2	-	2	50.00
Whole year	24	25	5	54	15	15	4	34	62.96

3.4 Blackbuck

Month	Number of samples examined				Number of samples found positive				Prevalence (%)
	Male	Female	1 month-1 year	Total	Male	Female	1 month-1 year	Total	
May-'98	2	1	1	4	2	1	1	4	100.00
Jun-'98	3	1	-	4	3	1	-	4	100.00
Jul-'98	2	-	1	3	2	-	1	3	100.00
Aug-'98	3	-	1	4	3	-	1	4	100.00
Sep-'98	4	-	-	4	4	-	-	4	100.00
Oct-'98	4	-	-	4	4	-	-	4	100.00
Nov-'98	4	-	-	4	4	-	-	4	100.00
Dec-'98	3	-	-	3	1	-	-	1	33.33
Jan-'99	4	-	-	4	1	-	-	1	25.00
Feb-'99	3	-	-	3	2	-	-	2	66.66
Mar-'99	4	-	-	4	4	-	-	4	100.00
Apr-'99	4	-	-	4	3	-	-	3	75.00
Whole year	40	2	3	45	33	2	3	38	84.44

3.5 Pony, Barking Deer and Kashmere Goat

Month	Pony (1 male)			Barking Deer (1 male)			Kashmere Goat (2 males)		
	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
May-'98	1	-	0.00	1	-	0.00	2	2	100.00
Jun-'98	1	1	100.00	1	-	0.00	2	2	100.00
Jul-'98	1	1	100.00	1	1	100.00	2	2	100.00
Aug-'98	1	1	100.00	1	1	100.00	2	2	100.00
Sep-'98	1	1	100.00	1	-	0.00	2	2	100.00
Oct-'98	1	1	100.00	1	1	100.00	2	2	100.00
Nov-'98	1	-	0.00	1	-	0.00	2	2	100.00
Dec-'98	1	-	0.00	1	-	0.00	2	1	50.00
Jan-'99	1	-	0.00	1	-	0.00	2	2	100.00
Feb-'99	1	-	0.00	1	-	0.00	2	2	100.00
Mar-'99	1	-	0.00	1	-	0.00	2	2	100.00
Apr-'99	1	-	0.00	1	-	0.00	2	2	100.00
Whole year	12	5	41.66	12	3	25.00	24	23	95.83

3.6 Camel and Hippopotamus

Month	Camel							Hippopotamus						
	Number of samples examined			Number of samples found positive			Prevalence (%)	Number of samples examined			Number of samples found positive			Prevalence (%)
	Male	Female	Total	Male	Female	Total		Male	Female	Total	Male	Female	Total	
May-'98	1	1	2	1	1	2	100.00	1	1	2	1	1	2	100.00
Jun-'98	1	1	2	1	1	2	100.00	1	2	3	1	2	3	100.00
Jul-'98	1	1	2	1	1	2	100.00	1	1	2	1	1	2	100.00
Aug-'98	1	1	2	1	1	2	100.00	1	1	2	1	1	2	100.00
Sep-'98	1	2	3	1	2	3	100.00	1	1	2	1	1	2	100.00
Oct-'98	2	2	4	2	1	3	75.00	1	1	2	1	1	2	100.00
Nov-'98	4	4	8	4	4	8	100.00	1	1	2	-	1	1	50.00
Dec-'98	2	2	4	2	-	2	50.00	1	2	3	1	2	3	100.00
Jan-'99	1	1	2	1	-	1	50.00	1	1	2	1	-	1	50.00
Feb-'99	1	1	2	1	1	2	100.00	1	1	2	1	1	2	100.00
Mar-'99	1	1	2	-	-	-	0.00	1	1	2	1	-	1	50.00
Apr-'99	1	1	2	1	-	1	50.00	1	1	2	-	1	1	50.00
Whole year	17	18	35	16	12	28	80.00	12	14	26	10	12	22	84.61

Table 4. Month-war prevalence of infection in the various species of Herbivores (details regarding intensity and nature of infection described in the text)

Month	Spotted Deer	Sambar	Hog-Deer	Blackbuck	Pony	BarkingDeer	Kashmere Goat	Camel	Hippopotamus
May-98	Amphistome Strongyle Ascarid	Strongyle Ascarid	Strongyle	Strongyle	-	-	Strongyle *Strongyloides* *Trichuris*	Strongyle	Strongyle
Jun-98	Amphistome Strongyle *Strongyloides* Spirurid	Strongyle Ascarid Amphistome	Strongyle *Strongyloides*	Strongyle Ascarid	*Strongyloides*	-	Strongyle *Strongyloides* *Fasciola*	Strongyle *Strongyloides* Ascarid	*Fasciola* Spirurid
Jul-98	Amphistome Strongyle *Strongyloides* Spirurid	Strogyle Amphistome Spirurid	Strongyle Amphistome	Strongyle	*Parascaris*	Spirurid	Strongyle *Fasciola*	Strongyle Ascarid Spirurid	*Fasciola* Spirurid Ascarid
Aug-98	Amphistome Strongyle *Strongyloides* Spirurid	Strongyle Amphistome Spirurid Ascarid	Strongyle Spirurid Ascarid	Strongyle *Strongyloides*	*Strongyloides* Spirurid	Spirurid	Strongyle *Strongyloides* *Fasciola*	Strongyle	Strongyle Spirurid Ascarid
Sep-98	Amphistome Strongyle *Strongyloides* Spirurid	Strongyle Amphistome Spirurid Ascarid	Strongyle Spirurid Amphistome	Strongyle	Spirurid	-	Strongyle *Stongyloides* *Trichuris*	Strongyle *Strongyloides* *Trichuris*	Strongyle Ascarid
Oct-98	Amphistome Strongyle *Strongyloides* Spirurid	Strongyle Amphistome Spirurid Ascarid	Strongyle Spirurid Amphistome Ascarid	Strongyle	*Parascaris*	Spirurid Strongyle	Strongyle Spirurid	Strongyle Spirurid *Trichuris*	Strongyle Spirurid
Nov-98	Amphistome Strongyle *Strongyloides* Spirurid	Strongyle Spirurid	Strongyle Spirurid	Strongyle	-	-	Strongyle Spirurid	Strongyle *Trichuris*	Strongyle

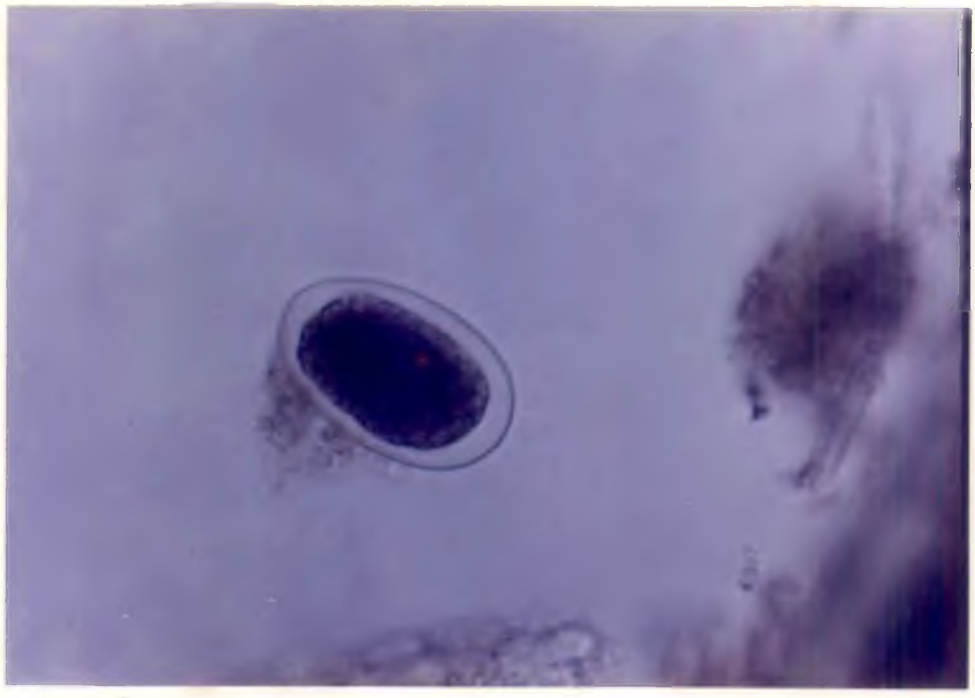
Contd.

Table 4 (Contd.)

Dec-98	Amphistome Strongyle *Strongyloides* Spirurid	Spirurid	Strongyle Spirurid	Strongyle	-	-	Strongyle	*Trichuris*	Strongyle Ascarid
Jan-99	Amphistome Strongyle *Strongyloides* Spirurid	Strongyle Spirurid	Strongyle Spirurid	Strongyle Spirurid	-	-	Strongyle Spirurid	*Trichuris*	Spirurid
Feb-99	Amphistome Strongyle *Strongyloides*	Strongyle Amphistome	Strongyle Spirurid	Strongyle Spirurid	-	-	Strongyle Spirurid	*Trichuris* *Strongyloides*	Strongle
Mar-99	Amphistome Strongyle Spirurid	Amphistome Spirurid	Amphistome Spirurid	Strongyle Spirurid	-	-	Strongyle	-	Strongyle
Apr-99	Amphistome Strongyle *Strongyloides*	Strongyle Amphistome Spirurid	Amphistome Strongyle Spirurid	Strongyle	-	-	Strongyle	*Trichuris*	Strongyle

Fig.1 A type of strongyle ovum from Spotted Deer (x 450)

Fig.2 Another type of strongyle ovum from Spotted Deer (x 450)



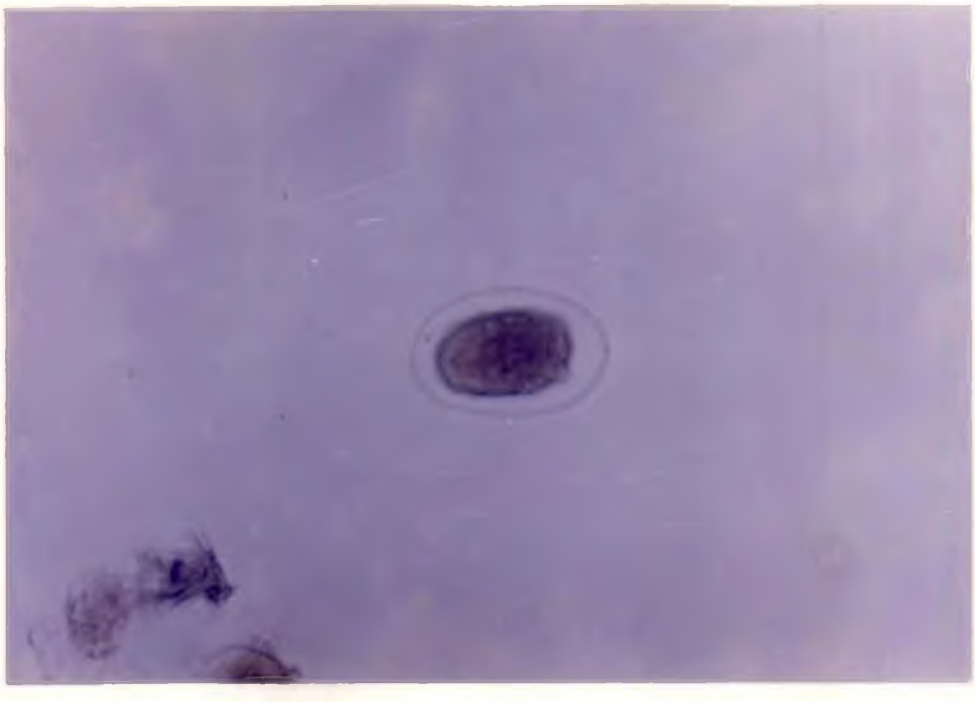


Fig.3 A third type of strongyle ovum from Spotted Deer (x 450)

Fig.4 Spirurid ovum from Spotted Deer (x 450)

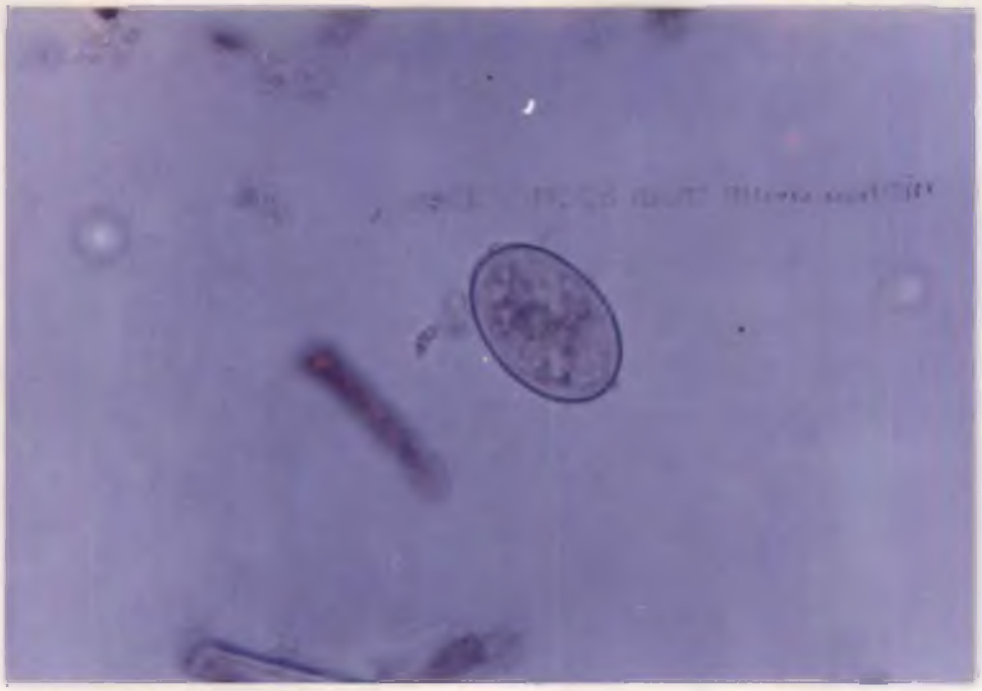
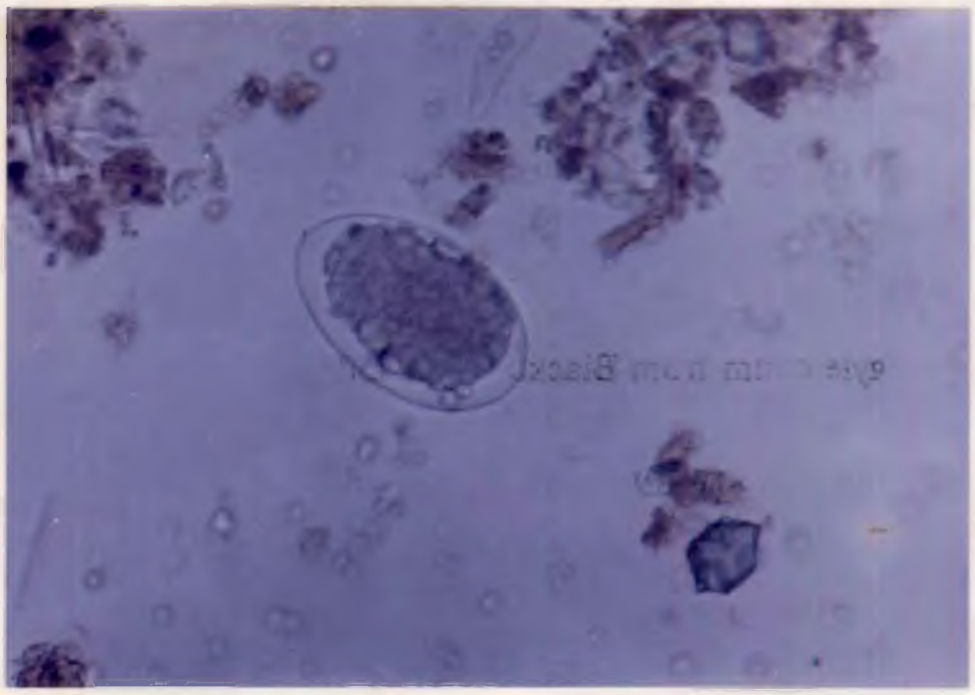
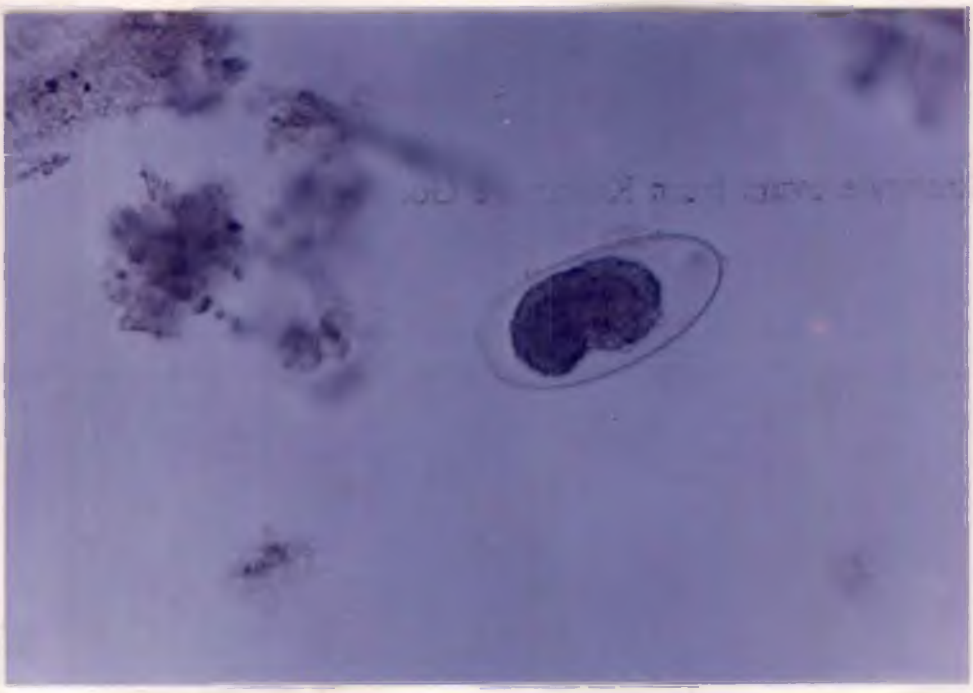
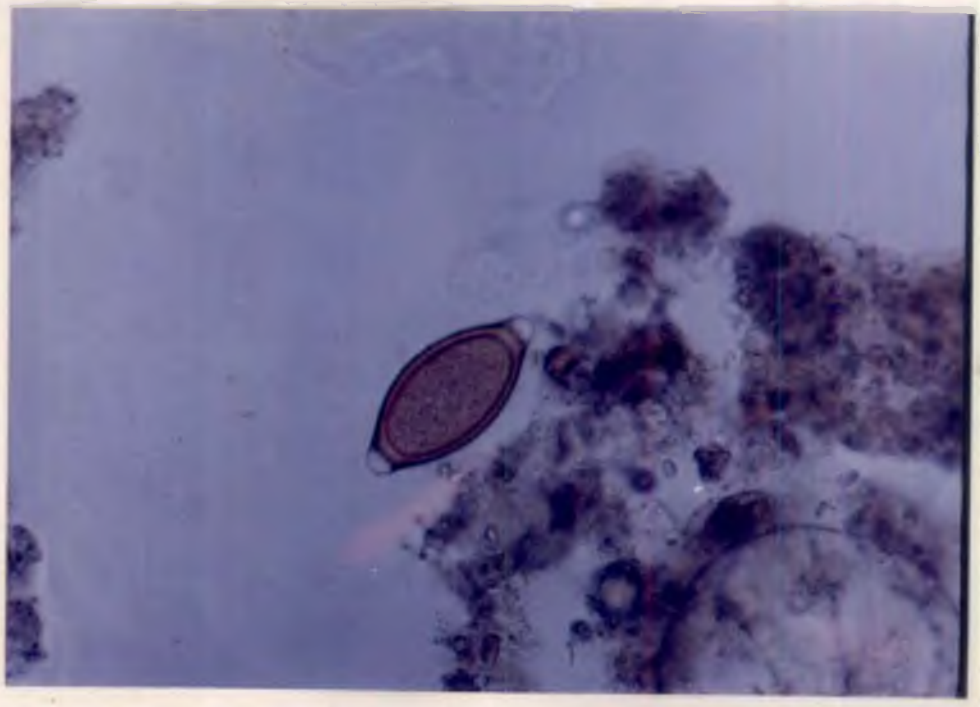


Fig.5 Strongyle ovum from Blackbuck (x 450)

Fig.6 Strongyle ovum from Kashmere Goat (x 450)







Omnivores

The species-wise monthly prevalence and the type of helminthic infections among omnivores are presented in Table 5and 6.

