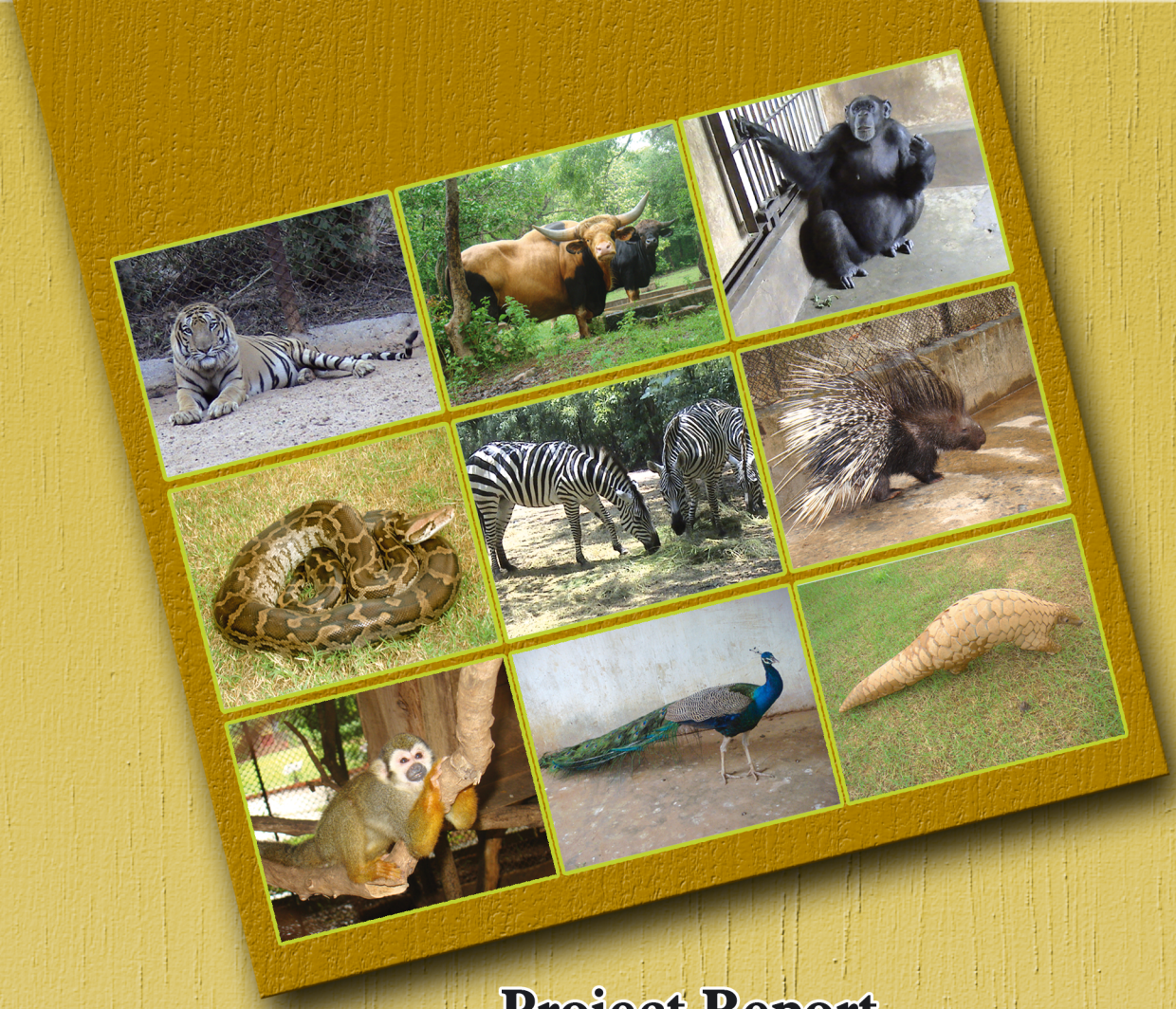

Project Report

ECTO AND ENDO PARASITES OF CAPTIVE ANIMALS AND BIRDS OF NANDANKANAN ZOO

Submitted by
Nandankanan Zoological Park
&
Orissa Veterinary College
Bhubaneswar

2010

Supported by
Central Zoo Authority
New Delhi

FINAL PROJECT REPORT

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BHUBANESWAR

Nodal Officer
Sri Arun Kumar Mishra
Assistant Director, Nandankanan Zoological Park

Investigators
Dr. P.K.Roy, Senior Veterinary Officer
Dr. R.K.Samantray, Veterinary Asst. Surgeon
Dr. A.K.Das, Veterinary Asst. Surgeon
Nandankanan Zoological Park
&
Prof. N.Sahoo, Project Coordinator
Centre for Wildlife Health
Orissa Veterinary College
Bhubaneswar

2010

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NANDANKANAN

Dr. S. Panda I.F.S.
DIRECTOR

Bhubaneswar
31st March, 2010

FOREWORD

The zoos in our country are witnessing significant improvements in the health care front. A number of factors including a lengthy profile of diseases/conditions prevailing in the zoos have been the stumbling blocks in the improvement of health conditions. The parasitic infections come in the forefront among such diseases. Endoparasitic infections due to their lingering morbidity often draw the attention of all concerns. Besides, ectoparasitic infestations cause considerable morbidity and sometimes are responsible for transmission of blood protozoan diseases. It is therefore necessary to define appropriate measures for control of those diseases and to take sincere initiatives for adoption of such practices by the zoo management. The present research project attempts to bridge the gap and add golden feathers to the impressive list of achievements.