In Bonnet Macaques out of 101 samples (38 males and 49 females from above 1 year; 10 males and 7 females from 1 month to 1 year group and 2 males from below one month group) examined, 63 (25 males as well as 27 females from above 1 year and 5 males as well as 6 females from one month to 1 year group) samples (62.37%) were positive for helminthic infections. *Strongyloides* infection was present throughout the study period; strongyle (Fig.8) present except in the month of May; spirurid present in the months of June, July, October and November; ascarid in the months of August and September; *Hymenolepis* (Fig.10) in the months of July and August; *Metagonimus* in the months of July and January and *Trichuris* (Fig.9) present only in May. The overall intensity of infection varied from + to ++++ and 32 samples were having multiple infections.

In case of the Liontailed Macaque, 38 samples (31 males and 7 females) were examined and 23 (18 males and 5 females) of the same (61.52%) were found positive for helminthic infections. *Strongyloides* and strongyle infections were present in the months of July, August, September, October, November, January and February and of July, August, September,

October, November and December respectively; spirurid in July, August and September and ascarid in September and October. Multiple infections were present in 15 samples and the overall intensity of infection varied from + to +++ during the study period.

Out of 12 samples of a female Rhesus Macaque examined, 8 (66.66%) were positive for helminthic infections. Strongyle and *Capillaria* (Fig.11) infections were present in the months of September, October and November and of June and July respectively; ascarid in May, July, September and October; spirurid in November and February and *Trichuris* (Fig.12) only in March. The overall intensity of infection ranged from + to ++++ and multiple infections were present in 3 samples.

In the case of Himalayan Black Bear, out of the 12 samples from male animal examined, 5 (41.66%) were found positive for helminthic infections and only strongyle infection was present in the months of July, August, September, October, and November. The overall intensity ranged from + to +++ during the study period.

Out of the 12 samples from a male animal examined in the case of the Sloth Bear, 4 (33.33%) were positive for infections; strongyle infection was present in July, October and November and spirurid infection only in August, October and November. The overall intensity of infection ranged from

+ to ++ and multiple infections were present in 2 samples during the study period.

In the Small Indian Civet, out of 26 samples (13 males and 13 females) examined, 8 (4 males and 4 females) samples (30.76%) were positive for helminthic infections; *Ancylostoma* and *Artyfechinostomum* (Fig.13) infections were present in the months of June to November and of November to April respectively; *Strongyloides* and spirurid in June, July, September and October and in May, June, July and August respectively and *Trichuris* only in November. The overall intensity of infection ranged from + to ++++ and multiple infections were present in 8 samples during the study period.

Among the 25 samples from Toddy Cat (12 males and 13 females) examined, 20 (11 males and 9 females) samples (80%) were positive for helminthic infections. *Strongyloides* infection was present during the months of June, August and September; *Joyeuxiella* in June; spirurid in September; strongyle (Fig.14) in October and *Artyfechinostomum* in January. Multiple infections were present in two samples and the intensity of infection ranged from + to +++ during the period.

In the Indian Porcupine, out of 23 samples from male animals examined, 23 (100%) were positive for helminthic infections and *Toxocara* (Fig.15) infection was present throughout the study period. *Strongyloides* was present during

all the months except in March and April; strongyle present in May, July, August and September and *Trichuris* (Fig.16) present only in October. The overall intensity of infection varied from + to ++++ and multiple infections were present in 19 samples examined.

Out of 31 samples (20 males and 11 females) examined in the Indian Wild Boar, 29 (18 males and 11 females) samples (93.54%) were positive; strongyle (Fig.17) infection was present throughout the study period; *Strongyloides* present except in May, June and February; spirurid present in July and August and ascarid present only in september. Nineteen samples were having multiple infections and the intensity of infection ranged from + to ++++ during the study period.

Table 5. Species-wise monthly prevalence of helminthic infections among omnivores:

5.1 Bonnet Macaque

Month	Number of samples examined							Number of samples found positive							Prevalence (%)
	Above 1 year		1 month-1 year		Below 1 month		Total	Above 1 year		1 month-1 year		Below 1 month		Total	
	Male	Female	Male	Female	Male	Female		Male	Female	Male	Female	Male	Female		
May-'98	3	4	1	1	-	-	9	1	1	-	1	-	-	3	33.33
Jun-'98	2	3	1	1	-	-	7	2	3	1	1	-	-	7	100.00
Jul-'98	4	4	1	1	-	-	10	3	3	1	1	-	-	8	80.00
Aug-'98	4	4	1	1	-	-	10	4	3	1	1	-	-	9	90.00
Sep-'98	3	5	1	1	-	-	10	3	4	1	-	-	-	8	80.00
Oct-'98	3	5	1	1	-	-	10	2	4	-	1	-	-	7	70.00
Nov-'98	5	5	-	-	-	-	10	2	3	-	-	-	-	5	50.00
Dec-'98	3	2	-	-	-	-	5	3	1	-	-	-	-	4	80.00
Jan-'99	2	3	-	-	1	-	6	2	2	-	-	-	-	4	66.66
Feb-'99	2	2	1	-	1	-	6	1	-	-	-	-	-	1	16.66
Mar-'99	4	4	1	1	-	-	10	1	1	-	1	-	-	3	30.00
Apr-'99	3	3	2	-	-	-	8	1	2	1	-	-	-	4	50.00
Whole year	38	44	10	7	2	-	101	25	27	5	6	-	-	63	62.37

5.2 Liontailed Macaque and Rhesus Macaque

Month	Liontailed Macaque							Rhesus Macaque (1 female)		
	Number of samples examined			Number of samples found positive			Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
	Male	Female	Total	Male	Female	Total				
May-'98	1	-	1	-	-	-	0.00	1	1	100.00
Jun-'98	1	1	2	-	-	-	0.00	1	1	100.00
Jul-'98	3	1	4	3	1	4	100.00	1	1	100.00
Aug-'98	3	1	4	3	1	4	100.00	1	-	0.00
Sep-'98	3	1	4	3	1	4	100.00	1	1	100.00
Oct-'98	3	1	4	3	1	4	100.00	1	1	100.00
Nov-'98	3	1	4	3	1	4	100.00	1	1	100.00
Dec-'98	3	1	4	1	-	1	25.00	1	-	0.00
Jan-'99	3	-	3	1	-	1	33.33	1	-	0.00
Feb-'99	3	-	3	1	-	1	33.33	1	1	100.00
Mar-'99	2	-	2	-	-	-	0.00	1	1	100.00
Apr-'99	3	-	3	-	-	-	0.00	1	-	0.00
Whole year	31	7	38	18	5	23	60.52	12	8	66.66

5.3 Himalayan Black Bear and Sloth Bear

Month	Himalayan Black Bear (1 male)			Sloth Bear (1 male)		
	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
May-'98	1	-	0.00	1	-	0.00
Jun-'98	1	-	0.00	1	-	0.00
Jul-'98	1	1	100.00	1	1	100.00
Aug-'98	1	1	100.00	1	1	100.00
Sep-'98	1	1	100.00	1	-	0.00
Oct-'98	1	1	100.00	1	1	100.00
Nov-'98	1	1	100.00	1	1	100.00
Dec-'98	1	-	0.00	1	-	0.00
Jan-'99	1	-	0.00	1	-	0.00
Feb-'99	1	-	0.00	1	-	0.00
Mar-'99	1	-	0.00	1	-	0.00
Apr-'99	1	-	0.00	1	-	0.00
Whole year	12	5	41.66	12	4	33.33

5.4 Small Indian Civet and Toddy Cat*

Month	Small Indian Civet							Toddy Cat						
	Number of samples examined			Number of samples found positive			Prevalence (%)	Number of samples examined			Number of samples found positive			Prevalence (%)
	Male	Female	Total	Male	Female	Total		Male	Female	Total	Male	Female	Total	
May-'98	1	1	2	-	-	-	0.00	1	1	2	1	-	1	50.00
Jun-'98	2	1	3	1	-	1	33.33	1	1	2	1	1	2	100.00
Jul-'98	1	1	2	-	1	1	50.00	1	1	2	1	1	2	100.00
Aug-'98	1	1	2	1	-	1	50.00	1	1	2	1	1	2	100.00
Sep-'98	1	1	2	1	1	2	100.00	1	1	2	1	1	2	100.00
Oct-'98	1	1	2	1	1	2	100.00	1	1	2	1	1	2	100.00
Nov-'98	1	1	2	-	-	-	0.00	1	1	2	1	1	2	100.00
Dec-'98	1	2	3	-	-	-	0.00	1	1	2	-	1	1	50.00
Jan-'99	1	1	2	-	1	1	50.00	1	1	2	1	1	2	100.00
Feb-'99	1	1	2	-	-	-	0.00	1	2	3	1	-	1	33.33
Mar-'99	1	1	2	-	-	-	0.00	1	1	2	1	-	1	50.00
Apr-'99	1	1	2	-	-	-	0.00	1	1	2	1	1	2	100.00
Whole year	13	13	26	4	4	8	30.76	12	13	25	11	9	20	80.00

* All animals more than 1 year old

5.5 Indian Wild Boar and Indian Porcupine*

Month	Indian Wild Boar							Indian Porcupine (2 males)		
	Number of samples examined			Number of samples found positive			Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
	Male	Female	Total	Male	Female	Total				
May-'98	1	1	2	1	1	2	100.00	1	1	100.00
Jun-'98	1	1	2	-	1	1	50.00	2	2	100.00
Jul-'98	1	1	2	1	1	2	100.00	2	2	100.00
Aug-'98	1	1	2	1	1	2	100.00	2	2	100.00
Sep-'98	3	-	3	3	-	3	100.00	2	2	100.00
Oct-'98	2	-	2	2	-	2	100.00	2	2	100.00
Nov-'98	2	2	4	2	2	4	100.00	2	2	100.00
Dec-'98	2	1	3	2	1	3	100.00	2	2	100.00
Jan-'99	2	-	2	2	-	2	100.00	2	2	100.00
Feb-'99	2	-	2	2	-	2	100.00	2	2	100.00
Mar-'99	1	1	2	1	1	2	100.00	2	2	100.00
Apr-'99	2	3	5	1	3	4	80.00	2	2	100.00
Whole year	20	11	31	18	11	29	93.54	23	23	100.00

* All animals more than 1 year old

Table 6. Month-war prevalence of infection in the various species of Omnivores (details regarding intensity and nature of infection described in the text)

Month	Bonnet Macaque	Liontailed Macaque	Rhesus Macaque	Himalayan Black Bear	Sloth Bear	Small Indian Civet	Toddy Cat	Indian Wild Boar	Indian Porcupine
May-98	*Strongyloides* Ascarid	-	Ascarid	-	-	Spirurid	-	Strongyle	*Strongyloide* *Toxocara* Strongyle
Jun-98	*Strongyloides* Strongyle Spirurid *Hymenolepis*	-	*Capillaria*	-	-	Spirurid *Ancylostoma* *Strongyloides*	*Joyeuxiella* *Strongyloides* Ascarid	Strongyle	*Strongyloides* *Toxocara*
Jul-98	*Strongyloides* Strongyle Spirurid *Hymenolepis* *Metagonimus*	*Strogyloides* Strongyle Spirurid	*Capillaria* Ascarid	Strongyle	Strongyle	Spirurid *Ancylostoma* *Strongylodies*	-	Strongyle *Strongyloides* Spirurid	*Strongyloides* *Toxocara* Strongyle
Aug-98	*Strongyloides* Strongyle *Hymenolepis* Ascarid	*Strongyloides* Strongyle	-	Strongyle	Spirurid	Spirurid *Ancylostoma*	*Strongyloides*	Strongyle *Strongyloides* Spirurid	Spirurid Strongyle
Sep-98	*Strongyloides* Strongyle Ascarid	*Strongyloides* Strongyle Spirurid Ascarid	Strongyle Ascarid	Strongyle	-	*Ancylostoma* *Strongyloides*	*Strongyloides* Spirurid	Strongyle *Strongyloides* Ascarid	*Strongyloides* *Toxocara* Strongyle
Oct-98	*Strongyloides* Strongyle Spirurid *Hymenolepis*	*Strongyloides* Strongyle Ascarid	Strongyle Ascarid	Strongyle	Strongyle Spirurid	*Ancylostoma* *Strongyloides*	Strongyle *Strongyloides*	Strongyle *Strongyloides*	*Strongyloides* *Toxocara* *Trichuris*
Nov-98	*Strongyloides* Strongyle Spirurid	*Strongyliodes* Strongyle	Strongyle Spirurid	Strongyle	Strongyle Spirurid	*Ancylostoma* *Trichuris* *Artyfechinostomum*	-	Strongyle *Strongyloides*	*Strongyloides* *Toxocara*

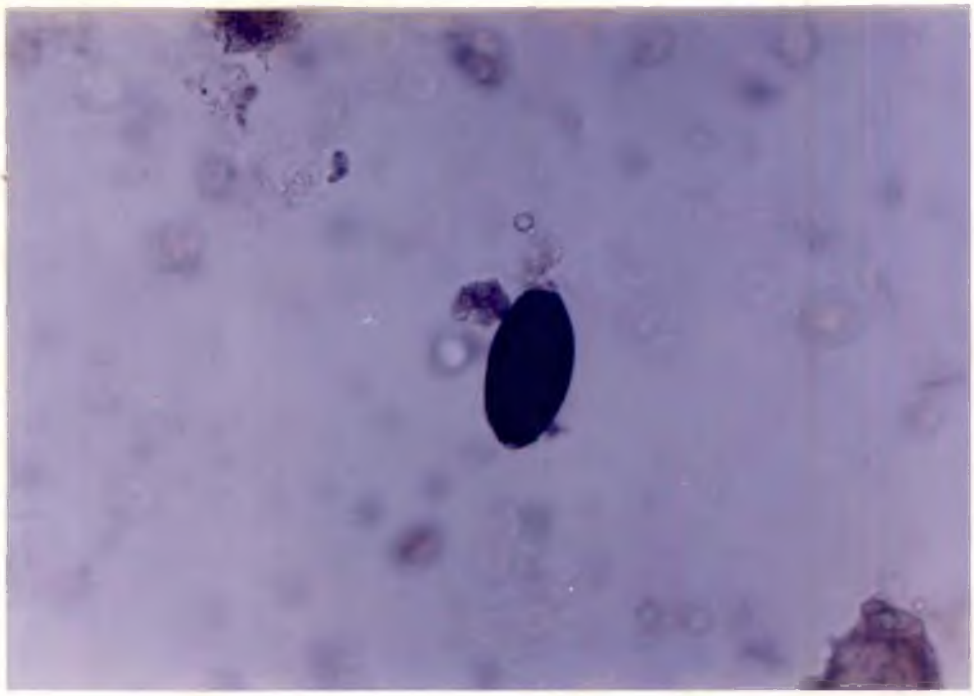
Contd.

Table 6 (Contd.)

Dec-98	*Strongyloides*	Strongyle	-	-	-	*Artyfechi-nostomum*	-	Strongyle *Strongyloides*	*Strongyloides* *Toxocara*
Jan-99	*Strongyloides* Strongyle *Metagonimus*	*Strongyloides* Spirurid	-	-	-	*Artyfechino-stomum*	*Artyfechino-stomum*	Strongyle *Strongyloides*	*Strongyloides* *Toxocara*
Feb-99	*Strongyloides* Strongyle	*Strongyloides*	Spirurid	-	-	*Artyfechino-stomum*	-	Strongyle	*Strongyloides* *Toxocara*
Mar-99	*Strongyloides* Strongyle	-	*Trichuris*	-	-	*Artyfechino-stomum*	-	Strongyle *Strongyloides*	*Toxocara*
Apr-99	*Strongyloides* Strongyle *Trichuris*	-	-	-	-	*Artyfechino-stomum*	-	Strongle *Strongyloides*	*Toxocara* Spirurid

Fig.9 *Trichuris* ovum from Bonnet Macaque (x 450)

Fig.10 *Hymenolepis* ovum from Bonnet Macaque (x 450)



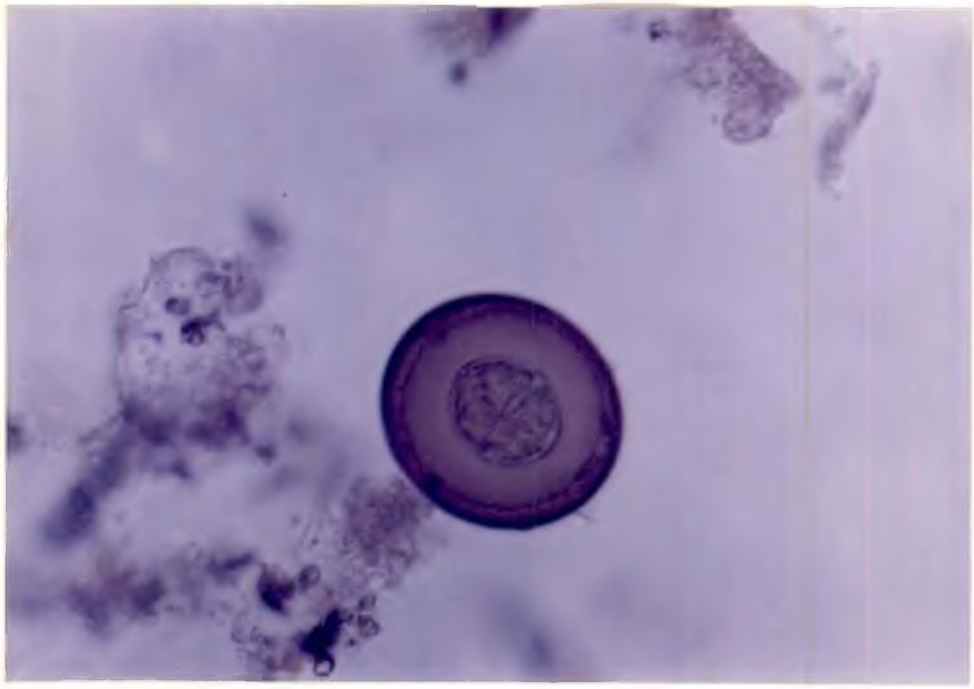
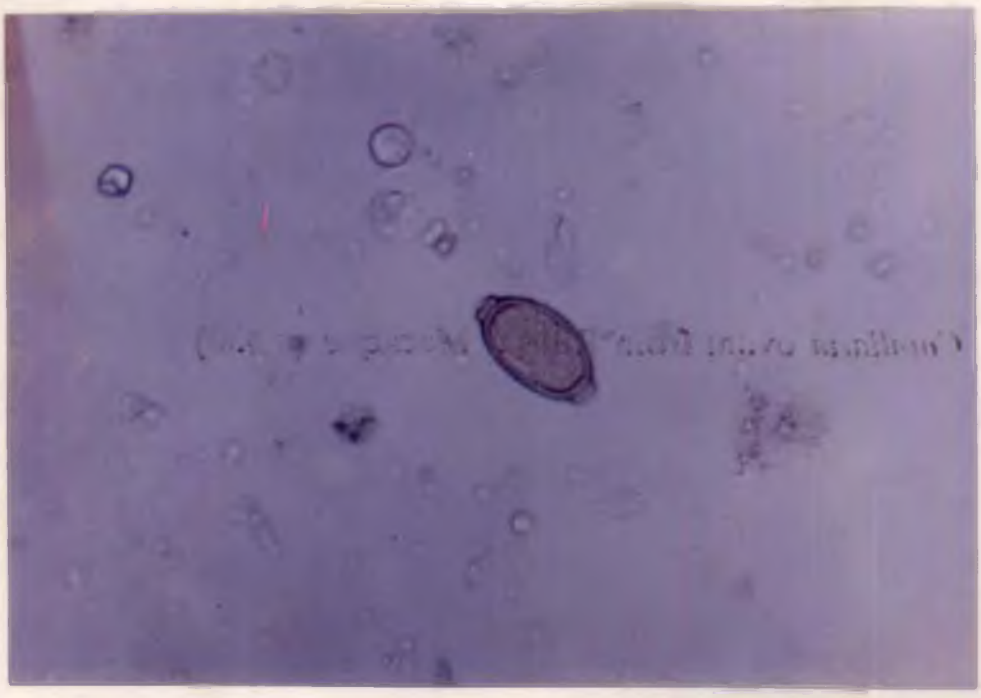


Fig.11 *Capillaria* ovum from Rhesus Macaque (x 450)

Fig.12 *Trichuris* ovum from Rhesus Macaque (x 450)



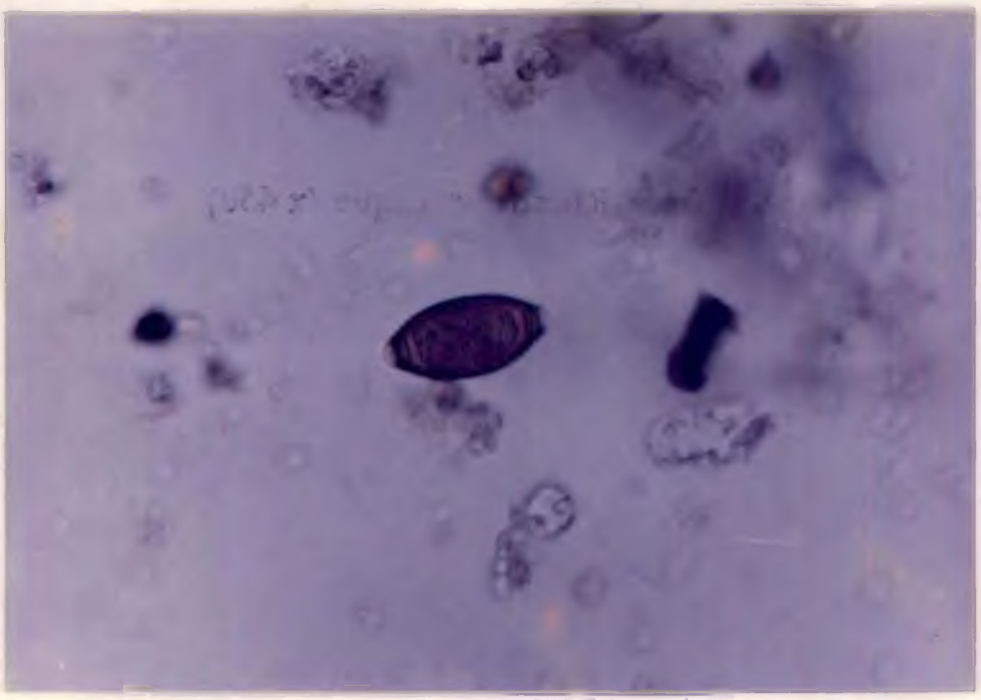


Fig.13 *Artyfechinostomum* ovum from Small Indian Civet (x 450)

Fig.14 Strongyle ova from Toddy Cat (x 450)

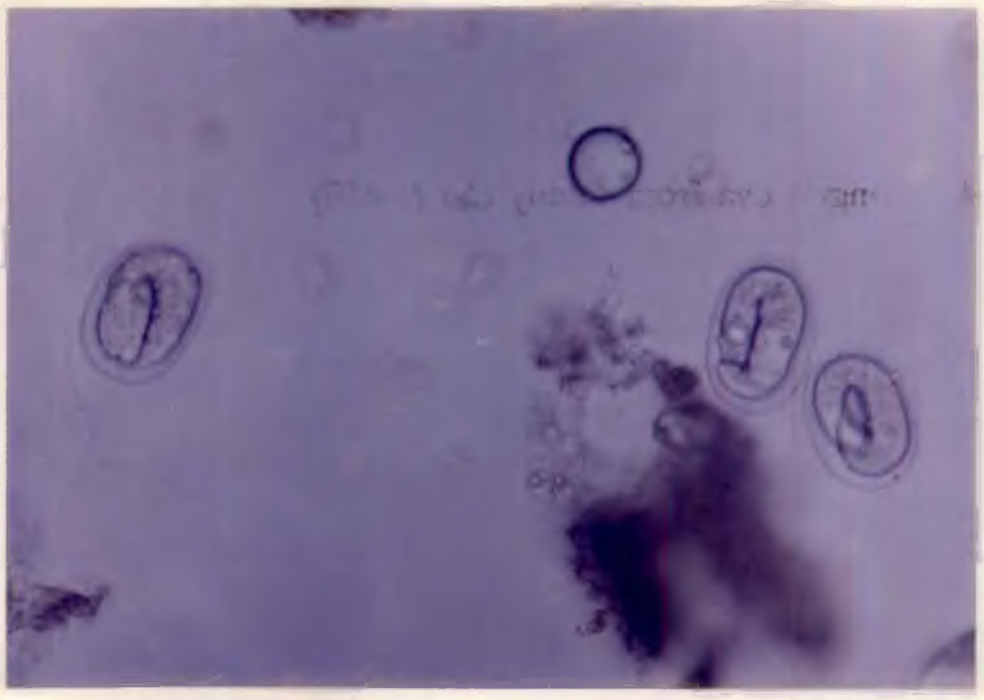


Fig.15 *Toxocara* ovum from Indian Porcupine (x 450)

Fig.16 *Trichuris* ovum from Indian Porcupine (x 450)

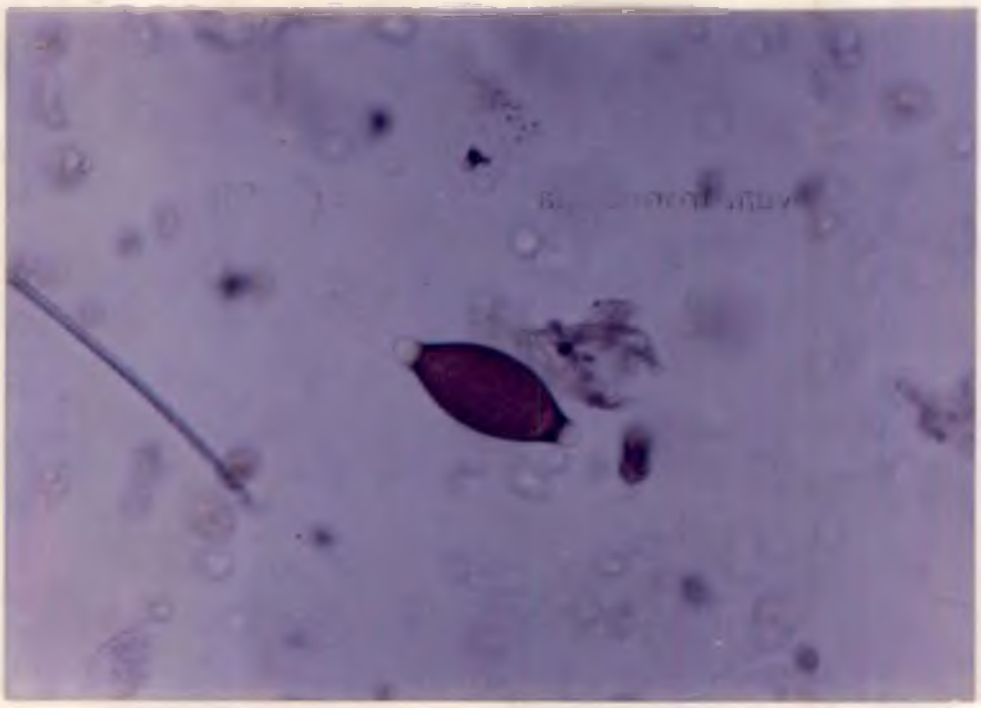
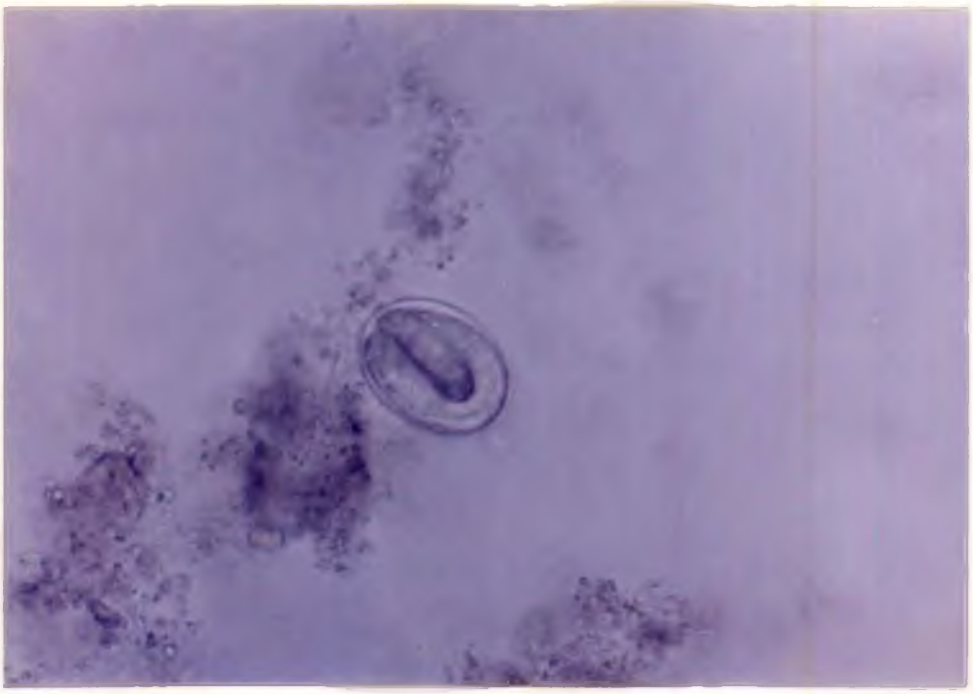
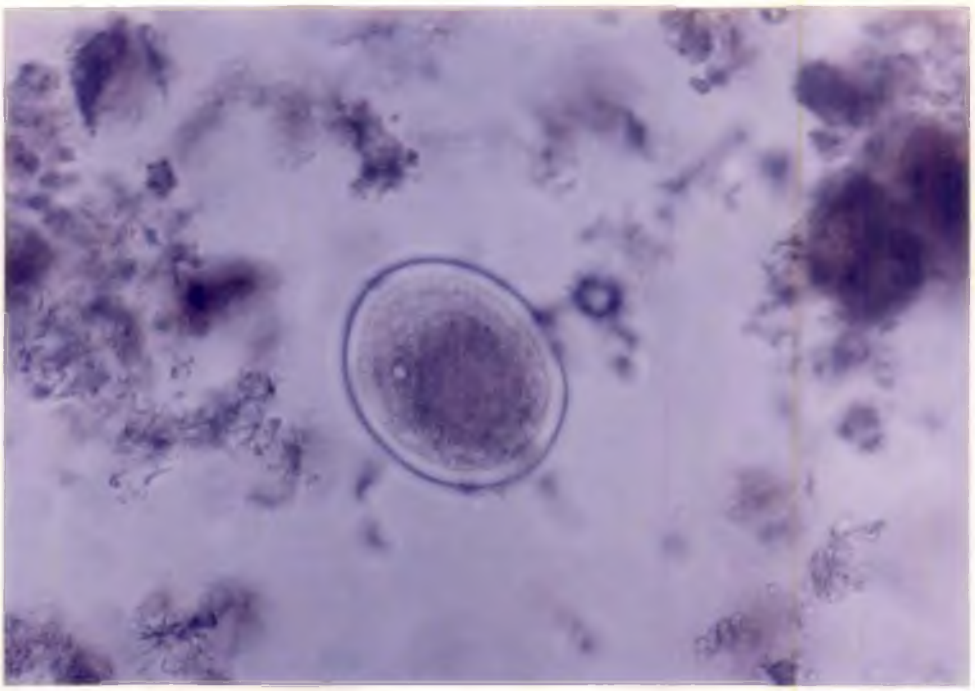


Fig.17 Strongyle ovum from Indian Wild Boar (x 450)

Fig.18 *Toxascaris* ovum from Asiatic Lion (x 450)





Carnivores

The species-wise monthly prevalence and the type of helminthic infections among carnivores are shown in Table 7 and 8.

In case of the Asiatic Lion, out of 75 samples (39 males and 36 females) examined, 52 (28 males and 24 females) samples (69.33%) were positive for helminthic infection; *Toxocara* infection was present during all the months except in October, November and January; *Toxascaris* (Fig.18) present except in August, October, November, January, March and April; *Ancylostoma* (Fig.19) present except in May, June and January and *Strongyloides* present only in August. The overall intensity of infection varied from + to ++++ and multiple infections were present in 21 samples examined.

Out of 43 samples from male animals examined in the Indian Leopard, 30 (69.76%) were positive for helminthic infections; *Diphyllobothrium* (Fig.21) infection was present during the entire study period; *Ancylostoma* (Fig.22) present during all the months except in May; *Paragonimus* (Fig.20) present except in May, July , August and October and *Strongyloides* present only in September. Twenty six samples were having multiple infections and the overall intensity of infection ranged from + to ++++++ during the study period.

In case of the Jungle Cat, out of 16 samples from a male animal examined, all (100%) were positive; *Toxocara* infection was present during all the months except in December, January, February and April; spirurid present during all the months except in December and March; *Diphyllobothrium* (Fig.25) present except in May, June and January and *Capillaria* (Fig.23) and *Hymenolepis* (Fig.24) present only in December. The overall intensity of infection varied from + to ++++++ and multiple infections were present in 13 samples examined.

In Jackal, out of 12 samples from a male animal examined, all the 12 (100%) were positive for helminthic infections; *Ancylostoma* infection was present during all the months except in May and June; *Strongyloides* infection present in May, July, August and September and *Capillaria* (Fig.26) present only in June, October and March. Seven samples were having multiple infections and the overall intensity of infection ranged from + to ++++ during the study period.