The project entitled, '**Ecto and endo parasites of captive animals and birds of Nandankanan Zoo**' was sanctioned by the Central Zoo Authority, New Delhi vide their letter no.F.No.9-6/2006–CZA (M) Dt.8.2.2007. The project was jointly carried out by the Nandankanan Zoological Park and Faculty of Veterinary Science and Animal Husbandry, Orissa University of Agriculture and Technology, Bhubaneswar from April 2007 to March 2010. The past three years was very much eventful. "Seeing is believing" – all the experimental designs were taken up with active involvement of the investigators, Range Officers/Foresters/Guards and animal keepers/attendants of Nandankanan Zoological Park. Impacts of the designed control program undertaken in the zoo with successful results were well perceived by one and all.

A comprehensive picture with respect to the prevalence of parasitic infections in different seasons, comparative efficacy of available anthelmintics / acaricides and studies pertaining to control of such infections were appropriately depicted in the report with suitable interpretations. I am quite confident that implementation of the results obtained from the study would definitely minimize the parasite-induced losses of mammals, birds and reptiles in captivity which in turn would be a fruitful step for the *ex-situ* conservation of wild fauna of our country.

(Dr. S. Panda)

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MISSION: To achieve the distinction of an outstanding Zoo through world class Conservation, Education, Research and exciting visitor experiences by connecting people to wildlife and conservation.

ACKNOWLEDGEMENT

I avail of this unique opportunity to express my sincere thanks to the Member Secretary, Central Zoo Authority, New Delhi for extending financial support to undertake such a need-based project which would go a long way for formulation of a long term strategy to manage the ecto-endo parasite in captive animals and birds.

It is my privilege to record deep sense of gratitude to Dr. L.N.Acharjyo, Veterinary Officer (Retd), Nandankanan Zoological Park for his constructive criticism and valuable advice as and when required.

The Principal Chief Conservator of Forests (WL) and Chief Wildlife Warden, Orissa woes special thanks for his keen interest in timely completion of the project.

Dr. A.K.Pattnaik, I.F.S., Ex Director, Nandankanan Biological Park deserves special appreciation as he was the brain child of the project.

I am deeply indebted to Dr. S. Panda I.F.S., Director, Nandankanan Biological Park who played vital role by way of periodic supervision, meticulous review and monitoring of the project activities.

I am extremely grateful to Mr. S.N.Mahapatra, I.F.S., Deputy Director for his valuable suggestions during the entire course of the project.

I feel honoured to extend my heartfelt thanks to the Dean, Faculty of Veterinary Science and Animal Husbandry, Bhubaneswar for extending all technical support as and when required in successful completion of the project.

Words run short to express my deep sense of gratitude to all the investigators of the project viz., Dr. P. K. Roy, Senior Veterinary Officer, Dr. R. K. Samantray, Veterinary Asst. Surgeon and Dr. A. K. Das, Veterinary Asst. Surgeon of Nandankanan Zoological Park and Prof. N. Sahoo, Project Coordinator, Centre for Wildlife Health, Orissa Veterinary College whose constant and dedicated efforts have made it possible to accomplish the objectives laid down in the project.

I do acknowledge the assistance rendered by Dr.K.M.N. Bharti,B.V.Sc. & A.H.; Dr. Satyanarayan Kar, B.V.Sc. & A.H. Dr. (Miss) Bismita Nandi, B.V.Sc. & A.H. Dr. (Mrs) Manaswini Dehuri, M.V.Sc. and Dr. (Miss) Priyadarshini Sahoo,B.V.Sc. & A.H. in the capacity of either Field Assistant or Laboratory Assistant during different stages of the project.

My heartfelt obligations are due to all the Range Officers, Foresters and Forest Guards of the sanctuary or management of the Nandankanan Biological Park for extending necessary cooperation in spite of their burden.

I acknowledge with thanks the help rendered by all the Animal Keepers of Nandankanan Zoological Park during the period under study.

(A.K.Mishra)
Nodal Officer

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PROJECT PROFILE

TITLE OF THE PROJECT: Ecto and endo parasites of captive animals and birds of Nandankanan Zoo.

BACKGROUND OF THE STUDY: The project proposal entitled, 'Ecto and endo parasites of captive animals and birds of Nandankanan Zoo' was jointly submitted by the Nandankanan Zoo, Govt. of Orissa and the Faculty of Veterinary Science and Animal Husbandry, Orissa University of Agriculture and Technology, Bhubaneswar. It was approved and sanctioned by the Central Zoo Authority, New Delhi vide their letter no.F.No.9-6/2006–CZA (M) Dt.8.2.2007.

CURRENCY OF THE PROJECT: 3 Years (April 2007 – March 2010)

NODAL OFFICER: Sri Arun Kumar Mishra, OFS
Assistant Director,
Nandankanan Zoological Park.

INVESTIGATORS:

Nandankanan Zoological Park

Dr.P.K.Roy, Senior Veterinary Officer
Dr.R.K.Samantray, Veterinary Assistant Surgeon
Dr.A.K.Das, Veterinary Assistant Surgeon

Orissa Veterinary College

Prof. N.Sahoo, Project Coordinator, Centre for Wildlife Health

ASSOCIATED TECHNICAL PERSONNEL

1. Dr.K.M.N. Bharti, Field Assistant
2. Dr.Satyanarayan Kar, Field Assistant
3. Dr.Bismita Nandi, Laboratory Assistant
4. Dr.Manaswini Dehuri, Laboratory Assistant
5. Dr.Priyadarshini Sahoo, Laboratory Assistant

The contractual staffs, after selection through walk-an-interviews conducted under the chairmanship of the Director, Nandankanan Zoological Park, were trained in the laboratories at Veterinary College and Zoo Hospital on various aspects relating to the project activities i.e., collection, transportation, storage and processing of the bio-samples and there services were utilized effectively for the interest of the project.

AREA OF OPERATION

1. Nandankanan Zoological Park, Baranga, Cuttack
2. Orissa Veterinary College
   Orissa University of Agriculture and Technology, Bhubaneswar

SUMMARY

SUMMARY

- A total of 534, 588 and 570 faecal samples collected from mammals of Nandankanan zoo were examined through concentration and/or floatation technique during the year 2007-08, 08-09 and 09-10, of which 265, 202 and 146 samples were found positive for one or more types of gastrointestinal helminthic (Endoparasites) infections indicating prevalence rates of 49.6, 34.4 and 25.6%, respectively.