Table 7. Species-wise monthly prevalence of helminthic infections among carnivores (All the animals were above 1 year age):

7.1 Asiatic Lion

Species	Number of samples examined			Number of samples found positive			Prevalence (%)
	Male	Female	Total	Male	Female	Total	
May-'98	1	1	2	1	1	2	100.00
Jun-'98	1	1	2	1	1	2	100.00
Jul-'98	3	3	6	3	3	6	100.00
Aug-'98	2	2	4	2	2	4	100.00
Sep-'98	3	1	4	3	1	4	100.00
Oct-'98	2	-	2	2	-	2	100.00
Nov-'98	8	8	16	6	7	13	81.25
Dec-'98	7	8	15	3	1	4	100.00
Jan-'99	3	3	6	-	-	-	0.00
Feb-'99	3	3	6	2	2	4	66.66
Mar-'99	3	3	6	2	3	5	83.33
Apr-'99	3	3	6	3	3	6	100.00
Whole year	39	36	75	28	24	52	69.33

7.2 Jungle Cat, Jackal and Indian Leopard

Month	Jungle cat (1 male)			Jackal (1 male)			Indian Leopard (3 males)		
	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
May-'98	1	1	100.00	1	1	100.00	2	1	50.00
Jun-'98	1	1	100.00	1	1	100.00	3	2	66.66
Jul-'98	1	1	100.00	1	1	100.00	2	1	50.00
Aug-'98	1	1	100.00	1	1	100.00	3	2	66.66
Sep-'98	1	1	100.00	1	1	100.00	3	2	66.66
Oct-'98	2	2	100.00	1	1	100.00	2	1	50.00
Nov-'98	1	1	100.00	1	1	100.00	10	7	70.00
Dec-'98	2	2	100.00	1	1	100.00	7	6	85.71
Jan-'99	1	1	100.00	1	1	100.00	3	2	66.66
Feb-'99	2	2	100.00	1	1	100.00	2	2	100.00
Mar-'99	1	1	100.00	1	1	100.00	3	2	66.66
Apr-'99	2	2	100.00	1	1	100.00	3	2	66.66
Whole year	16	16	100.00	12	12	100.00	43	30	69.76

Table 8. Month-war prevalence of infection in the various species of Carnivores (details regarding intensity and nature of infection described in the text)

Month	Asiatic Lion	Indian Leopard	Jungle Cat	Jackal
May-98	*Toxocara* *Toxascaris*	*Diphyllobothrium*	*Toxocara* Spirurid	*Strongyloides*
Jun-98	*Toxocara* *Toxascaris*	*Diphyllobothrium* *Paragonimus* *Ancylostoma*	*Toxocara* Spirurid	*Capillaria*
Jul-98	*Toxocara* *Toxascaris* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma*	*Toxocara* *Diphyllobothrium* Spirurid	*Strongyloides* *Ancylostoma*
Aug-98	*Toxocara* *Ancylostoma* *Strongyloides*	*Diphyllobothrium* *Ancylostoma*	*Toxocara* *Diphyllobothirum* Spirurid	*Strongyloides* *Ancylostoma*
Sep-98	*Toxocara* *Toxascaris* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma* *Paragonimus* *Strongyloides*	*Toxocara* *Diphyllobothrium* Spirurid	*Strongyloides* *Acylostoma*
Oct-98	*Toxascaris* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma*	*Toxocara* *Diphyllobothrium* Spirurid	*Ancylostoma* *Capillaria*

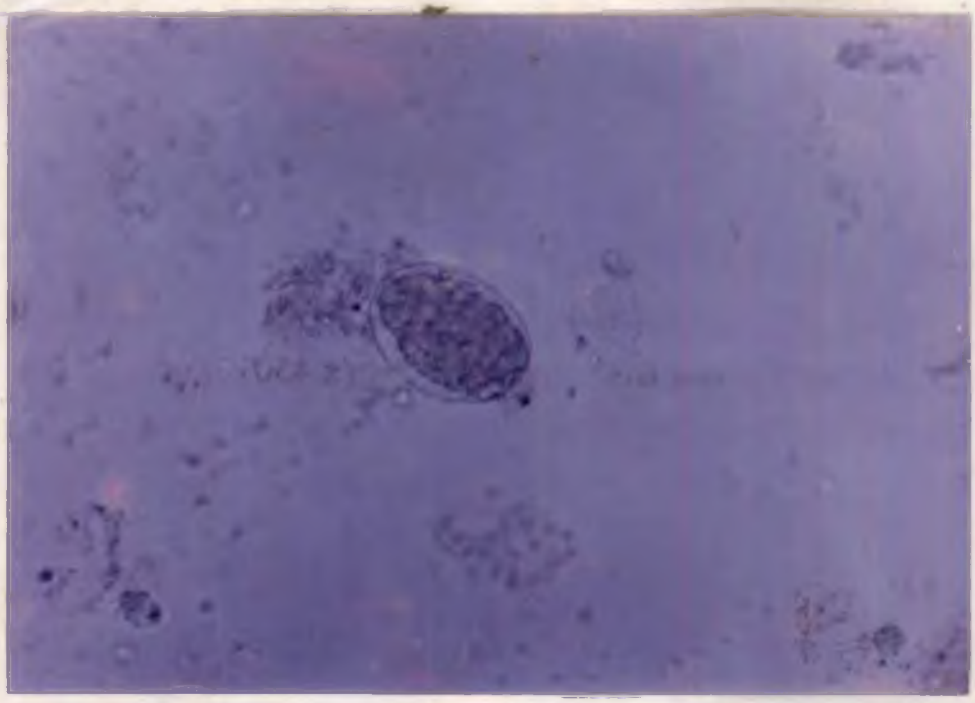
Contd.

Table 8 (Contd.)

Nov-98	*Toxascaris* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma* *Paragonimus*	*Toxocara* *Diphyllobothrium* Spirurid	*Ancylostoma*
Dec-98	*Toxocara* *Toxascaris* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma* *Paragonimus*	*Diphyllobothrium* *Capillaria* *Hymenolepis*	*Ancylostoma*
Jan-99	-	*Diphyllobothrium* *Ancylostoma* *Paragonimus*	Spirurid	*Ancylostoma*
Feb-98	*Toxocara* *Toxascaris* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma* *Paragonimus*	*Diphyllobothrium* Spirurid	*Ancylostoma*
Mar-99	*Toxocara* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma* *Paragonimus*	*Diphyllobothrium* *Toxocara*	*Ancylostoma* *Capillaria*
Apr-99	*Toxocara* *Ancylostoma*	*Diphyllobothrium* *Ancylostoma* *Paragonimus*	*Diphyllobothrium* *Toxocara* Spirurid	*Ancylostoma*

Fig.19 *Ancylostoma* ovum from Asiatic Lion (x 450)

Fig.20 *Paragonimus* ovum from Indian Leopard (x 450)



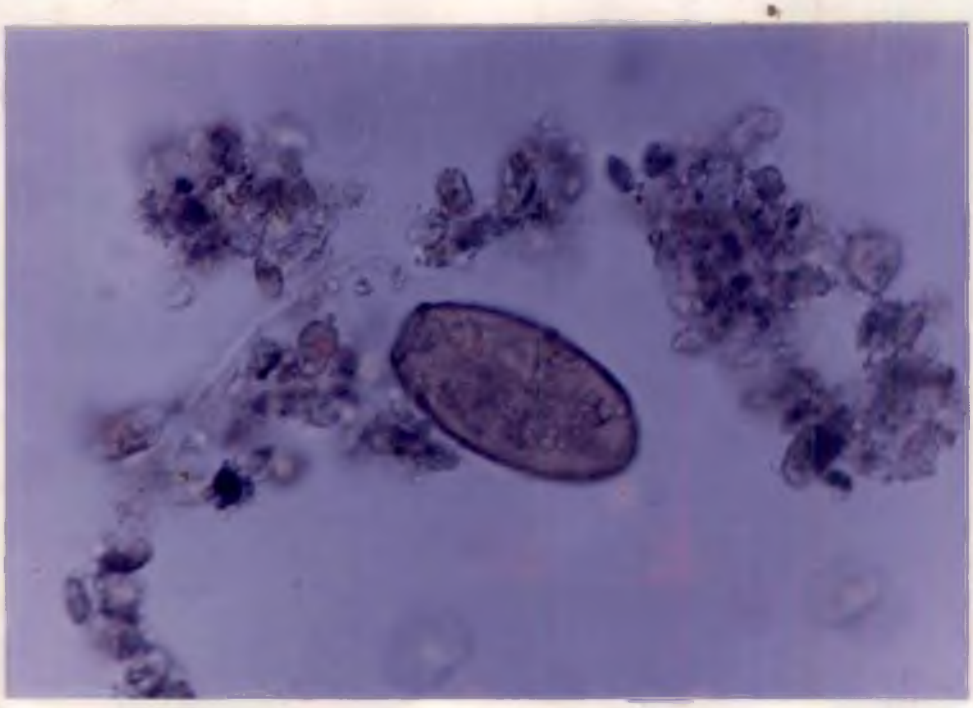


Fig.21 *Diphyllobothrium* ovum from Indian Leopard (x 450)

Fig.22 *Ancylostoma* ovum from Indian Leopard (x 450)

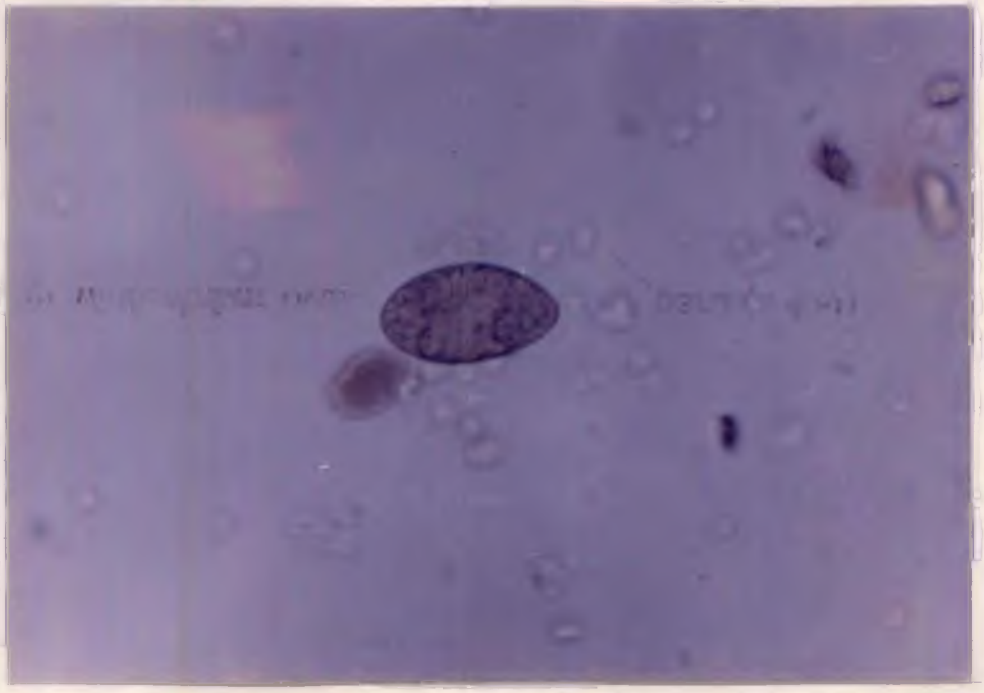
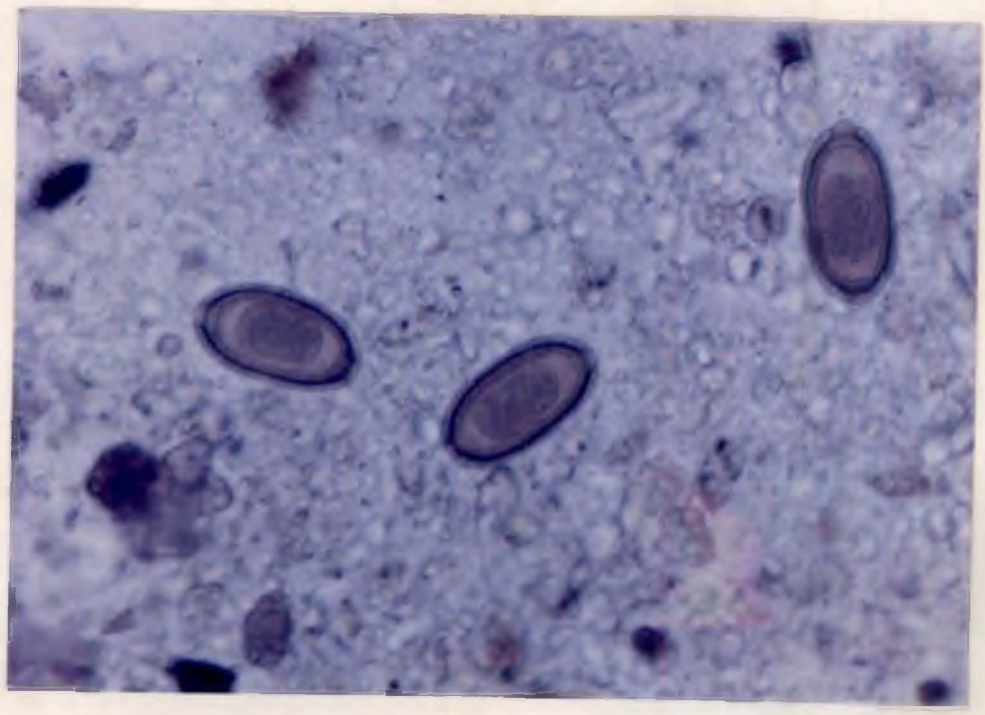


Fig.23 *Capillaria* ova from Jungle Cat (x 450)

Fig.24 *Hymenolepis* ovum from Jungle Cat (x 450)



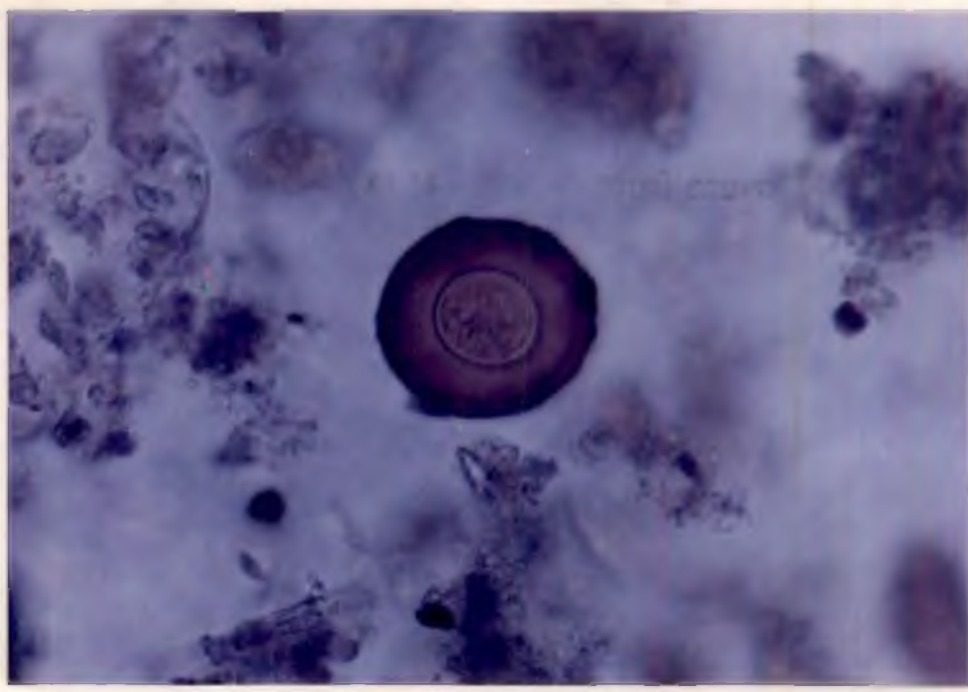
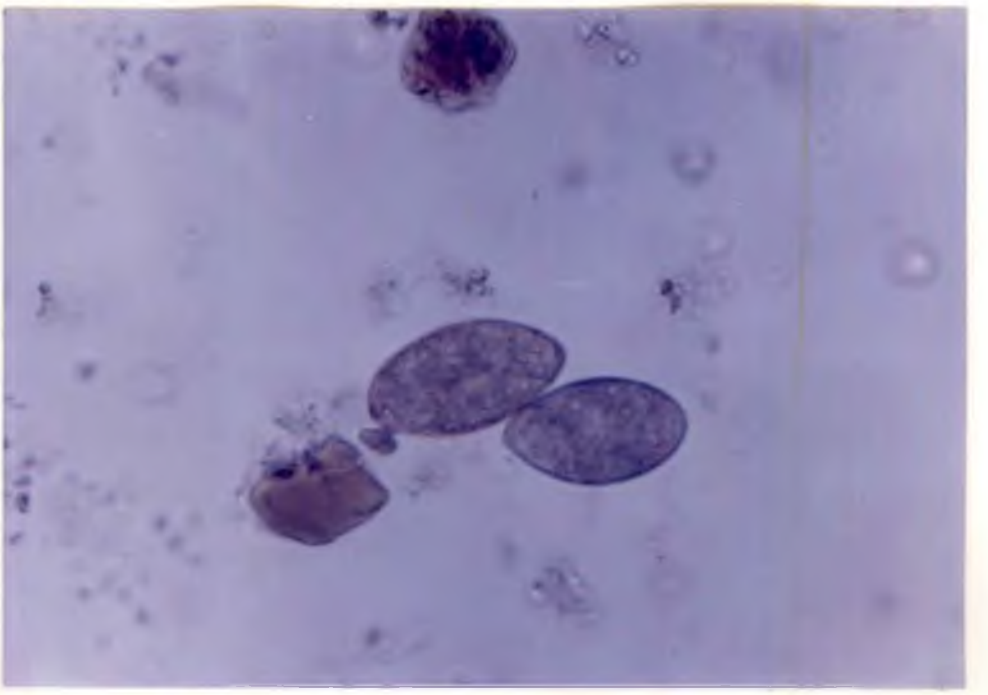
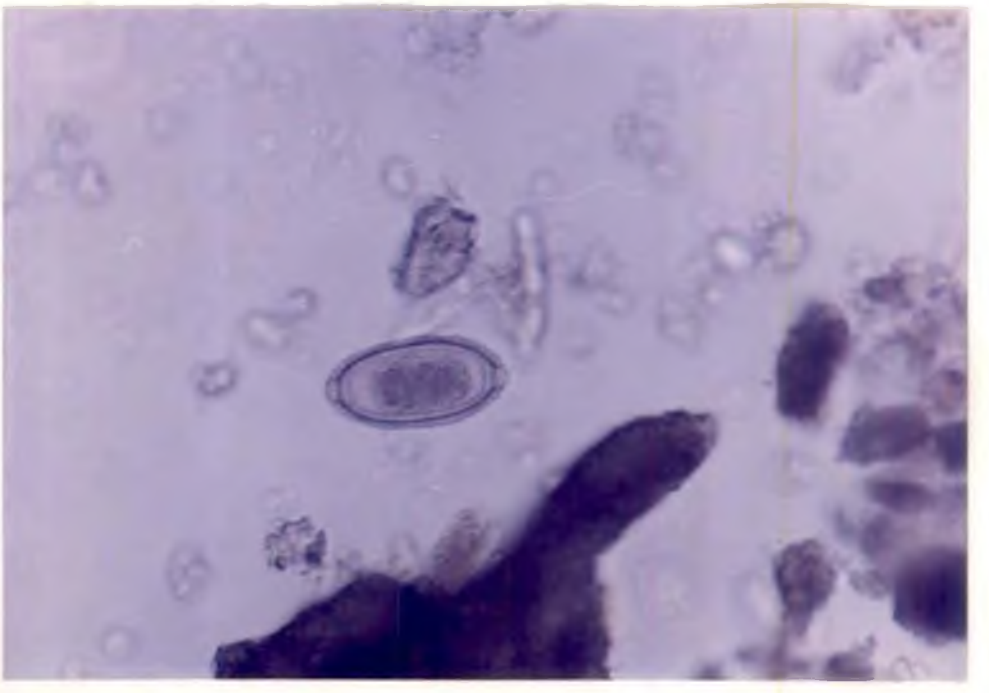


Fig.25 *Diphyllobothrium* ova from Jungle Cat (x 450)

Fig.26 *Capillaria* ovum from Jackal (x 450)





4.2.2 Determination by post-mortem examination

Although 24 animals were known to have been autopsied during the study period, only 3 of the same could be screened for parasites as the autopsies of the rest were not known in time. The zoo autopsy records revealed no parasitic infections whereas the 3 screenings revealed parasitic infections. The details are furnished hereunder:

1. A 6 year old female blackbuck, which had died due to post-partum uterine rupture, revealed ova of strongyle as well as spirurid in the rectal faecal sample and a few round worms in the abomasal contents. Based on the morphological parameters and measurements, the recovered worms were identified as *Haemonchus contortus*.