- Prevalence of parasitic infection in mammals of Nandankanan Zoo during pre-monsoon, monsoon and post-monsoon season showed a declining trend from 2007-08 to 2009-10. The prevalence of helminthic infection in large carnivores was highest among all the mammals of zoo.

- Out of 145, 152 and 144 faecal samples collected from birds of Nandankanan zoo were examined through concentration and/or floatation technique during the year 2007-08, 08-09 and 09-10 where single or mixed gastrointestinal infections were found in 46, 47 and 17 samples indicating prevalence rates of 31.7, 31.0 and 11.8%, respectively.

- A total of 50, 48 and 51 faecal samples collected from reptiles of Nandankanan zoo were examined through concentration and/or floatation technique during 2007-08, 08-09 and 09-10, of which 7, 5 and 4 samples were found positive for endoparasitic infections indicating prevalence rates of 13.9, 10.3 and 8.1%, respectively.

- Based on the morphological and cultural characteristics of the eggs excreted in the faeces and morphological features of adult parasites, if any collected from vomitus/faeces or during post-mortem examination of mammals, reptiles and birds, the parasites were identified to be *Toxocara* , *Toxascaris*, *Ancylostoma* , *Paramphistomum* , *Strongyloides, Paragonimus, Trichuris* , *Ascaridia , Capillaria , Isospora* and *Eimeria* spp

- Anthelmintic trial conducted against nematode infection with *Toxocara* and/or *Ancylostoma* spp. in tigers and lions on the basis of epg count revealed that all the anthelmintics used in the study i.e., Ivermectin (Ivermectol), Levamisole (Dewormis), Pyrantel pamoate (Nemocid) and

Albendazole (Valbazen) were highly effective against nematode infection which varied from 92-100 %. Remarkable reduction in epg count was recorded by 3rd day post-treatment.

- Drugs used in the trial were well tolerated by the animals at the given dose rate i.e., pyrantel pamoate @ 20.0 mg, levamisole @ 4.4 mg, albendazole @ 25.0 mg and ivermectin @ 200 mcg per kg b.wt. and none of the animals exhibited any drug related undesirable effects during post-administration period.

- During the examination of fecal samples from ruminants *Paramphistomum* sp. of eggs were detected. However, none of the animal in any of the group showed the typical signs of immature amphistomiasis i.e., persistent fetid diarrhea during the period under study.

- The anthelmintic efficacy against *Paramphistomum* sp. infection in ruminants revealed that Oxyclozanide (Talzan F) and Albendazole (Analgon) administered each @ 10.0mg/kg b.w. were 85 and 78% efficacious, respectively.

- Mixed infection due to *Toxocara* and *Ancylostoma* spp. in large carnivores of Nandankanan Zoological Park was always in higher side (30.1-59.0%) during the period from 2007 to 2010 than the single infection due to either of the parasite.

- Reinfections to *Toxocara, Toxascaris* and *Anyclostoma* spp. in lions and tigers were recorded through detection of eggs in the faeces as early as 22 days post-administration of anthelmintics. However, none of the animals exhibited any clinical signs suggestive of pathogenic load of parasites.

- Turmeric (*Curcuma longa*) powder administered @ 5.0g/day for seven days to lion and tiger having Ascarid and/or *Ancylostoma* sp. infection reduced the epg count by 64 to 67 % on 10th day post-treatment.

- Ectoparasites such as Ticks (*Boophilus* and *Rhipicephalus* spp.), Mites *(Ophionyssus* sp) and Fleas (*Vermipsylla* sp) were isolated from tiger, pangolin, python and swamp deer during restraint or P.M. examination.

- External application of cypermethrin (Clinar) or deltamethrin (Butox) in the form of spray and subcutaneous injection ivermectin (Hitek) was found effective against tick infestation in tigers. Reappearance of ticks was recorded as early as 15 days post-application.

- Ivermectin in the form of tablet or injection were found effective against mixed infection due to nematodes and ticks in tigers.

- The epg count became negative for presence of helminthic ova during the observation period of 10 months when the entire top soil was changed upto a depth of the six inches from the tiger enclosures. The amount spent towards removal of top soil and refilling with sand varied from Rs.19/- to 53/- per sq mt.

- An integrated strategic approach consisting of anthelmintic treatment followed by change of top soils and oral administration of turmeric to the large carnivores would be not only effective and cost beneficial than reliance on routine dosing but also less likely to induce anthelmintic resistance.

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INTRODUCTION

INTRODUCTION

Wildlife population in their natural habitat is declining day by day. Under this situation the modern zoos play important role in their conservation through captive breeding, rehabilitation of the species in the wild, education and scientific research. However, none of these objectives could be successfully achieved unless the animals are maintained in optimum health. As evident from the scientific journals and bulletins, incidence of different diseases in Indian zoos is in increasing trend. Of the various diseases affecting the wild mammals, birds and reptiles, parasitic diseases, external (Ectoparasites) and/or internal (Endoparasites), are comparatively common in our country. Helminths, commonly called as worms, are categorized under endoparasites (Macroparasites). The helminths are classified under three classes i.e., Cestodes (Tapeworms), Nematodes (Roundworms) and Trematodes (Flukes). Majority of the adult helminths inhabitate in the gastro-intestinal tract. Common ectoparasites include ticks, lice, fleas and mites.

The damages caused by the parasites in general and helminths in particular are enormous e.g., sharing the host's ingested food; feedings on body tissues; sucking body fluids; causing mechanical obstruction in intestine/bile ducts/blood vessel/lymphatic/bronchi; causing damages in organs; producing toxic substances; transmitting other infections; affecting the host's growth/reproductive/productive functions. Though death is an uncommon sequel, the possibility of mortality can not be ruled out on heavy infestation especially in young stock. As a general rule, young animals exposed to infestation for the first time are more susceptible group than any other category of animals. The peculiarity of parasitism in many species indicates that the animal harbouring parasites seldom exhibit clinical sign(S) rather continue to be apparently healthy for a prolonged period.

Epidemiological patterns differ for each species and vary considerably from region to region or more specifically locality to locality. It is therefore considered ideal to acquire adequate knowledge of the source of contamination, degree of parasitism with respect to season in order to formulate clear and precise control program.

At present, five groups of drugs are available for treatment of endoparasites i.e., (a) **Benzimidazoles**: Triclabendazole, Albendazoles, Fenbendazoles, Febantel, Oxfendazole and Mebendazole; (b) **Imidazothiazoles**: Levamizole and tetramizole; (c) **Tetrahydropyrimidine**: Pyrantel (Tartrate, pamoate and embonate) and Morantel (d) **Microcyclic lactones**: Avermectin (Ivermectin, Doramectin) and Milbemycin and (e) **Salicylanilides**: Oxyclosanides, Closantel, Niclosamide and Rafoxanides.

Although effective drugs are available for treatment of the endoparasitic and ectoparasitic infection, occurrence of such problems are perpetuating among the susceptible hosts because it is practically difficult to completely eliminate the infective stages of the parasite from the environment as well as the host, especially in the animals reared in groups. In addition, anthelmintic resistance is an important consideration influencing the choice for therapeutic as well as control program. Frequent treatment practices may impose strong selection pressure on worm population and can encourage the development of resistant strains. Hence, it is imperative for their judicious use in order to extract the maximum benefit of such drugs as long as possible. Treatment at periodic interval is considered ideal for control of the parasitism. However, managemental practices aimed at reducing the contamination of environment would exert synergistic action on the control program. Keeping these facts back drop, the study was undertaken with the following objectives.

Objective – I

To study the season-wise (pre-monsoon, monsoon and post-monsoon) prevalence of endoparasitic infection in different species of captive animals and birds in the zoo.

Objective – II

To study the prevalence of ectoparasitic infestation in different species of captive animals and birds.

Objective – III

To compare the efficacy of available drugs against the endo and ecto-parasites in different species of animals and birds.

Objective – IV

Rcommendations for management of parasitic (ecto-endo) infection in wild animals in captivity.

METHODOLOGY AND RESULTS

OBJECTIVE – I

To study the season-wise (pre-monsoon, monsoon and post-monsoon) prevalence of endoparasitic infection in different species of captive animals and birds in the zoo.

METHODOLOGY

The prevalence of gastrointestinal parasitic diseases in various species of mammals (Annexure 1), birds (Annexure 2) and reptiles (Annexure 3) were ascertained on the basis of faecal examination during three seasons i.e., summer or pre-monsoon (February-May), rainy or monsoon (June-September) and winter or post-monsoon (October-January). The eggs, oocysts, larvae or adult parasites were identified on the basis of morphological characteristics as described by Soulsby (1986).

1.1 Procedure for collection of faecal sample

Approximately two gms of freshly passed faeces was collected from the individual enclosure/animal in a clean, dry and air tight plastic container and brought to the laboratory for qualitative and quantitative examination. The faecal samples were collected from multiple spots inside one enclosures following the similar procedure described earlier where animals were reared in groups. Precaution was taken to avoid all possible external contaminations. The adult parasites, if any, present in the faecal mass during collection were also brought to the laboratory for better interpretation.

1.2 Fixation of adult parasites

The nematodes recovered either during post-mortem examination or freshly passed faeces/vomitus of live animals was fixed in 70% simmering alcohol after thorough washing. The fixed parasites were then cleared in lacto-phenol. The head, tail and body portion were cut and mounted in DPX on a clean glass slide and the identification was done through their morphological characteristics.

1.3 Qualitative examination of faecal sample for eggs

Each faecal sample was subjected to qualitative examination by Sedimentation / Floatation method for detection of parasitic ova.

1.3.1 Sedimentation method

One gm of faeces was taken in a clean glass pestle and little quantity of water was added and mixed well. The suspension was strained to remove debris. The suspension was centrifuged for 2 to 3 minutes at 1500 rpm. A drop of sediment was taken and examined under low power objective (10X and 40X) of research microscope by covering with a cover slip for presence of ova.

1.3.2 Floatation method

One gm of faeces was taken in a clean glass pestle and little quantity of saturated solution of magnesium sulphate was added and mixed well. The suspension was strained to remove debris. The suspension was centrifuged for 2 to 3 minutes at 1500 rpm. The surface layer was examined under low power objective (10X and 40X) of research microscope by covering with a cover slip for presence of eggs.

1.4 Culture of faeces for larvae

The faecal samples of tigers found positive for *Toxascaris leonina* eggs were selected for culture. The faecal samples mixed with charcoal were placed in a glass jar covered with a lid and stored for seven days at 26^0C temperature for incubation. The fecal sample selected were of appropriate consistency i.e. not too dry or wet. After 7 days of incubation, the sample was transferred to the Baermann's apparatus, which is made up of a glass funnel with wire mesh and rubber tubing having a pinchcock attached to the stem of the funnel. The funnel was filled with warm water until the faecal samples were immersed and the water level was raised $1/4^{th}$ to ½ an inch above the sieve. The larva migrated to the water in the stem and the water from the stem was examined for larval nematodes. The larva was identified based on their morphological features and through micrometry.