2. A 10 year old male spotted deer had died due to acute pneumonia. The rectal faecal samples revealed the ova of two strongyle, one spirurid and one ascarid species but no worms were recovered from the animal.

3. A 7 year old female spotted deer died due to traumatic shock. The rectal faecal samples from the animal revealed one type each of strongyle and spirurid ova. No worms were recovered from the animal.

4.3 Variation in the prevalence of helminthic infections

4.3.1 Seasonal variation

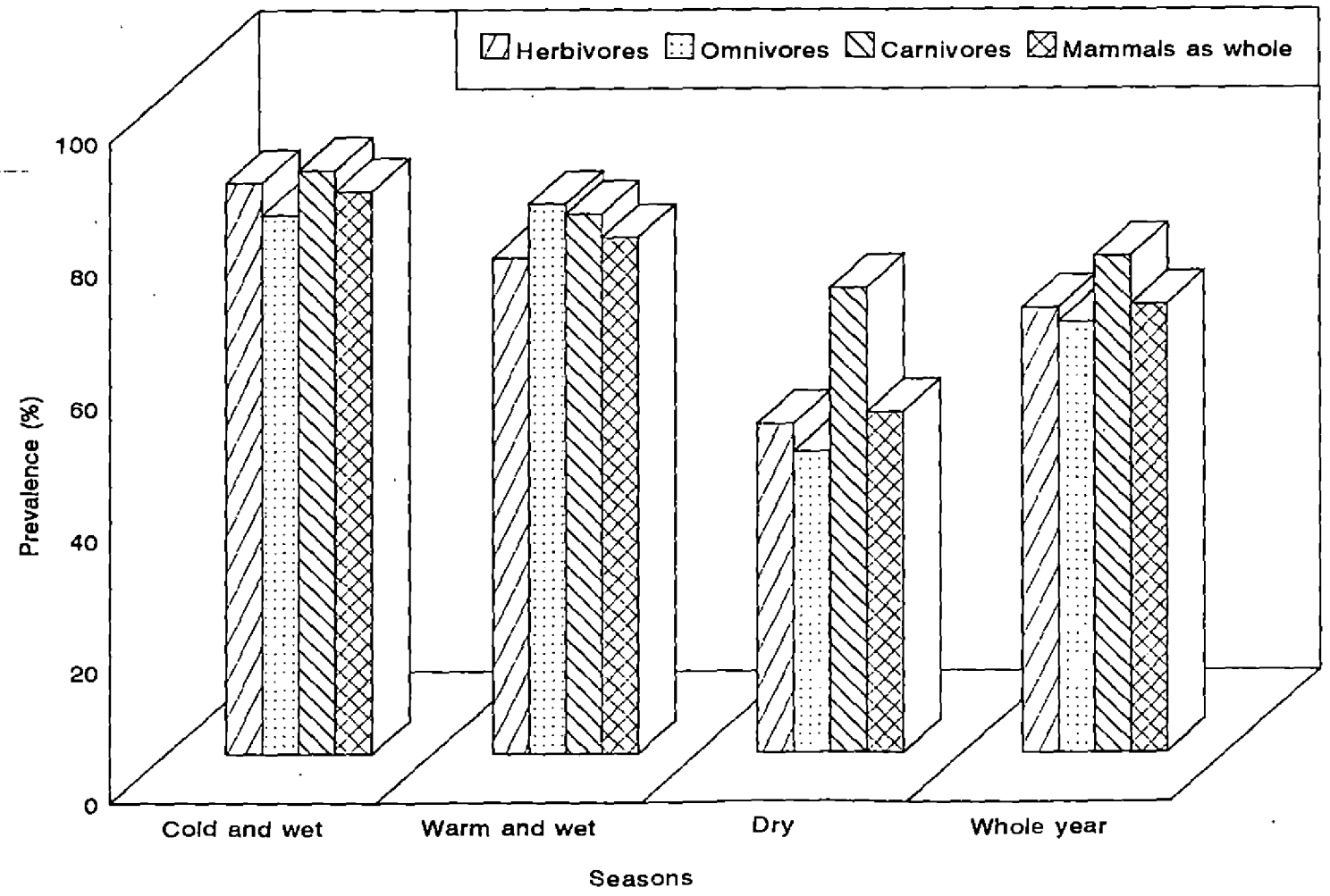
Seasonal variation in the prevalence of helminthic infections among mammals is presented in Table 9 and Graph 2. The prevalence of infection was higher among herbivores during both the rainy seasons i.e., South-West monsoon and North-East monsoon, the rates being 86.56 per cent and 75.14 per cent respectively, when compared to the dry season (50.00%). Among omnivores, the prevalence was higher during the rainy seasons - South-West and North-East monsoons (81.69% and 83.33% respectively) -, as against the dry season with the prevalence rate being only 45.80 per cent. Carnivores had comparatively higher prevalence in all the seasons, South-West monsoon, North-East monsoon and dry season, the rates being 88.46 per cent, 81.81 per cent and 70.58 per cent respectively.

In general, the prevalence was comparatively higher in the rainy seasons - South-West and North-East monsoons -, the rates being 85.28 per cent and 78.26 per cent respectively as against only 51.74 per cent in the dry season.

Table 9. Seasonal variation in the prevalence of helminthic infections among mammals

Season	Herbivores			Omnivores			Carnivores			Mammals as whole		
	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
Cold and wet South-West monsoon (June-August)	134	116	86.56	71	58	81.69	26	23	88.46	231	197	85.28
Warm and wet North-East monsoon (September-November)	177	133	75.14	78	65	83.33	44	36	81.81	299	234	78.26
Dry (December-May)	224	112	50.00	131	60	45.80	76	51	70.58	431	223	51.74
Whole year	535	361	67.47	280	183	65.35	146	110	75.34	961	654	68.05

Graph 2. Seasonal variation in the prevalence of helminthic infections among mammals



4.3.2 Age variation

Effect of age variation in the prevalence of helminthic infections among mammals is presented in Table 10 and Graph 3. It was observed that among mammals as a whole, the adult animals (age of 1 year and above) had comparatively higher prevalence, the rate being 70.50 per cent, as against only 54 per cent in case of younger animals (age of 1 month to 1 year).

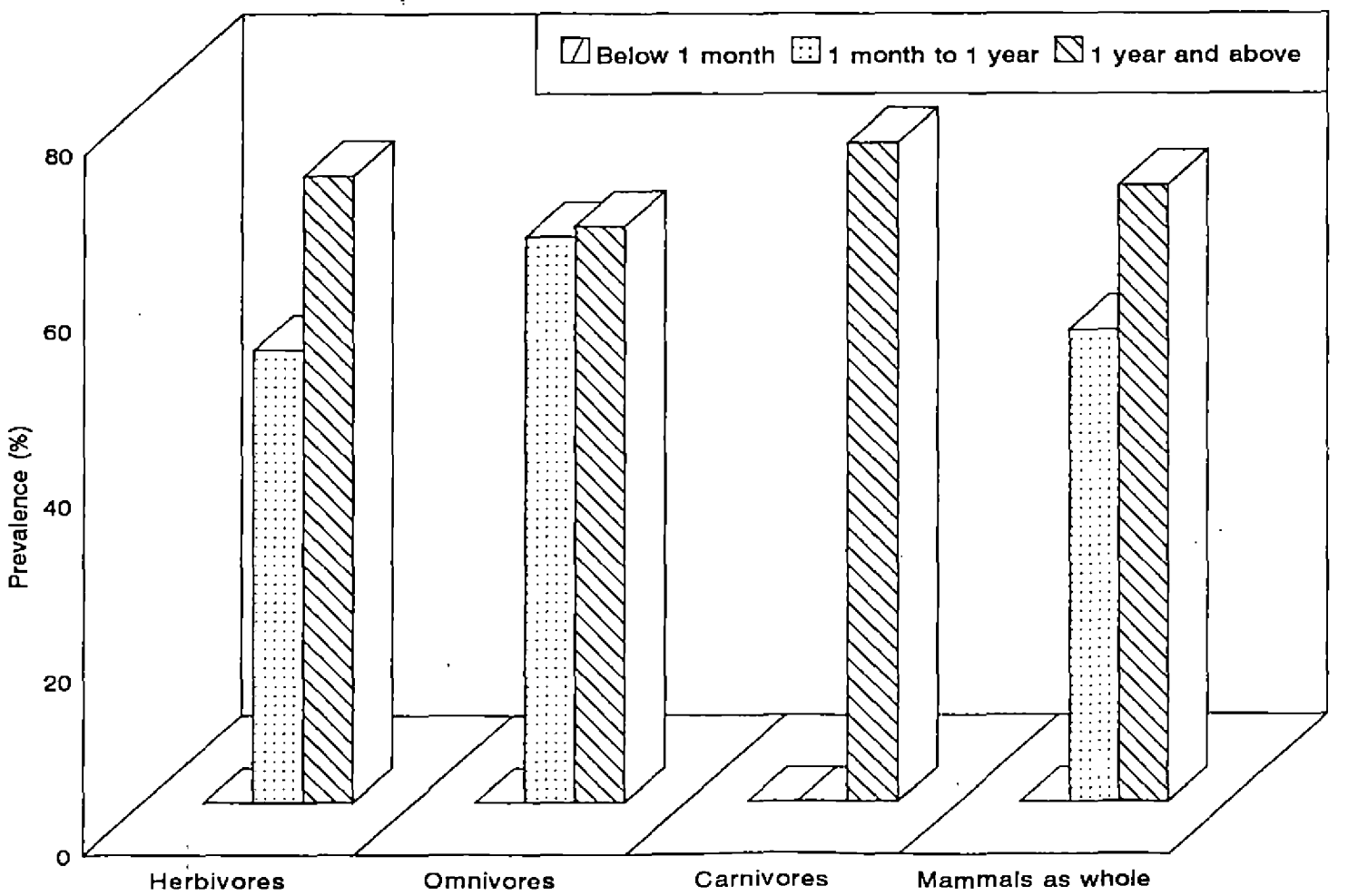
Influence of age on the prevalence of helminthic infections revealed that the adult ones (age of 1 year and above) of herbivores and omnivores had higher prevalence of infection, the rates being 71.62 per cent and 65.90 per cent respectively, when compared to their younger counterparts (age of 1 month to 1 year), the rates being only 51.80 per cent and 64.70 per cent respectively. The young animals belonging to below 1 month of age were found to be negative for helminthic infections in both groups.

Table 10. Age variation in the prevalence of helminthic infections among mammals

Age group	Herbivores			Omnivores			Carnivores			Mammals as whole		
	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)	Number of samples examined	Number of samples found positive	Prevalence (%)
Below 1 month	8	-	0.00	2	-	0.00	*-	-	-	10	-	0.00
1 month to 1 year	83	43	51.80	17	11	64.70	*-	-	-	100	54	54.00
1 year and above	444	318	71.62	261	172	65.90	146	110	75.34	851	600	70.50
Total	535	361	67.47	280	183	65.32	146	110	75.34	961	654	68.05

* No animal of the age group present

Graph 3. Age variation in the prevalence of helminthic infections among mammals



4.3.3 Sex variation

Sex variation in the prevalence of helminthic infections among herbivores, omnivores and carnivores is presented in Table 11.1, 11.2 and 11.3 respectively and in Graph 4.

In herbivores, the prevalence of infection was comparatively higher in males (72.62%) than in females (70.21%).

In case of carnivores also, the prevalence was higher in males (78.18%) when compared to females (66.66%).

Among omnivores, the prevalence of infection was more or less equal in case of males (65.31%) and females (65.42%).

Table 11. Sex variation in the prevalence of helminthic infections among mammals

11.1 Herbivores*

Species	Number of samples examined		Number of samples found positive		Prevalence (%)	
	Male	Female	Male	Female	Male	Female
Spotted Deer	84	96	61	66	72.61	68.75
Sambar	31	33	20	25	64.51	75.75
Hog-Deer	24	25	15	15	62.50	60.00
Blackbuck	40	2	33	2	82.50	100.00
Camel	17	18	16	12	94.11	66.66
Hippopotamus	12	14	10	12	83.33	85.71
Pony	12	-	5	-	41.66	-
Barking Deer	12	-	3	-	25.00	-
Kashmere Goat	24	-	23	-	95.83	-
Total	256	188	186	132	72.65	70.21

* 91 samples from young animals (below 1 year in age) including 72 from spotted deer, 11 from sambar, 5 from hog-deer and 3 from blackbuck have not been included due to inability in determining the sex

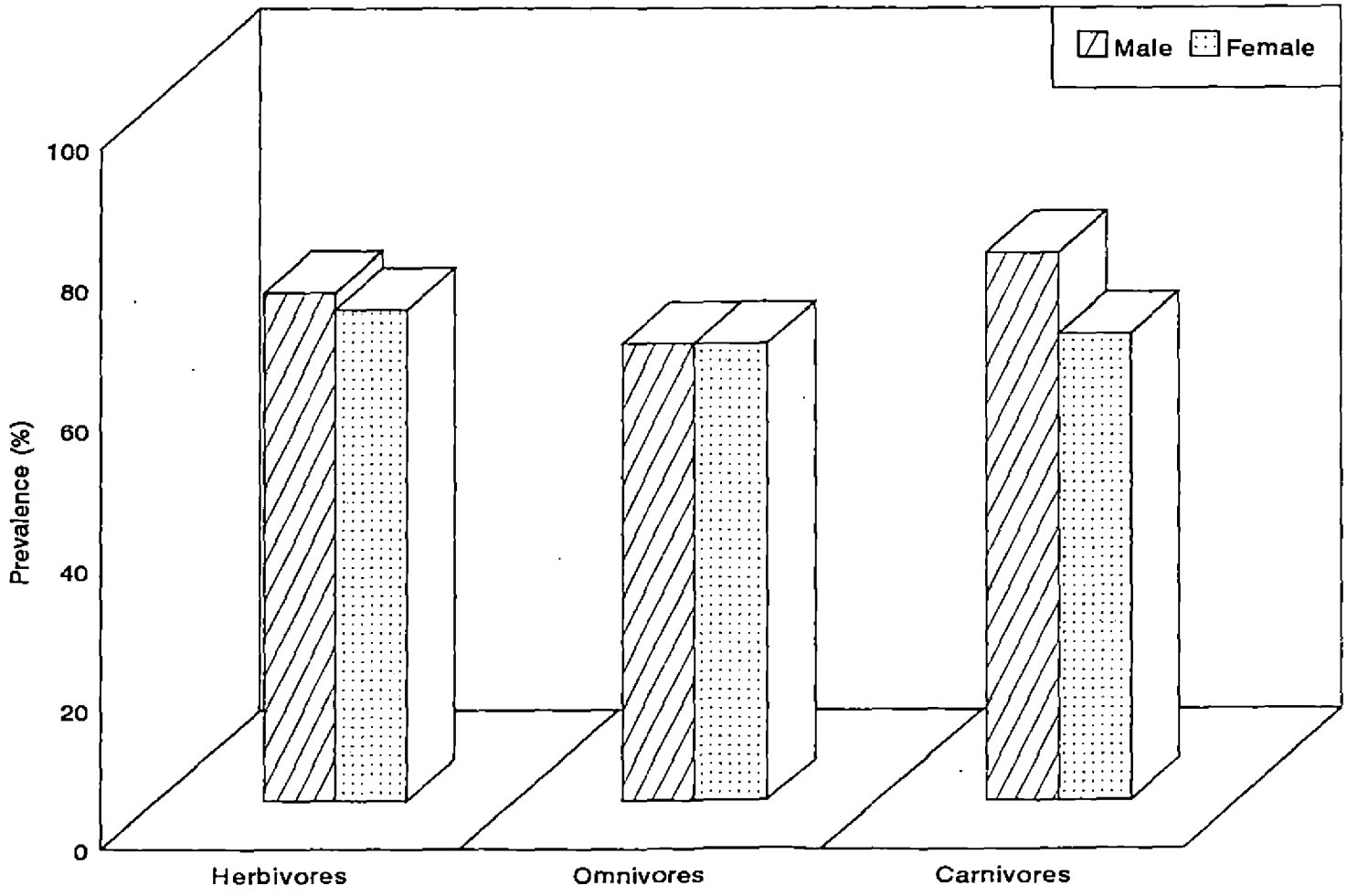
11.2 Omnivores

Species	Number of samples examined		Number of samples found positive		Prevalence (%)	
	Male	Female	Male	Female	Male	Female
Bonnet Macaque	50	51	30	33	60.00	64.70
Liontailed Macaque	31	7	18	5	58.06	71.42
Toddy Cat	13	13	4	4	30.76	30.76
Small Indian Civet	12	13	11	9	91.66	69.23
Indian Wild Boar	20	11	18	11	90.00	100.00
Himalayan Black Bear	12	-	5	-	41.66	-
Sloth Bear	12	-	4	-	33.33	-
Indian Porcupine	23	-	23	-	100.00	-
Rhesus Macaque	-	12	-	8	-	66.66
Total	173	107	113	70	65.31	65.42

11.3 Carnivores

Species	Number of samples examined		Number of samples found positive		Prevalence (%)	
	Male	Female	Male	Female	Male	Female
Asiatic Lion	39	36	28	24	71.79	66.66
Indian Leopard	43	-	30	-	69.76	-
Jackal	12	-	12	-	100.00	-
Jungle Cat	16	-	16	-	100.00	-
Total	110	36	86	24	78.18	66.66

Graph 4. Sex variation in the prevalence of helminthic infections among mammals



4.4 Observations on the treatment for helminthic infections in zoo mammals

The following treatments for parasitic infections were carried out by the zoo personnel during the study period.

1. Faecal sample examination of the 2 camels had revealed infections with strongyle, *Strongyloides*, ascarid and *Trichuris*. Single dose of Fenbendazole at the rate of 3 g/animal was given orally in banana, to the 2 camels each during the month of September, 1998. It was observed that the drug was effective against strongyle, ascarid and *Strongyloides* infections but was ineffective against *Trichuris*.

2. Faecal examination of 2 out of the 3 Indian leopards had revealed infections with *Diphyllobothrium*, *Paragonimus* and *Ancylostoma*. Two treatments at 21 days interval were given with Pyrantel Pamoate (Nemocid) at the rate of 750 mg/animal orally in meat. It was observed that the drug was ineffective against the above mentioned helminths.