Table 1. Group-wise distribution of wild mammals reared at Nandankanan Zoo

Group No.	Type of animals	Sl. No.	Name of Species
A	Large Carnivores	A_1	Tiger (Normal/ White colored)
		A_2	African Lion
		A_3	Leopard
		A_4	Jaguar
		A_5	Hyena
		A_6	Bear (Sloth, Himalayan black)
	Small Carnivores	A_7	Jackal
		A_8	Jungle cat
		A_9	Mongoose
		A_{10}	Civet
		A_{11}	Ratel
B	Large Herbivores	B_1	Asiatic Elephant
		B_2	Grant's Zebra
		B_3	Bluebull / Nilgai
		B_4	Deer (Spotted Deer, Swamp Deer, Thamin Deer & Sambar deer)
		B_5	Mithun
		B_6	One horned Rhinoceros
		B_7	Hippopotamus
	Small Herbivores	B_9	Deer (Hog deer, Barking deer & Mouse deer)
		B_{10}	Antelope (Black buck & Chousingha)
		B_{11}	Porcupine
C	Primates	C_1	Macaque (Assamese, Rhesus, Bonnet & Lion tailed)
		C_2	Langur
		C_3	Baboon
		C_4	Monkey (Patas & Squirrel)
		C_5	Chimpanzee
		C_6	Orangutan
D	Others	D1	Pangolin

RESULTS (Mammals)

Based on micrometry and morphological features the following larvae/eggs/adults were identified from various species of animals and birds.

Morphological features of Nematode eggs

Toxocara cati

- Yellowish brown in colour.
- Spherical in shape.
- Uniform pitted shell surrounding a single embryonic mass.
- Average size of egg: 67 x 58µm.

Toxascaris leonina

- Sub-spherical in shape with smooth shell surface and prominent lipid layer.
- Colourless or transparent than *Toxocara cati*.
- 1 to 2 spherical cells in the centre.
- Average size: 80 x 66 µm.

***Ancylostoma* sp.**

- Ovoid in shape.
- Thin and transparent shell having 8-16 cells.
- Average size of egg: 60 x 39µm.

***Strongyloides* sp.**

- Oval in shape with blunt ends.
- Thin shelled and having a larva when freshly laid.
- Average size of egg: 61 x 28 µm.

Ascaridia galli

- Eggs oval in shape.
- Smooth egg shell.
- Average size: 81 x 51 µm.

***Trichuris* sp.**

- Eggs barrel shaped.
- Brown in color with a transparent plug at either pole.
- Average size: 72 µm x 34 µm.

Strongyle sp.

- Eggs oval in shape
- Size varied with species.
- Thin egg shell.
- 2-64 cell divisions in centre.

***Capillaria* sp.**

- Eggs barrel shaped with transparent plugs at either pole.
- Thick shell.
- Average size: 52 x 22 µm.

Morphological features of Trematodes eggs

Paramphistomum

- Oval shaped having transparent shell and distinct operculum.
- Embryonic cells clear
- Small knob at the posterior pole.
- Average size: 130 x 81 µm.

***Paragonimus* sp.**

- Eggs yellowish-brown in colour
- An operculum present.
- Shell thickened at the pole.
- Average size: 84 x 57 µm.

Morphological features of Protozoa oocysts

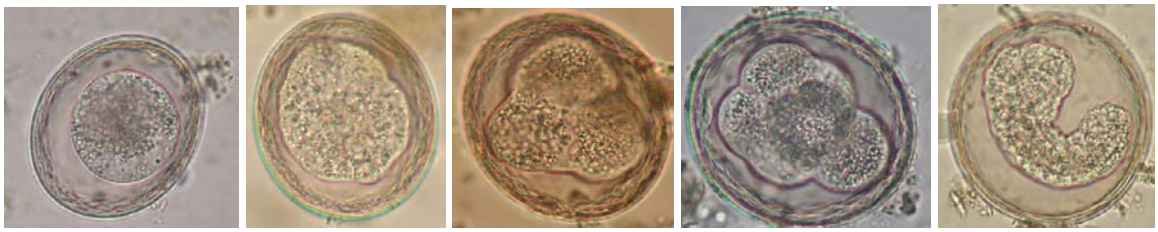
***Isospora* sp.**

- Ocysts broadly ovoid.
- Colourless oocyst wall.
- Average size: 33 x 48 µm.

***Eimeria* sp.**

- Oocysts ovoidal
- Smooth and colourless oocyst wall.
- Average size: 18 x 11 µm.

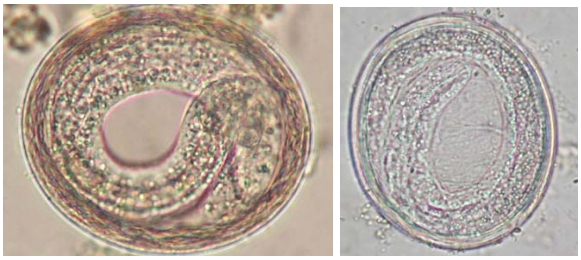
Fig 1. Chronological development of egg/larva of *Toxascaris leonina* sp.