3. Faecal examination of 6 Asiatic lions had revealed infections with *Toxocara*, *Toxascaris*, *Strongyloides* and *Ancylostoma*. In the case of the 6 Asiatic lions also, two treatments were given during the months of November and December with Pyrantel Pamoate (Nemocid) at the rate of 1,000 mg/animal orally in meat. It was observed that the drug was effective against the gastro-intestinal nematodes *Toxocara*, *Toxascaris*, *Strongyloides* and *Ancylostoma*.

Discussion

Chapter - V

DISCUSSION

5.1 General health alternations in the zoo animals due to parasitic infections

The present investigation revealed that wild mammals in the zoo did not show in general, considerable specific clinical symptoms due to parasitic infections. This is in accordance with the observation of Muraleedharan *et al.* (1990), who have also stated that in the long run the parasitic infections might produce ill effects such as emaciation and weakness which would later be responsible for inviting other pathogens. However, the present study also showed clinical symptoms like general weakness, debility, occasional diarrhoea, dehydration and alopecia due to parasitic infections in a variety of wild mammals. This is in agreement with the observations of Gaur *et al.* (1979); Maske *et al.* (1990); Gogoi (1994); Maity *et al.* (1994) and Thiruthalinathan *et al.* (1998). But, Zuchowka (1988) reported that most of the helminthic infections were asymptomatic in wild ruminants.

In the present study, respiratory distress with consistent cough was observed in an Indian leopard which was

having *Paragonimus* infection. Such reports are lacking in literature.

5.2 Prevalence of heminthic infections among zoo mammals

5.2.1 Determination by faecal examination

The overall prevalence of helminthic infections among the mammals of the zoo was seen to be 68.05 per cent (Table 2) as against only 36.1 per cent in wild animals of the Korean Zoo (Lim and Lee, 1977); 30.3 per cent in wild animals of Lubumbashi Zoo, Zaire (Pandey, 1978); 45.49 per cent in wild and zoo animals in Uttar Pradesh (Gaur *et al.*, 1979); 45 per cent in wild animals at Khartoum Zoo, Sudan (Saad *et al.*, 1983); only as low as 9.6 per cent in mammals at Zoological Gardens, Dublin (Geraghty *et al.*, 1982); 31.10 per cent in mammals of the Mysore Zoo (Muraleedharan *et al.*, 1990) and 60.71 per cent in zoo animals of Maharaj Bag, Nagpur (Maske *et al.*, 1990). The comparatively higher prevalence of helminthic infection in the present study might be due to the fact that the animals were not being screened regularly for parasitic infections and also that regular deworming schedules were not being followed.

In the present study, it is observed that carnivores carried the highest prevalence (75.34%) when compared to

herbivores (67.47%) and omnivores (65.35%). This is in contrast with the findings of Tigin *et al.* (1989) who have reported that omnivores had the highest infection rate of 50 per cent while herbivores and carnivores had the infection rates of only 39.4 per cent and 28.8 per cent respectively in AOC Zoological Garden, Ankara, Turkey; but in agreement with that of Niphadkar *et al.* (1989) who have reported the prevalence rates of 36.79 per cent and 15.2 per cent in carnivores and herbivores respectively in Bombay Zoo. The present observation is comparatively higher than the prevalence rates of 41.66 per cent, 43.39 per cent and 40.00 per cent in cases of primates, herbivores and carnivores respectively in Bannerghatta National Park, Bangalore (Reddy *et al.*, 1992).

The finding that the highest prevalence of helminthic infection occurs in carnivores is in agreement with the observations of Hansel and Ruscher (1980) as also Salman and Shah (1989) who have examined carnivores only and found that the rates of prevalence were 72.6 per cent and 91.80 per cent in the case of wild cats in Germany and large cats of Lucky Irani Circus as well as the Lahore and Bahavalpur Zoos in Pakistan respectively. However, this finding is in contrast with those of Khan (1987) and Hasslinger *et al.* (1992) who have also examined carnivores only and found the prevalence rate to be 13.3 per cent and 51.9 per cent as well as 22.2 per

cent in the cases of wild cats in Lucknow and of carnivorous animals of Zoological Gardens in Egypt as well as in Germany respectively. The higher prevalence of helminthic infection in the case of carnivorous animals in the present study might be due to the fact that the animals were kept in cages without provision for moving out, coupled with unhygienic conditions prevailing in the cages. Continued exposure to the infective stages of the helminth parasites leads to consistent reinfections in the animals.

It is found in the present study that the prevalence of helminthic infection was 67.47 per cent in the case of the zoo herbivores as against only 40.35 per cent in free-living herbivores in Kaziranga National Park, Assam (Chakraborty and Islam, 1996). So, it is clear that in captivity in the zoo the animals were present in a confined locality and exposed themselves continuously to the infective stages of the parasites, which would be responsible for consistent reinfections as in the carnivores.

Herbivores

It can be seen from Table 3 that the rates of prevalence of helminthic infection in the cases of Spotted Deer, Sambar, Hog-Deer, Barking Deer, Blackbuck, Kashmere Goat, Camel, Hippopotamus and Pony were 63.88 per cent, 62.66 per cent, 62.96 per cent, 25.00 per cent, 84.44 per cent, 95.83 per

cent, 80.00 per cent, 84.61 per cent and 41.66 per cent respectively.

Ramasamy *et al.* (1985) have reported that only 30.96 per cent of spotted deer in 3 National Parks had *Muellerius* infection while Su and Lee (1987) have reported that 39.6 per cent of deer from Taiwan were infected with endoparasites. In the case of camels also, identical findings were encountered by Magzoub *et al.* (1997). Information regarding the prevalence of infection in cases of the rest of the animals is lacking in literature.

From Table 4 it is found that strongyle, *Strongyloides*, spirurid, ascarid, amphistome, *Fasciola*, *Trichuris* and *Parascaris* infections were present in a variety of species of herbivores. This is in agreement with the findings of Chauhan *et al.* (1973); Lim and Lee (1977); Khan (1979); Quesada and Maggio (1982); Adkoli *et al.* (1986); Su and Lee (1987); Tigin *et al.* (1989); Chakraborty and Islam (1996); Gupta and Yadav (1997) and Magzoub *et al.* (1997). In the present study, *Trichuris* sp. infection was not noticed in Sambar whereas Hiregoudar (1976) reported the eggs of *Trichuris* sp. only in Sambar.

Omnivores

In the present investigation, it is observed that the rates of the prevalence of helminthic infection were 62.37 per cent, 60.52 per cent, 66.66 per cent, 41.66 per cent, 33.33 per cent, 30.76 per cent, 80.00 per cent, 100.00 per cent and 93.54 per cent in the cases of Bonnet Macaque, Liontailed Macaque, Rhesus Macaque, Himalayan Black Bear, Sloth Bear, Small Indian Civet, Toddy Cat, Indian Porcupine and Indian Wild Boar respectively (Table 5). The prevalence rate of helminthic infection in Bonnet Macaques in the present study is in contrast with the finding of Varadharajan and Pythal (1999) who have reported that the prevalence rate was 90 per cent in free living, feral Bonnet Macaques in Tamil Nadu. Such reports in the rest of animals are lacking in literature.

It can be seen from Table 6 that the types of infection in various species of omnivores were strongyle, *Strongyloides*, spirurid, ascarid, *Ancylostoma*, *Capillaria*, *Toxocara*, *Trichuris*, *Metagonimus*, *Artyfechinostomum* , *Joyeuxiella* and *Hymenolepis*. This is in accordance with the findings of Gaur *et al.* (1979);Lim and Lee (1977); Pandey (1978); Khan (1979); Adkoli *et al.* (1986); Tigin *et al.* (1989); Panda and Pal (1996) and Varadharajan and Pythal (1999).

Carnivores

In the present study, it is found that the rates of the prevalence of helminthic infection were 69.33 per cent, 69.76 per cent, 100.00 per cent and 100.00 per cent in the cases of Asiatic Lion, Indian Leopard, Jungle Cat and Jackal respectively (Table 7). This is in contrast with the observations of Sarode *et al.* (1993) who have reported that the rates of the prevalence of infection were 61.00 per cent and 60.00 per cent in case of lions and leopards respectively in Maharaj Bag Zoo, Nagpur and also with that of Modi *et al.* (1997a) who have reported that the prevalence of infection was 33.33 per cent and 53.85 per cent in case of lion and leopard respectively from Sanjay Gandhi Zoological Park, Patna and Jawaharlal Nehru Biological Park, Bokaro Steel City. However, the prevalence of infection in the jungle cat in the present study is in accordance with that reported by Modi *et al.* (*loc. cit.*). The information regarding the prevalence of infection in jackal is lacking in literature.

It can be seen from Table 8 that the types of helminthic infections observed in the different carnivorous animals were *Ancylostoma*, *Toxocara*, *Toxascaris*, *Strongyloides*, *Capillaria*, spirurid, *Diphyllobothrium*, *Hymenolepis* and *Paragonimus*. This is in accordance with the findings of Chauhan *et al.* (1973); Khan (1979); Hansel and Ruscher (1980); Lakshmanan and Joseph

(1980); Mandal and Choudhury (1985); Adkoli *et al.* (1986); Khan (1987); Tigin *et al.* (1989); Salman and Shah (1989); Niphadkar *et al.* (1989); Maske *et al.* (1992); Lu *et al.* (1992); Sarode *et al.* (1993); Rao and Acharjyo (1994) and Modi *et al.* (1997a).

5.2.2 Determination by post-mortem examination

In the present study, it is observed that only *Haemonchus contortus* was collected from the abomasum of a 6 year old female blackbuck. Although *Haemonchus contortus* was recovered from blackbuck in a zoo in the German Democratic Republic by Petersen (1977) and in the Edinburgh Zoo by Flach and Sewell (1987), in India only Patnaik (1964) has reported the same.

Examination of faecal samples collected from the rectum of a male and a female spotted deer were positive for two strongyle, one spirurid as well as one ascarid and one strongyle as well as one spirurid species respectively, during the post-mortem examinations but no worms could be recovered from the animals.

5.3 Variation in the prevalence of helminthic infections

5.3.1 Seasonal variation

Kerala, in which the place of present study located, is having a peculiar topography and climate. The rainfall is occurring from June to November comprising of the South-West and North-East monsoons followed by the hot dry season from December to May. During the rainy season, there will be lush growth of grasses and other plants and the climate is most suitable for the development and existence of infective stages of helminth parasites. So, the infection recurs repeatedly throughout the year.

From Table 9, it is observed that the prevalence of helminthic infections among wild mammals was comparatively higher in the rainy seasons - South-West monsoon and North-East monsoon -, the rates being 85.28 per cent and 78.26 per cent respectively as against only 51.74 per cent in the dry season. This is in agreement with the observations of Chauhan *et al.* (1973); Pandey (1978) and Niphadkar *et al.* (1989) who have reported that the prevalence of helminthic infections among wild mammals was higher during the months of rainy and winter seasons. But in Kerala there is no winter season and the rainy seasons extend upto November with higher prevalence rate during the time.

In the present study, it is observed that the rate of prevalence of infection was higher in carnivores during all the seasons when compared to omnivores and herbivores. This observation is contrary to the findings of Modi *et al.* (1997b) who have reported that herbivorous zoo animals in Bihar had comparatively higher prevalence of infection in all the seasons than carnivorous animals.

The seasonal variation in the prevalence of helminthic infection is pronounced only in the cases of herbivores and omnivores. This is in agreement with the observations of Mirck (1978), Su and Lee (1987), Gupta and Yadav (1997) and Magzoub *et al.* (1997) who have reported the seasonal influence in the parasitic burdens in case of ponies, deer, pony mares and Najdi camels respectively. Such reports in case of omnivores are lacking in literature. However, this is contrary to the finding of Bhat and Manickam (1998a) who have reported that the mean egg per gram of nematode infections in Sambar of different sanctuaries and parks in Tamil Nadu were not significant between seasons and parks. The seasonal influence in the prevalence of infection might be due to the fact that during rainy season the climate is conducive for the development of infective stages of the parasites and that the fodder is obtained from outside may be contaminated with such infective stages.

In case of carnivores, the seasonal influence on the prevalence of infection is not much pronounced. This is in agreement with the observations of Sarode *et al.* (1993). Majority of the carnivorous animals remain infected for the most part of the year irrespective of seasonal variation. This is in accordance with the findings of Modi *et al.* (1997b). However, Bhat and Manickam (1998b) have reported that in zoos, where regular deworming is followed, the infection was comparatively lower than in parks and sanctuaries.

5.3.2 Age variation

It can be seen from Table 10 that among mammals as a whole there is higher prevalence of helminthic infection in the adult animals (age of 1 year and above), the rate being 70.50 per cent, as against only 54 per cent in case of younger animals (age of 1 months to 1 year). Similar report is lacking in literature.

It is also observed that the adults of herbivores and omnivores had higher rates of infection, the rates being 71.62 per cent and 65.90 per cent respectively, when compared to their younger counterparts, the rates in which were only 51.80 per cent and 64.70 per cent respectively. This is in accordance with the findings of Modi *et al.* (1997c) who examined herbivorous and carnivorous animals (which included

some omnivorous animals also) in 2 wildlife preserves in Bihar and reported that the adult animals were having higher infections (47.89% in herbivorous and 57.81% in carnivorous animals) as compared to their younger counterparts (44.12% in herbivorous and 18.75% in carnivorous animals).

In the present study, the prevalence is comparatively lower in young animals (age of 1 month to 1 year) and zero in case of animals below one month old. This may be due to the fact that the numbers of samples of young animals (of both the 2 groups) were very small when compared to those from the adults.

5.3.3 Sex variation

It is observed that in omnivores the prevalence of infection was more or less equal in case of males (65.31 %) and females (65.42%) (Table 11.2). This is in contrast with the findings of Conti *et al.* (1983) who have reported that among black bears in Florida, USA, the intensities of helminthic infections were significantly higher in male animals.

In the case of carnivores, the prevalence is higher in males (78.18%) when compared to females (66.66%) (Table 11.3). This is also in contrast with the observation of Delahay *et al.* (1998) who have reported that female wild cats had significantly higher infection than males.

In herbivores, the prevalence of infection is comparatively higher in males (72.62%) than in females (70.21%) (Table 11.1). Similar report is lacking in literature.

However, the above-mentioned observations are comparable with those of Modi *et al.* (1998) who have reported that the average infection rate among zoo animals in Bihar was higher in males in both herbivorous (50%) and carnivorous (58.54%) animals as compared to those of females of both groups of animals i.e., 44.26 per cent and 41.03 per cent respectively.

5.4 Observations on the treatment for helminthic infections in zoo mammals

In the present study, it is observed that single dose of Fenbendazole at the rate of 3 g/animal was effective against strongyle, ascarid and *Strongyloides* infections but was ineffective against *Trichuris* infection in camels. This is in contrast with the observations of Partani *et al.* (1997) who have noticed a suspected resistance of *Strongyloides pappilosus* to Fenbendazole in camels. Ineffectiveness of a variety of Benzimidazole compounds against *Trichuris* infection in camels was reported by many authors; however, report of such lack of effect for Fenbendazole is lacking in literature. Chandrasekharan *et al.* (1970) reported that Thiabendazole was not effective in *Trichuris* infection in camels. Similar

finding was observed by Lodha *et al.* (1977) who have reported that Thiabendazole did not give encouraging results in camels. Bansal *et al.* (1989) have reported that Albendazole was ineffective against *Trichuris* infection in camels.

In the present study, it is found that 2 treatments at 21 days interval with Pyrantel Pamoate (Nemocid) at the rate of 750 mg/animal orally were not effective against *Diphyllobothrium*, *Paragonimus* and *Ancylostoma* infections in the Indian leopards. However, Maity *et al.* (1994) have reported that Nemocid at 1.5 tablets (i.e., 375 mg of Pyrantel Pamoate/animal) orally was effective against clinical toxocariasis in snow leopards. The lack of effect of the drug even against *Ancylostoma* infection in the present study might be due to the fact that the animals did not take the therapeutic dose of the drug. The same situation was observed also during the second treatment after 21 days interval.

However, in the present study, Pyrantel Pamoate at the rate of 1000 mg/animal was found to be effective against *Toxocara*, *Toxascaris*, *Strongyloides* and *Ancylostoma* infections in the Asiatic lions. No such report is available in literature. But, Tanwar *et al.* (1984) reported that Piperazine Adipate was highly effective against *Toxocara cati* and *Toxascaris leonina* infections in an Asian lion.

Control measures for the helminth parasites in zoo animals

There are a number of measures which the zoo authorities can adopt to reduce the incidence and intensity of gastro-intestinal parasites in the wild animals in captivity. Complete elimination of parasites is neither practicable nor necessary, but it must be remembered that an infected animal will keep on passing the eggs of the parasites along with the faeces and thus contaminating the areas where it frequents. Given the right conditions, particularly appropriate temperature and humidity, the eggs will soon develop to the infective stage and remain infective for considerable periods of time. However, in cases of trematodes, cestodes and also certain nematodes a suitable intermediate host is necessary for the development of infective stage. Thus, the following procedure may be adopted for the control of parasites in zoo animals.

1. Prompt removal and suitable disposal of faeces especially of the older animals.

2. Keeping cages, enclosures, open yards, etc. as clean and dry as possible.

3. Adequate, nutritious and wholesome feeding, specially the minerals.

4. Grasses, roughages and green leaves procured for feeding from outside should be obtained from sources known to be free of infection.

5. Drinking water should be available in raised troughs to avoid contamination.

6. Overstocking should be avoided as it leads to stress and lowers the animals' resistance for infection.

7. Mother and young stock should be raised separately from the other animals.

8. Regular screening of the zoo animals for parasitic infection followed by necessary routine anthelminthic treatment.

9. In certain cases, immature parasites are more resistant to treatment and hence the treatment may be repeated at 3-4 weeks interval.

10. Avoid any chance of stray animals frequenting the zoo area.

11. Proper quarantine measures should be adopted.

12. The post-mortem examination of any dead animal should be conducted in a separate place and disposal of the carcass should be carried out promptly and properly.

13. Visitors may be properly instructed not to feed the animals or disturb them.

14. Keepers should be properly trained for handling, cleaning, feeding and other routine activities.

15. Above all, a separate veterinary hospital and a full-time veterinarian should be available to monitor and control all the managemental and clinical measures in order to prevent parasitic infections among the zoo animals.

Anthelmintics recommended for the control of parasitic infections in zoo mammals

There are a good number of effective anthemintics available for the treatment of parasitic infections in domesticated animals. However, their use in wild animals is rare due mainly to the inability to recognise the clinical disease properly, to determine the effective dosage of the drugs and also to find out the drug toxicity in various species of wild animals. However, according to the available information the following anthelmintics may be used for the treatment of the different parasitic infections in wild animals.