One-celled egg

Morula stage

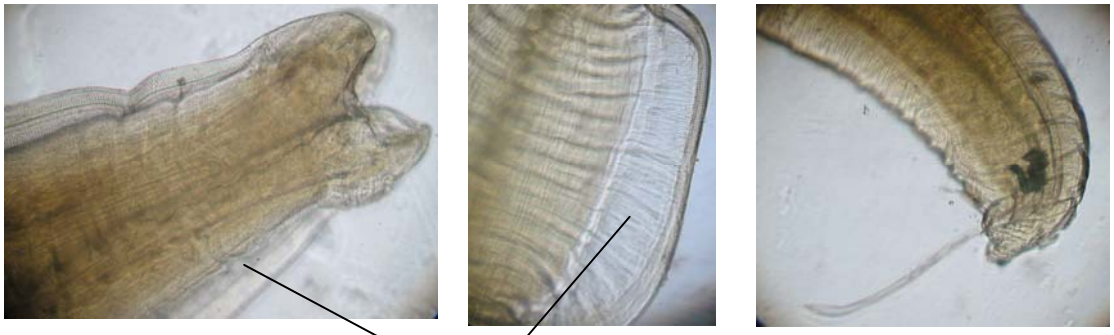
Early vermiform embryo



Infective larva inside egg shell

- Eggs developed to infective stage in one week

Fig 2. Characteristics of adult *Toxocara cati* recovered from tiger



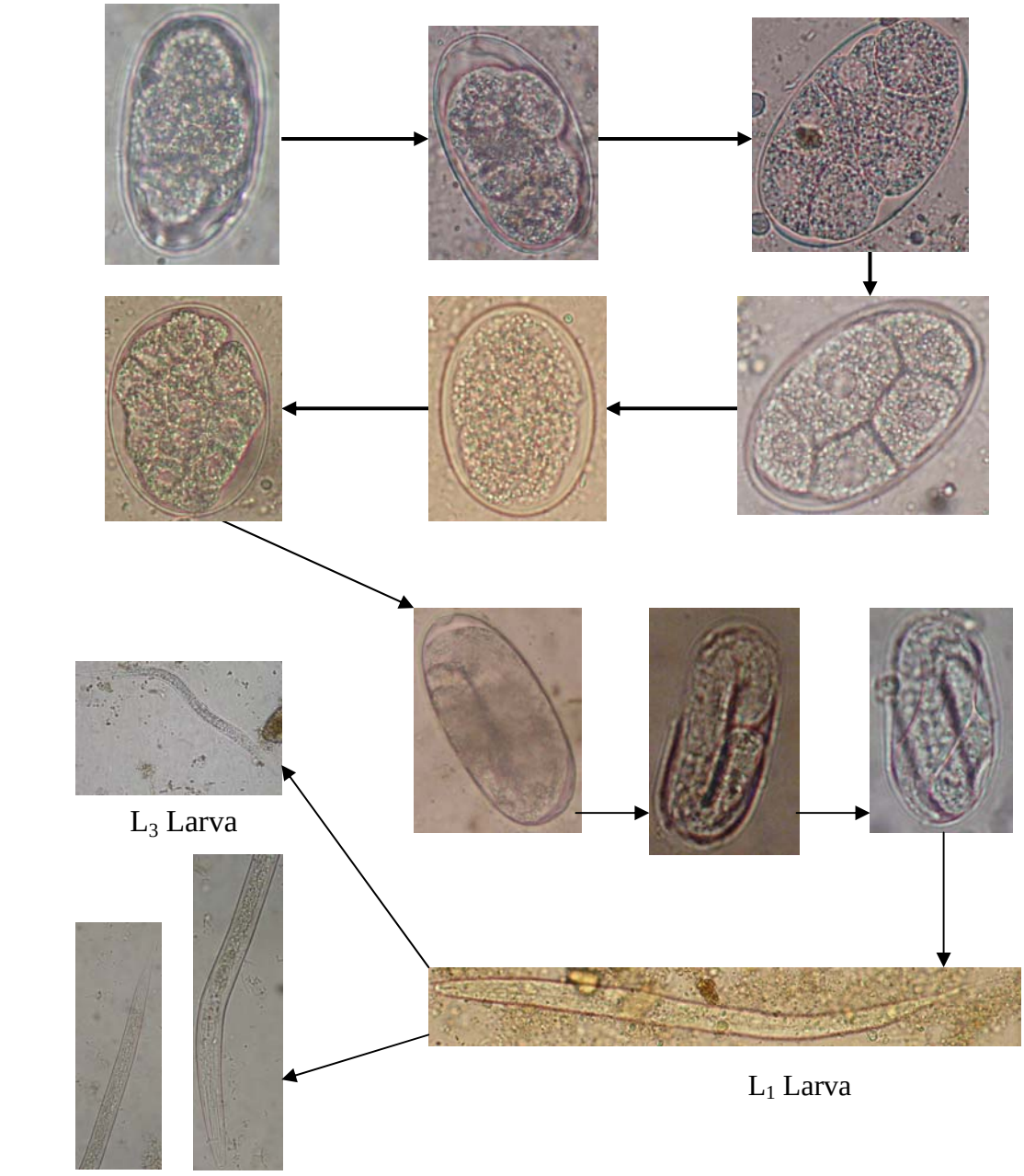
Head

Cervical alae

Tail

- *T.cati* has a very elegant cervical alae, the ventral curvature of the anterior end along with the large cervical alae gives it a cobra like appearance.
- The tail of *T.cati* male is finger like.

Fig 3. Chronological development of egg of *Ancylostoma* sp.



- First stage larva was seen within 2-8 days of faecal culture.
- First stage larva was 342 µm. It had long buccal cavity and bulb shaped esophagus.
- Third stage larva was measured 628.32 µm having esophageal length up to 1/4th of the body length. It had a pointed tail.
- Larval lengths were similar to both *A. caninum* and *A. tubaeforme* for which identification of the species was not possible.

There are 3 species of *Ancylostoma* found in wild carnivores in India i.e., *Ancylostoma caninum, Ancylostoma tubaeforme* and *Ancylostoma braziliense.* The characteristics of egg / larva of all the three species are similar. Hence, the species is best identified on the basis of difference in the buccal capsule of the adult parasite.

PREVALENCE OF ENDOPARASITIC INFESTATION

Table2. Season-wise prevalence of endoparasitic infections in different species of mammals at Nandankanan Zoological Park during 2007-08.

Sl. No.	Species of the animals	Season	No. of faecal samples examined	No. of samples positive for parasitic infection	Percentage of infection	Overall percentage of infection
1	Large Carnivores	Pre-monsoon	57	46	80.7	**88.5**
		Monsoon	53	49	92.5	
		Post-monsoon	52	48	92.3	
2	Small carnivores	Pre-monsoon	9	2	22.2	**24.1**
		Monsoon	12	3	25.0	
		Post-monsoon	8	2	25.0	
3	Large Herbivores	Pre-monsoon	54	26	48.1	**47.3**
		Monsoon	64	33	51.6	
		Post-monsoon	57	24	42.1	
4	Small herbivores	Pre-monsoon	14	5	35.7	**31.5**
		Monsoon	14	5	35.7	
		Post-monsoon	13	3	23.1	
5	Primates	Pre-monsoon	26	4	15.4	**15.8**
		Monsoon	20	4	20.0	
		Post-monsoon	25	3	12.0	
6	Others (Pangolin)	Pre-monsoon	1	0	0.0	**11.1**
		Monsoon	3	1	33.3	
		Post-monsoon	2	0	0.0	
Total		**Pre-monsoon**	**177**	**85**	**48.0**	**49.6**
		Monsoon	**180**	**97**	**53.9**	
		Post-monsoon	**177**	**83**	**46.9**	

Key points

1. Among all the animals maintained in the zoo, the maximum and minimum prevalence of endoparasitic infection during the year 2007-08 was recorded in large carnivores (88.5%) and pangolin (11.1%), respectively.

2. The overall prevalence of endoparasitic infection was highest during monsoon (53.9%) followed by pre-monsoon (48.0%) and post-monsoon (46.9%).

Table 3. Season-wise Prevalence of endoparasitic infections in different species of mammals at Nandankanan Zoological Park during 2008-09

Sl. No.	Species of the animals	Season	No. of faecal samples examined	No. of samples positive for parasitic infection	Percentage of infection	Overall percentage of infection
1	Large Carnivores	Pre-monsoon	57	40	70.2	**69.9**
		Monsoon	58	40	69.0	
		Post-monsoon	61	43	70.5	
2	Small carnivores	Pre-monsoon	10	1	10.0	**22.1**
		Monsoon	13	3	23.1	
		Post-monsoon	9	3	33.3	
3	Large Herbivores	Pre-monsoon	59	12	20.3	**25.3**
		Monsoon	64	18	28.1	
		Post-monsoon	51	14	27.5	
4	Small herbivores	Pre-monsoon	23	4	17.4	**13.0**
		Monsoon	20	2	10.0	
		Post-monsoon	26	3	11.5	
5	Primates	Pre-monsoon	22	2	9.1	**12.5**
		Monsoon	25	4	16.0	
		Post-monsoon	24	3	12.5	
6	Others (Pangolin)	Pre-monsoon	5	0	0.0	**26.2**
		Monsoon	7	2	28.6	
		Post-monsoon	6	3	50.0	
Total		**Pre-monsoon**	**195**	**61**	**31.3**	**34.4**
		Monsoon	**201**	**70**	**34.8**	
		Post-monsoon	**192**	**71**	**37.0**	

Key points

1. Prevalence of endoparasitic infection during the year 2008-09 was highest in Large Carnivores (69.9%) followed by Pangolin (26.2%), Large Herbivores (25.3%), Small Carnivores (22.1%), Small Herbivores (13.0%) and Primates (12.5%).

2. Maximum prevalence of endoparasitic infection was recorded in large carnivores during all the three seasons i.e., pre-monsoon (70.2%), monsoon (69%) and post-monsoon (70.5%) as compared to the corresponding values for rest of the species.

Table 4. Season-wise Prevalence of endoparasitic infections in different species of mammals at Nandankanan Zoological Park during 2009-10

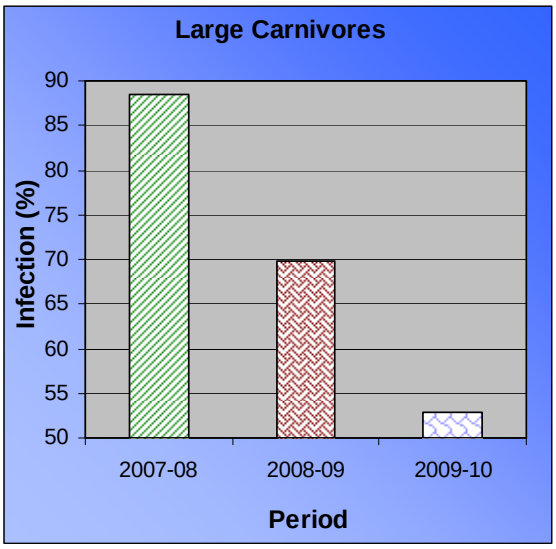
Sl. No.	Species of the animals	Season	No. of faecal samples examined	No. of samples positive for parasitic infection	Percentage of infection	Overall percentage of infection
1	Large Carnivores	Pre-monsoon	54	33	61.1	**52.8**
		Monsoon	57	26	45.6	
		Post-monsoon	60	31	51.7	
2	Small Carnivores	Pre-monsoon	13	1	7.7	**14.0**
		Monsoon	14	2	14.3	
		Post-monsoon	15	3	20.0	
3	Large Herbivores	Pre-monsoon	55	9	16.4	**17.8**
		Monsoon	56	12	21.4	
		Post-monsoon	51	8	15.7	
4	Small herbivores	Pre-monsoon	20	2	10.0	**12.2**
		Monsoon	18	3	16.7	
		Post-monsoon	20	2	10.0	
5	Primates	Pre-monsoon	24	2	8.3	**6.7**
		Monsoon	29	1	3.4	
		Post-monsoon	12	1	8.3	
6	Others (Pangolin)	Pre-monsoon	2	0	0.0	**20.6**
		Monsoon	7	2	28.6	
		Post-monsoon	12	4	33.3	
Total		**Pre-monsoon**	**188**	**48**	**25.5**	**25.6**
		Monsoon	**197**	**48**	**24.4**	
		Post-monsoon	**185**	**50**	**27.0**	