For Nematodes

Piperazine Adipate (Vermex, Helmacid), Tetramisole (Curaminth, Decaris), Thiabendazole (Thiabendazole, Thiabendole), Morantel Tartrate (Banminth II), Mebendazole, (Mebex, Meben, Wormin), Fenbendazole (Panacur), Thiophanate (Thiophanate 70% w/w), Levamisole (Helmonil, Lemasol, Vermisol), Albendazole (Albomar, Valbazen, Vibex), Pyrantel Pamoate (Nemocid, Combantrin) and Ivermectin (Ivomec) may be used for the nematode infections in the zoo animals.

Lakshmanan and Joseph (1980) used Helmacid for the treatment of ascariasis in lion. Subsequently, Tanwar *et al.* (1984) have reported that Piperazine Adipate at the dose rate of 100 mg/kg body weight was highly effective for the treatment of clinical ascariasis in an Asian lion. Knottenbelt (1989) suggested that Piperazine Hydrochloride (64.5%) at the dose rate of 30 gm/100 kg body weight would be useful against ascarids in zoo animals.

The anthelmintic efficacy of Tetramisole in different species of zoo animals has been noted by various authors; Kageruka and Puijenbroeck (1967) reported that Tetramisole at the dose rate of 1.5 mg/kg orally or parenterally was effective against *Toxascaris* sp., *Toxocara* sp. and *Ancylostoma* sp., but not effective against *Trichuris* sp. in various species of carnivores. Chandrasekharan *et al.* (1972) reported

that the drug at 15 mg/kg body weight was 100 per cent effective against *Trichostrongylus colubriformis* and *Impalaia* sp. in camels. Lodha *et al.* (1977) reported that Tetramisole Hydrochloride (3%) at 0.5ml/kg body weight was effective against gastro-intestinal nematodes in camel. Similar finding was observed by Partani *et al.* (1997) who also reported a suspected resistance of *Haemonchus longistipes* to the drug in camels. Movchan and Veselova (1975) used Tetramisole for the treatment of gastro-intestinal parasites of primates at the dose rate of 1, 5 or 15 mg/kg body weight in Sukhumi Primate Centre, Moscow, USSR. Krait *et al.* (1977) have observed that at the dose rate of 10-15 mg/kg body weight, Tetramisole was highly effective against many nematodes in deer in the Voronezh National Park, USSR.

In the case of Thiabendazole, Chandrasekharan *et al.* (1970) have reported that at the dose rate of 50 mg/kg body weight orally, it was 100 per cent effective against *Trichostrongylus* in camels but not effective against *Trichuris* infection. Jones (1989) suggested that the drug at 50 mg/kg body weight was effective against gastro-intestinal nematodes in deer. Movchan and Veselova (*loc. cit.*) suggested that the drug at 25 or 100 mg/kg body weight was effective against certain nematodes in primates.

The efficacy of Morantel Tartrate was noted by Chandrasekharan *et al.* (1973) who have reported that at the dose rate of 10 mg/kg body weight it was 100 per cent and 48 per cent effective against *Trichostrongylous colubriformis* and *Trichuris globulosa* respectively in camel, 100 per cent effective against *Toxascaris leonina* in lion cub and 96.77 per cent effective against *Oesophagostomum* sp. in wild boar. Lodha *et al.* (1977) have reported that the drug (4%) at the dose rate of 1 ml/4 kg body weight was highly effective against mixed infection of *Trichuris, Haemonchus, Nematodirus* and *Strongyloides* in camels.

The efficacy of Mebendazole at 40 mg/kg body weight for 5 succesive days was 97-100 per cent against *Trichuris* infection in monkeys (Dollinger and Ruedi, 1974). However, 14 days treatment with the drug at 5 mg/kg body weight was necessary in zoo ruminants (Forstner *et al.*, 1976). Church (1983) successfully treated a suspected case of dictyocauliasis in a pony with the drug at 20 mg/kg body weight daily for 4 days.

In the case of Fenbendazole, Ramisz *et al.* (1978) reported that 2 treatments at the dose rate of 25 mg/kg body weight were highly effective against *Trichocephalus* sp. and *Ancylostoma* sp. in monkeys in a zoo in Poland. However, Bockeler and Lindau (1978) reported that the drug at 7.5 mg/kg

body weight and 50 mg/kg body weight in wild ruminants and wild carnivores respectively had good effect for the treatment of gastro-intestinal nematodes. Knottenbelt (1989) suggested that the drug as 10 per cent solution at the rate of 1 ml/20 kg body weight was effective against nematodes in zoo animals.

Chandrasekharan *et al.* (1979) reported that Thiophanate at 50 mg/kg body weight was 100 per cent and 85.72 to 100 per cent effective against nematodes of two wild boars and of 5 lion cubs respectively.

The efficacy of Levamisole was reported by Kumar *et al.* (1981) who successfully treated the spirurid infection in *Ateles* monkeys with the drug at 8 mg/kg body weight on day 1 and at 10 mg/kg body weight on days 5 to 8. Knottenbelt (*loc. cit.*) suggested that Levamisole (2.5%) at the dose rate of 3 ml/10 kg body weight orally in water was effective against nematodes in zoo animals. Jones (1989) also suggested that oral and parenteral administration of Levamisole at 7.5 mg/kg body weight was effective against nematodes of deer.

Bansal *et al.* (1989) reported that Albendazole at the dose rate of 5 mg/kg body weight was 100 per cent effective against various gastro-intestinal nematodes except *Trichuris* sp. in camels. Jones (*loc. cit.*) suggested that the drug at the same dose rate orally was effective against nematodes and cestodes in deer.

According to Maity *et al.* (1994) the efficacy of Pyrantel Pamoate at 375 mg/ animal was 100 per cent against clinical toxocariasis in snow leopards. In the present study, it is observed that the drug at 1,000 mg/animal was effective against *Toxocara*, *Toxascaris*, *Strongyloides* and *Ancylostoma* infections in Asiatic lions.

Knottenbelt (1989) suggested that parenteral administration of Ivermectin (1%) at 1 ml/kg body weight sub-cutaneously was highly effective against nematode infections in zoo animals.

For Cestodes

Mebendazole (Mebex, Meben, Wormin), Albendazole (Vibex, Valbazen, Albomar) and Niclosamide (Niclex, Niclosan) may be used for the treatment of cestode,infections in zoo animals.

It was Eriksen (1978) who recommended Mebendazole for the cestode infections in zoo primates, carnivores and Artiodactyla at the dosage of 5-10 mg/kg body weight over 5 successive days, of 15 mg/kg body weight over 2 successive days and of 15 mg/kg body weight over 2 successive days respectively.

Jones (1989) suggested that Albendazole at the dose rate of 5 mg/kg body weight orally was effective against cestode infections in deer.

Knottenbelt (1989) suggested that Niclosamide (20%) at the dose rate of 1 ml/4 kg body weight orally in water was effective against cestode infections in zoo animals.

For Trematodes

Rafoxanide (Ranide, Amfanide) and Nitroxynil (Trodax) may be used for the treatment of trematodes infections in zoo animals.

Knottenbelt (*loc.cit.*) suggested that Rafoxanide (3%) at the dose rate of 2.5 ml/10 kg body weight orally in water as well as Nitroxynil (34%) at the dose rate of 1.5 ml/150 kg body weight subcutaneously were effective against trematode infections in zoo animals.

Information regarding the effect of the other anthelmintics, routinely used in case of domesticated animals, for the treatment of helminthic infections of zoo animals appears to be lacking in literature.

Summary

Chapter - VI

SUMMARY

An investigation into the prevalence of helminthic infections among the wild mammals in captivity in the Thrissur Zoo and also the variations thereof on account of season, age and sex were carried out by regular faecal examination, using the concentration method of centrifugation-cum-sedimentation technique, over a period of one year from May-'98 to April-'99. Certain non-specific clinical symptoms such as general weakness, debility, occasional diarrhoea, dehydration and respiratory distress with cough were observed during the study period in a variety of the animals which were having helminthic infections.

The overall prevalence of the helminthic infection was 68.05 per cent. The highest prevalence was found during the months of July, August, September and October, the rates being 87.80 per cent, 88.76 per cent, 86.17 per cent and 82.41 per cent respectively; the moderate prevalence during June (76.66%) and November (68.42%) and the lowest prevalence during December (49.38%), January (49.23%), February (50%), March (50.72%), April (54.44%) and May (56.66%).

Carnivores had the highest overall prevalence of infection (75.34%) when compared to herbivores (67.47%) and omnivores (65.35%). Strongyle, *Strongyloides*, spirurid, ascarid,

amphistome, *Fasciola*, *Trichuris* and *Parascaris* infections in a variety of herbivores; strongyle, *Strongyloides*, spirurid, ascarid, *Ancylostoma*, *Capillaria*, *Toxocara*, *Trichuris*, *Metagonimus*, *Artyfechinostomum* and *Hymenolepis* infections in a variety of omnivores and *Ancylostoma*, *Toxocara*, *Toxascaris*, *Strongyloides*, *Capillaria*, spirurid, *Diphyllobothrium*, *Hymenolepis* and *Paragonimus* infections in a variety of carnivores were found during the present study.

During the post-mortem examination of a 6 year old female blackbuck, a few specimens of *Haemonchus contortus* were collected from the abomasum.

The prevalence of infection was comparatively higher during both the rainy seasons viz the South-West monsoon and the North-East monsoon (86.56% as also 75.14% respectively in herbvores and 81.69% as also 83.33% respectively in omnivores) than during the dry season (50% in herbivores and 45.80% in omnivores). Carnivores had comparatively higher prevalence in all the seasons, with the rates of 88.46 per cent, 81.81 per cent and 70.58 per cent respectively. The overall prevalence among the mammals was higher in the rainy seasons (South-west and North-East monsoons), the rates being 85.28 per cent and 78.26 per cent respectively, when compared to the dry season (51.74%).

The prevalence of helminthic infection was higher among the adult ones (age of 1 year and above) of herbivores and

omnivores, the rates being 71.62 per cent and 65.90 per cent respectively, when compared to their younger counterparts (age of 1 month to 1 year), the rates being only 51.80 per cent and 64.70 per cent respectively. The youngest animals (age below 1 month) of both the groups were found to be negative for helminthic infections. The overall prevalence of infections was comparatively higher in adult animals, being 70.50 per cent as against only 54 per cent in the case of younger animals.

The prevalence of helminthic infection was comparatively higher among the males of herbivores and carnivores, the rates being 72.62 per cent and 78.18 per cent respectively, as against those in the females of both the groups (only 70.21% and 66.66% respectively). Among the omnivores, the prevalence was more or less equal in the case of males (65.31%) and females (65.42%).

Two treatments at 21 days interval with Pyrantel Pamoate (Nemocid) at the dose rate of 1000 mg/animal were found to be effective against gastro-intestinal nematode infections with *Toxocara*, *Toxascaris*, *Strongyloides* and *Ancylostoma* in Asiatic lions. A single dose of Fenbendazole at 3 gm/animal was found to be effective against strongyle, *Strongyloides* and ascarid infections, but not against *Trichuris* infection in camels.

Control measures for the helminthic infections in the mammals have also been suggested.

References

REFERENCES

Addison, E.M., Pybus, M.J. and Retveld, H.J. (1978). Helminth and arthropod parasites of black bears (*Ursus americanus*) in Central Ontario. *Canadian J. Zool.* **56**(10): 2122-2126. [*Helminth. Abstr.* (1979) **48**: 2739].

Adkoli, N.S., Mondal, C.K. and Ghose, J.N. (1986). Parasitic infection in zoo animals. *Zoo Zen* **2**(3): 22-26.

Agrawal, R.D. and Ahluwalia, S.S. (1980). A note on the occurrence of *Gastrothylax crumenifer* in sambar (*Cervus unicolor*). *Indian Vet. J.* **57**(5): 436.

Agrawal, R.D., Ahluwalia, S.S. and Chauhan, P.P.S. (1986). Occurrence of aortic spirocercosis in jackal. *Indian J. Anim. Sci.* **56**(4): 402-403.

Amrithraj, M., Michael, B. and Pillai, K.M. (1999). *Artyfechinostomum malayanum* (Leiper, 1911) Mendheim, 1943 from a small Indian civet (*Viverricula indica*). *Zoos' Print* **24**(4): 6.

Arora, B.M. (1992). Impact of parasitic diseases on wild mammals. *Indian Zoo Bull.* **6**(1-2): 15-18.

Arora, B.M. and Das, S.C. (1988). Helminth infestation in a tigress (*Panthera tigris*). *Indian J. Vet. Med.* **8**(2): 154-156.

Ashizawa, H., Habe, S., Nosaka, D., Tateyama, S., Yamamoto, H., Yamaguchi, M. and Ogihara, T. (1979). Natural infection of a wild boar with *Paragonimus ohirai*. *Bull. Fac. Agric. Miyazaki Univ.* **26**(2): 299-304. [*Helminth. Abstr.* (1980) **49**: 416].

Bamidele, O. and Ogunrinade, A.F. (1980). Helminth parasites of captive animals. *African J. Eco.* 18(4): 265-266. [*Helminth. Abstr.* (1982) 51: 1127].

Bansal, S.R., Bhardwaj, R.M., Ram, S.M.T. and Bhatnagar, P.K. (1989). Preliminary field studies on the efficacy of albendazole against clinical cases of gastro-intestinal nematodiasis in camels in Haryana. *J. Vet. Parasitol.* 3(2): 143-144.

Bhat, M.N. and Manickam, R. (1998a). Coproculture and study of seasonal variation in parasitic burden in spotted deer (*Axis axis*) in different sancturies in Tamil Nadu. *Indian Vet. J.* 75(5): 469-471.

Bhat, M.N. and Manickam, R. (1998b). Intensity of nematode infection and coproculturing in sambar (*Cervus unicolor*). *Indian J. Anim. Sci.* 68(7): 643-644.

Bockeler, W. and Lindau, K.H. (1978). Experiences with fenbendazole in mammals at Cologne Zoo. *Zeitschrift des Kolnov Zoo.* 20(4):115-118. [*Helminth. Abstr.* (1980) 49: 32].

Brglez, J. and Zeleznik, Z. (1976). A survey of the parasites of wild cat (*Felis silvestris* Schreber) in Slovenia. *Zeitschrift fur Jagdwissenschaft.* 22(2): 109-112.

Chakraborty, A. and Chaudhury, B. (1996). Incidence and causes of mortality in captive wild herbivores of Assam State Zoo, India: 1985-1989. *Zoos' Print* 11(10): 11-12.

Chakraborty, A., Gogoi, A.R. and Chaudhury, B. (1994). Prevalence of parasitic infection in captive wild herbivores in a zoo in Assam, India. *Intl. J. Anim. Sci.* 9(2): 149-152.

Chakraborty, A. and Islam, S. (1996). A survey of gastrointestinal parasitic infection in some free-living herbivores in the Kaziranga National Park. *Zoos' Print* 11(3): 3-5.

Chandrasekharan, K., Nair, K.P.D., Sundaram, R.K. and Peter, C.T. (1970). On the use of Thiabendazole against *Trichostrongylus* infection and *Trichuris* infection in camel. *Kerala J. Vet. Sci.* 1(2): 129-132.

Chandrasekharan, K., Nair, K.P.D., Sundaram, R.K. and Peter, C.T. (1971). Anthelmintic activity of Parbendazole (Helmatac Premix) in Camel (*Camelus dromedarius*) and Nilgiri Tahr (*Hemitragus hylocrius*). *Kerala J. Vet. Sci.* 2(2): 135-138.

Chandrasekharan, K., Nair, K.P.D., Sundaram, R.K. and Peter, C.T. (1972). A note on a clinical trial with Tetramisole (Nilverm) in Camel (*Camelus dromedarius*) and Nilgiri Tahr (*Hemitragus hylocrius*) infected with gastro-intestinal helminths. *Kerala J. Vet. Sci.* 3(2): 120-126.

Chandrasekharan, K., Nair, K.P.D., Sundaram, R.K. and Peter, C.T. (1973). Use of Morantel Tartrate (Banminth-II) as an anthelmintic in zoo animals. *Kerala J. Vet. Sci.* 4(2): 193-195.

Chandrasekharan, K., Sathianesan, V., Pythal, C. and Sundaram, R.K. (1979). Anthelmintic activity of Thiophanate (Nemafax) in elephants and zoo animals. *Kerala J. Vet. Sci.* 10(1): 167-170.

Chauhan, P.P.S., Bhatia, B.B., Arora, G.S., Agrawal, R.D. and Ahluwalia, S.S. (1973). A preliminary survey of parasitic infections among mammals and birds at Lucknow and Delhi Zoos. *Indian J. Anim. Sci.* 43(2): 163-168.

Cheema, H.I., Iqbal, Z. and Jameel, N. (1992). Surveillance studies on parasitism in wild boar (*Sus scrofa*) in Punjab, Pakistan. *Vet. Rec.* 131(1): 16.

Church, S. (1983). Eosinophilic bronchitis associated with suspected *Dictyocaulus arnfieldi* infection in a pony. *Aus. Vet. Pract.* 13(2): 65-66. [*Helminth. Abstr.* (1983) 52: 5337].

Conti, J.A., Forrester, D.J. and Brandy, J.R. (1983). Helminths of black bears in Florida. *Proc. Helminth. Soc. Washington* 60(9): 285-286. [*Helminth. Abstr.* (1984) 53: 427].

Delahay, R.J., Daniels, M.J., Macdonald, D.W., McGuire, K. and Balharry, D. (1998). Do patterns of helminth parasitism differ between groups of wild-living cats in Scotland? *J. Zool.* 245(2): 175-183.

Diego, J.A., Mayer, R.D. and Reycalero, J.D. (1984). Coproparasitological study of toxoplasmosis in zoo felids. *Revista Iberica de Parasitologia.* 44(3): 247-251. [*Helminth. Abstr.* (1985) 54: 2339].

Dies, K.H. (1979). Helminths recovered from black bears in the Peace River Region of North-Western Alberta. *J. Wildl. Dis.* 15(1): 49-50.

Dollinger, P. and Ruedi, D. (1974). Endoparasites in the primate colony of the Basle Zoo and treatment trials with mebendazole and levamisole. *Zoologische Garten.* **44**(6): 329-337. [*Helminth. Abstr.* (1977) **46**: 1258].

Enigk, K. and Dey-Hazra, A. (1978). The treatment of round worm infections in wild animals and birds with Rintal. *Vet. Med. Rev.* 2: 195-203.

Eriksen, E. (1978). Control of cestodes in herds of animals in zoo and animal reserves. *Dansk Veterinaertidsskrift.* **61**(7): 333-336. [*Vet. Bull.* (1978) **48**: 5487].

Flach, E.J. and Sewell, M.M.H. (1987). Gastrointestinal nematodiasis in blackbuck (*Antelope cervicapra*) at Edinburgh Zoo. *J. Zoo Anim. Med.* **18**(2-3): 56-61.

Forstner, M.J., Wiesner, H., Jonas, D. and Kraneburg, W. (1976). Worming of zoo ruminants and Equidae with mebendazole. *Zoologische Garten.* **46**(6): 401-416. [*Vet. Bull.* (1977) **47**: 5258].

Gaur, S.N.S., Sethi, M.S., Tewari, H.C. and Prakash, O. (1979). A note on the prevalence of helminth parasites in wild and zoo animals in Uttar Pradesh. *Indian J. Anim. Sci.* **49**(2): 156-161.

Geraghty, V., Mooney, J. and Pike, K. (1982). A study of parasitic infections in mammals and birds at Dublin Zoological Gardens. *Vet. Res. Comm.* 5(4): 343-348.

Gogoi, B.K. (1994). A note on hookworm infestation of a tiger at Zoological Park, Itanagar. *Zoos' Print* 9(11): 20.

Goltenboth, R. (1981). Experiences with the new anthelmintic Rintal (Febantel) in zoo animals at Berlin Zoo. *Vet. Med. Rev.* 1(2): 144-149.

Gupta, P.P.S. and Yadav, M.P. (1997). Occurrence of parasitic infections in ponies of Tarai Region, Uttar Pradesh. *Indian J. Anim. Sci.* 67(6): 460-462.

Hafeez, M., Reddy, P.R. and Rao, B.V. (1983). A note on the occurrence of amphistomes (Trematoda-Digenea) from the reticulum of spotted deer. *Indian J. Anim. Hlth.* 22(1): 81.

Hansel, U. and Ruscher, H.J. (1980). The prevalence of parasites in wild cats from the intake of an animal carcass utilization organisation. *Angewandte Parasitologie*. 21(2): 69-70. [*Helminth. Abstr.* (1981)50: 602].

Hartmannova, B. (1989). Parasitic diseases of monkeys and of big feline predators in the zoological garden in Brno (Czech Republic). *Sbornik Vedeckych Praci Ustredniho Statniho Veterinarniho Ustavu-v-Praze.* No-17: 48-50.

Hasslinger, M.A., El-Assaly, T.M. and Selim, M.K. (1992). Comparative studies on coprologic results of carnivorous animals in zoological gardens of Giza, Egypt and Munich, Germany. *Assuit Vet. Med. J.* 26(52): 102-109.

Hiregoudar, L.S. (1976). Some parasites of wild ruminants in Gir Forest of India. *Indian Vet. J.* 53(5): 237.

Humbert, J.F. and Henry, C. (1989). Studies on the prevalence and the transmission of lung and stomach nematodes of wild boar in France. *J. Wildl. Dis.* 25(3): 335-341.

Jones, M.D. (1989). Routine Procedures. In "The Capture and Handling of Deer". Ed. Rudge, A.J.B. Nature Conservancy Council, Northminster House, Peterborough, PEI IUA, United Kingdom [Cited in *Zoo Zen* 6(12) :99-102].

Kageruka, P. and Puijenbroeck, V. (1967). Anthelmintic activity of Tetramisole in wild carnivores. *Acta. Zool. Path. Antverp.* 44: 101-117. [*Vet. Bull.* (1969) 39: 1204].

Khan, A.H. (1987). Prevalence of helminth parasites in cats in Lucknow district of Uttar Pradesh (India). *Helminthologia.* 24(4): 275-279.

Khan, A.M. (1979). Incidence of different parasites in wildlife of Nehru Zoological Park, Hyderabad. Summer Institute in Pathology of Wildlife, UAS, Bangalore, May, 1979.

Kinis, A., Suoronos, S., Haralabidis, S., Antoniadou-Sotiriadou, K. and Heimonas, H. (1985). Parasitological survey of ponies of Skyros Island. *Hellenic Vet. Med.* 28(3): 139-150. [*Helminth. Abstr.* (1986) 55: 1086].

Knottenbelt, M. (1989). Control of helminths in wildlife in Zimbabwe. *Zimbabwe Vet. J.* 20(1): 1-10.

Krait, I., Romashov, V.A., Nazarova, N.S. and Akbaev, M.S.H. (1977). Trial of Nilverm against gastrointestinal nematodes of deer in Voronezh National Park, USSR. *Veterinarnaya Akademiya*. 90: 91-92. [*Vet. Bull.* (1978) 48: 5516].

Kumar, V., De-Meurichy, W., Delahaye, A.M. and Mortelmans, J. (1981). Chemotherapy of helminthiasis among wild mammals. V. Gastric involvement of spider monkeys with *Physaloptera* sp. and Chemotherapy of the infection. *Acta. Zool. Path. Antverp.* 76: 191-199.

Lakshmanan, P. and Joseph, S.A. (1980). On the occurrence of a mixed infection of *Toxascaris leonina* and *Ancylostoma caninum* in Indian lion (*Panthera leo persica*). *Cheiron Tamil Nadu J. Vet. Sci. A.H.* 9(2): 134.

Lall, H.K. (1994). Liver fluke infection in a hippo. *Indian Vet. J.* 71(2): 181-184.

Lim, Y.J. and Lee, W.C. (1977). Epidemiological study on infection rates of parasites in zoo animals. *Korean J. Vet. Res.* 17(1): 17-26. [*Helminth. Abstr.* (1979) 48: 1723].

Litvinov, V.F. and Zen'-Kov, A.V. (1979). Role of wild boar in the epizootiology of parasitoses of swine. *Veterinariya Moscow.* 11: 51-52. [*Helminth. Abstr.* (1980) 49: 1776].

Lodha, K.R., Raisinghani, P.M. and Karwasra, R.S. (1977). Chemotherapeutic trials of some anthelmintics against helminth parasites in camels. *Indian J. Anim. Sci.* 47(10): 677-682.

Lu, F.L., Li, P.Y., Liao, S.F. and Jiang, F.L. (1992). A survey of the helminths of carnivorous zoo animals. *Chinese J. Vet. Med.* 18(10): 11-13.

Magzoub, M., Omer, O.H., Haroun, E.M., Mahmoud, O.M. and Hamid, Y.M.A. (1997). Gastro-intestinal parasites of dromedary camels in Gassim Region, Saudi Arabia. *Indian Vet. J.* 74(5): 373-376.

Maity, B., Chakraborty, G. and Pradhan, K.K. (1994). Toxocariasis in snow leopard (*Panthera uncia*). *Indian Vet. J.* 71(5): 499-501.

Mandal, D. and Choudhury, A. (1985). Helminth parasites of wild tiger of Sundarbans Forest, West Bengal, India. *Akademie Verlag* (1985): 499-501.

Manville, A.M. (1978). Ecto-and endoparasites of black bears in Northern Wisconsin, USA. *J. Wildl. Dis.* 14(1): 97-101.

Maske, D.K., Sardey, M.R. and Bhilegaonkar, N.G. (1990). Helminth parasites in zoo animals of Maharaj Bag, Nagpur, Maharashtra State. *Indian J. Anim. Sci.* 60(8): 952.

Mirck, M.H. (1978). Faecal examinations for the presence of parasites in horses and ponies. *Tijdschrift voor Diergeneeskunde* 103(19): 991-997. [*Helminth. Abstr.* (1979) 48: 1609].

Modi, G.S., Prasad, B.N. and Sinha, B.K. (1997a). Parasitic infection in carnivorous zoo animals of Bihar and its public health importance. *Indian Vet. Med. J.* 21(2): 112-116.

Modi, G.S., Prasad, B.N. and Sinha, B.K. (1997b). Seasonal effect on the prevalence of parasitic zoonotic diseases among zoo animals of Bihar. *Zoos' Print* 12(4): 8-11.

Modi, G.S., Prasad, B.N. and Sinha, B.K. (1997c). Effect of age on the prevalence of intestinal parasitism among zoo animals in Bihar. *Indian Vet. J.* 74(4): 351-353.

Modi, G.S., Prasad, B.N. and Sinha, B.K. (1998). Influence of sex on the prevalence of parasitic infection among zoo animals of Bihar. *Indian Vet. Med. J.* 22(3): 211-214.

Movchan, A.T. and Veselova, T.P. (1975). Trials of preparations for helminthoses in monkeys (Diethylcarbamazine phosphate, Thiabendazole and Tetramisole). *Veterinariya Moscow.* 12: 76. [*Vet. Bull.* (1976) 46: 3166].

Muraleedharan, K., Iswaraiah, V., Ziauddin, K.S. and Srinivasan, K. (1990). A survey of gastro-intestinal parasites of animals of zoological gardens at Mysore. *Mysore J. agric. Sci.* 24: 250-256.

Niphadkar, S.M., Narsapur, V.S., Deshpande, V.S. and Nehete, R.S. (1989). Parasitic infections of zoo animals in Bombay. *J. Bombay Vet. Col.* 1(1): 37-40.

Padhi, B.C., Mohanty, A.K., Misra, S.C. and Panda, D.N. (1987). A note on the occurrence of amphistomes in the rumen of spotted deer (*Axis axis*) at the Nandankanan Park, Barang, Orissa. *Indian Vet. J.* 64(10): 893.

Panda, A.K. and Pal, D. (1996). Association of *Balantidium coli* with other parasitic infections in captive monkeys. *Indian Vet. J.* 73(10): 1082-1083.

Pandey, V.S. (1978). Observations on gastro-intestinal helminths of zoo animals in Lubumbashi, Zaire-Coprological Survey. *Bull. Anim. Hlth. Prod. Africa* 26(4): 361.

Partani, A.K., Kumar, D., Manohar, G.S. and Swarnkar, C.P. (1995). Suspected resistance of gastro-intestinal nematodes in camel to Tetramisole and Fenbendazole. *J. Vet. Parasitol.* 9(2): 99-103.

Patnaik, M.M. (1964). A note on the helminth parasites of the blackbuck (*Antelope cervicapra*). *Curr. Sci.* (Bangalore) 33: 180.

Pavlovic, I., Nesic, D., Valter, D., Mitic, G. and Hudina, U. (1992). Helminth fauna of bison, camels, llamas, barbary, somali and domestic sheep and goats in Belgrade Zoo in 1990. *Veterinarski Glasnik.* 46(5): 271-275. [*Helminth. Abstr.* (1993) 62: 1830].

Petersen, K. (1977). Occurrence of helminths in elephants, blackbucks and wapiti in zoological gardens, Rostock. *Akademie Verlag* (1977): 263-266.

Pillai, K.M., Pythal, C. and Sundaram, R.K. (1981). A note on the occurrence of *Cylicospirura subaequalis* in a jungle kitten (*Felis chaus*) in Kerala. *Kerala J. Vet. Sci.* 12(1): 155-156.

Presidente, P.J.A. (1984). Ectoparasites, endoparasites and some diseases reported from sambar deer throughout its native range and in Australia and NewZealand. Proc. No.72, Deer Refresher Course, Univ. of Sydney, Australia, Dec., 1984.

Pythal, C., Pillai, K.M., Varghese, C.G. and Surendranathan, T. (1993). Death of a wild Indian leopard, *Panthera pardus fusca* (Meyer) due to parasitism with the lung fluke, *Paragonimus westermanii* (Kerbert, 1878) and the hookworm *Galonchus perniciosus* (Linstow, 1885). *J. Vet. Anim Sci.* 24(1): 44-46.

Quesada, A. and Maggio, V. (1982). Parasites of the digestive tract in exotic animals. *Atti-della Societa Italiana delle Scienze Veterinarie* **36**: 655-657.

Rajasekaraiah, G.R., Hegde, K.S., Gowda, R.N.S., Rahman, S.A. and Rao, H.S. (1971). A study of some parasites from Panther cubs (*Felis pardus*, Linn.) with the description of *Eimeria anakalensis* N.sp. *Mysore J. agric. Sci.* 5: 404-409.

Ramanujachari, G. and Alwar, V.S. (1955). A note on the occurrence of *Oesophagostomum apiostomum* (Willach, 1891) Railliet and Henry, 1905 (The Simian Nodular Worms) in Indian monkeys. *Indian Vet. J.* **32**: 47.

Ramasamy, K., Singh, B.P. and Arora, B.M. (1985). Occurrence of *Muellerius* sp. in spotted deer (*Axis axis*) in India. *Indian J. Parasitol.* 9(2): 187.

Ramisz, A., Skotnicki, J. and Krzakowski, A. (1978). Efficacy of Fenbendazole (Panacur) against *Trichocephalus* and *Ancylostoma* in monkeys. *Medycyna Weterynaryjna.* **34**(9): 523-524. [*Vet. Bull.* (1979) **49**: 3340].

Rao, A.T. and Acharjyo, L.N. (1972). Further observations on fascioliasis among wild ungulates at Nandankanan Zoo. *Indian Vet. J.* 49(2): 133-135.

Rao, A.T. and Acharjyo, L.N. (1984). Diagnosis and classification of common diseases of captive animals at Nandankanan Zoo in Orisa (India). *Indian J. Anim. Hlth.* 23(2): 147-152.

Rao, A.T. and Acharjyo, L.N. (1994). Etiopathology of mortality in Indian lesser cats at Nandankanan Biological Park. *Indian Vet. J.* 71(6): 550-553.

Rao, P.B. and Singh, K.R. (198). Diphyllobothriasis in a Tiger (*Panthera tigris*). *J. Vet. Parasitol.* 12(2): 148.

Raquib, A., Gogoi, A.R. and Lakhar, B.C. (1972). Incidence of helminthic infection of zoo animals of Assam. *Vetcol.* 13: 112-114.

Rathore, B.S. and Khera, S.S. (1981a). Causes of mortality in felines in free-living state and captivity in India. *Indian Vet. J.* 58(4): 271-276.

Rathore, B.S. and Khera, S.S. (1981b). Causes of mortality in captive primates in India. *Indian Vet. J.* 58(5): 348-352.

Reddy, N.R.J., Jagannath, M.S., D'Souza, P.E., Rahman, S.A. and Basavarajappa, K. (1992). Prevalence of gastro-intestinal parasites in wild mammals and captive birds at Bannerghatta National Park, Bangalore. *Indian J. Anim. Sci.* 62(11): 1046-1048.

Saad, M.B., El-Sinnary, K.A., El-Mubarak, S. and El-Badari, S.S. (1983). Endoparasites in wild animals at Khartoum Zoo. *Bull. Anim. Hlth. Prod. Africa* 31(1): 9-15.

Salman, R. and Shah, B.H. (1989). Incidence of gastro-intestinal nematodes in wild Felidae in Pakistan. *Pakistan J. Zool.* 21(3): 255-259.

Sarode, D.B., Arbat, S.A. and Hirwade, K.W. (1993). Helminth infections in zoo carnivores. *Indian J. Vet. Med.* 13(1): 41.

Siam, M.A., Salem, G.H., Ghonem, N.H., Michael, S.A. and El-Refay, M.A.H. (1994). Public health importance of enteric parasitosis in captive Carnivora. *Assuit Vet. Med. J.* 32(63): 131-140.

Sleeman, D.P. (1983). Parasites of deer in Ireland. *J. Life Sci.* 4(2): 203-210.

Somvanshi, R., Koul, G.L. and Biswas, J.C. (1987). Sarcocystis in a leopard (*Panthera pardus*). *Indian Vet. Med. J.* 11(3): 174-175.

Su, Y.C. and Lee, Y.C. (1987). The prevalence of endoparasites of deer in Midland Taiwan. *J. Chinese Soc. Vet. Sci.* 13(1): 57-65. [*Helminth. Abstr.* (1989) 58: 1350].

Tanwar, R.K., Mittal, L.M., Sharma, S.N. and Yadav, J.S. (1984). Parasitic gastritis in an Asian lion - a case report. *Indian J. Vet. Med.* 4(1): 48-49.

Thiruthalinathan, R., Latha, B.R. and Swaminathan, D. (1998). Incidence and treatment of *Spirometra* infections in wild carnivores under captivity. *Cheiron* 27(1&2): 33-34.

Tigin, Y., Burgu, A., Doganay, A., Oge, S. and Umur, S. (1989). Helminthic faecal examination of some mammals and birds in Ankara Zoological Garden. *Veteriner Fakultesi Dergisi, Univ. Ankara.* 36(3): 646-664.

Varadharajan, A. and Pythal, C. (1999). Incidence of gastro-intestinal parasitism in freeliving, feral Bonnet Macaque (*Macaca radiata* L.) *Zoos' Print* 14(6): 41-42.

Varma, T.K., Arora, B.M. and Prasad, A. (1996). Helminth parasites from digestive tract of blackbuck (*Antelope cervicapra*). *J. Vet. Parasitol.* 10(1): 97.

Zuchowska, E. (1988). Helminthiasis of zoo ruminants. *Akademie Verlag* (1988): 171-172.

HELMINTH PARASITES OF MAMMALS IN THRISSUR ZOO

By

VARADHARAJAN, A.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF VETERINARY SCIENCE

Faculty of Veterinary and Animal Sciences

Kerala Agricultural University

DEPARTMENT OF PARASITOLOGY

COLLEGE OF VETERINARY AND ANIMAL SCIENCES

MANNUTHY, THRISSUR, KERALA

1999

ABSTRACT

An investigation on the prevalence of helminthic infections among the wild mammals in captivity in the Thrissur Zoo and also the variations thereof on account of season, age and sex were carried out by regular faecal examination using the concentration method of centrifugation-cum-sedimentation technique, over a period of one year from May-'98 to April-'99. Non-specific symptoms like general weakness, debility, occasional diarrhoea, dehydration and respiratory distress with cough were observed in a variety of mammals.

The overall prevalence of the helminthic infection among the mammals was 68.05 per cent. Carnivores had the highest prevalence of infection (75.34%) when compared to herbivores (67.47%) and omnivores (65.35%). Strongyle, *Strongyloides* spirurid, ascarid, amphistome, *Fasciola*, *Trichuris* and *Parascaris* infections in a variety of herbivores; strongyle, *Strongyloides*, spirurid, *Ancylostoma*, *Capillaria*, *Toxocara*, *Trichuris*, *Metagonimus*, *Artyfechinostomum* and *Hymenolepis* infections in a variety of omnivores and *Ancylostoma*, *Toxocara*, *Toxascaris*, *Strongyloides*, *Capillaria*, spirurid, *Diphyllobothrium*, *Hymenolepis* and *Paragonimus* infections in a variety of carnivores were observed.

A few specimens of *Haemonchus contortus* were recovered from the abomasum of a 6 year old female balckbuck during post-mortem examination.

The overall prevalence of infection among the mammals was higher in the rainy seasons (South-West and North-East monsoons) than in the dry season. The prevalence of infection was higher in the adults of herbivores and omnivores than in the young ones of both the groups. The prevalence was also higher in the males of herbivores and carnivores than in the females and was more or less equal in both sexes of omnivores.

Treatments with Fenbendazole and Pyrantel Pamoate were effective against gastro-intestinal nematodes in camels and in Asiatic lions respectively.

Control measures for the helminthic infections in the zoo mammals have also been suggested.