Key observations

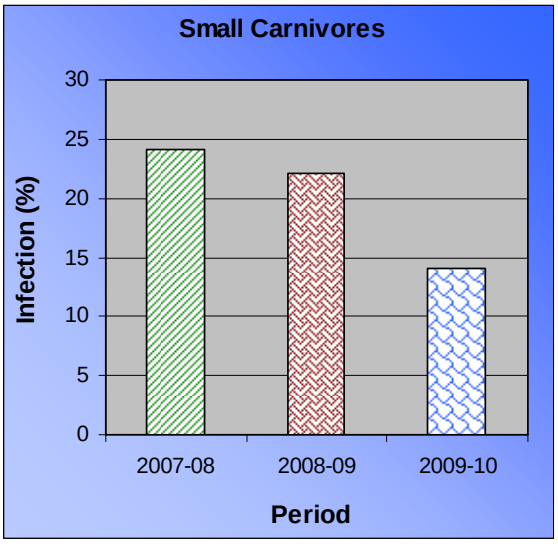
1. Among all the species of animals in the zoo the, prevalence of endoparasitic infection during 2009-10 was maximum in carnivores during pre-monsoon (61.1%) followed by post monsoon (51.7%) and monsoon (45.6%).

2. The prevalence of endoparasitic infection ranged between 24.4% (Monsoon) to 27.0 % (Post-monsoon) with an overall prevalence of 25.6%.

Fig 4 (a-f). Prevalence of endoparasitic infections in different species of mammals at Nandankanan Zoological Park during 2007 to 2010



(a)



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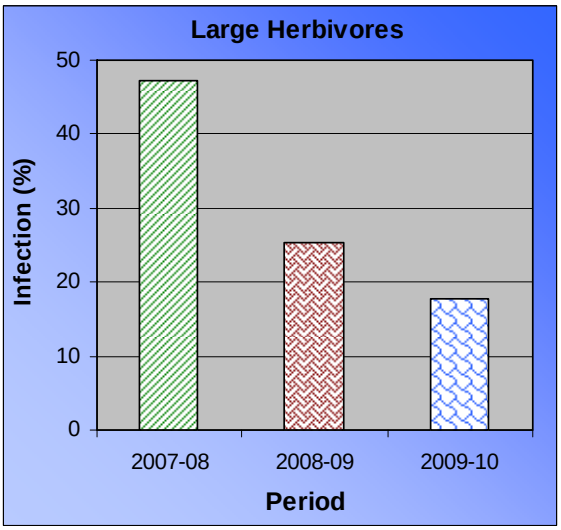
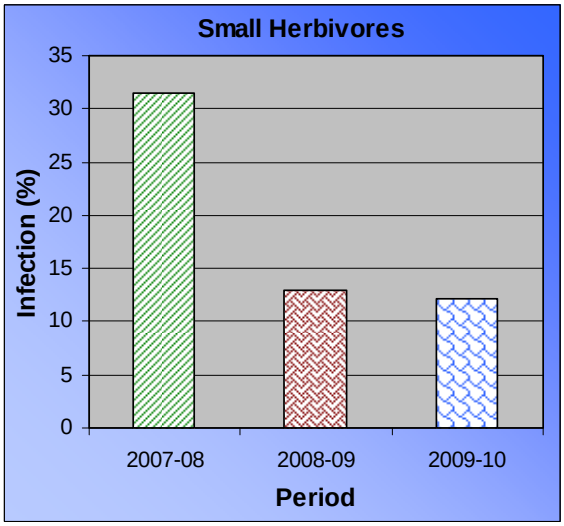
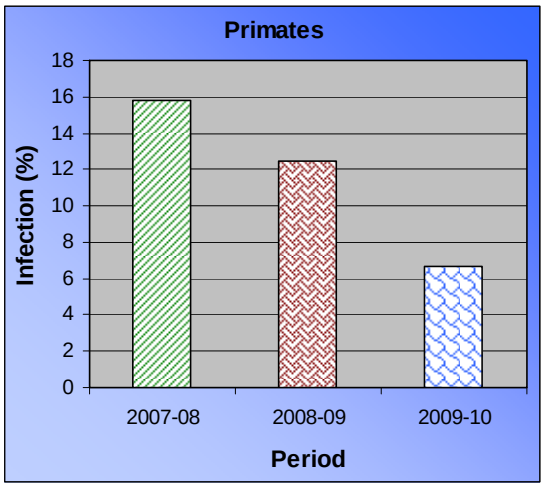


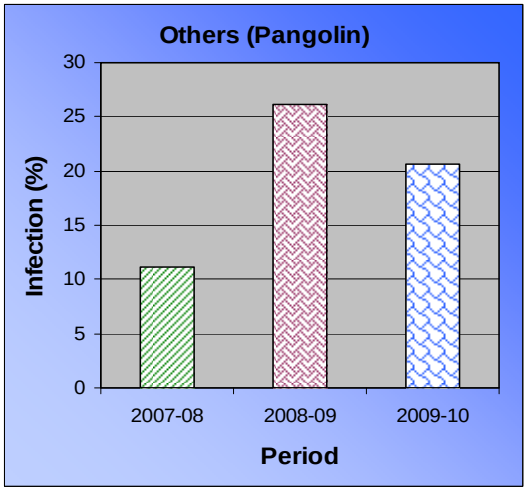
(c)



(d)



(e)



(f)

1. Prevalence of endoparasitic infection in large carnivores, small carnivores large herbivores, small herbivores and primates showed a decreasing trend from beginning of the study period (2007-08) to end of the study period (2009-10). The decline was significantly low in large carnivores.

2. At the end of study period i.e., 2009-10, the prevalence of endoparasitic infection in small carnivores, large herbivores and small herbivores were about 15%.

3. The prevalence of infection in Pangolin was highest during 2008-09 followed by 2009-10 and 2007-08.

Fig 5. Season-wise parasitic infection in mammals of Nandankanan Zoo during 2007-10.

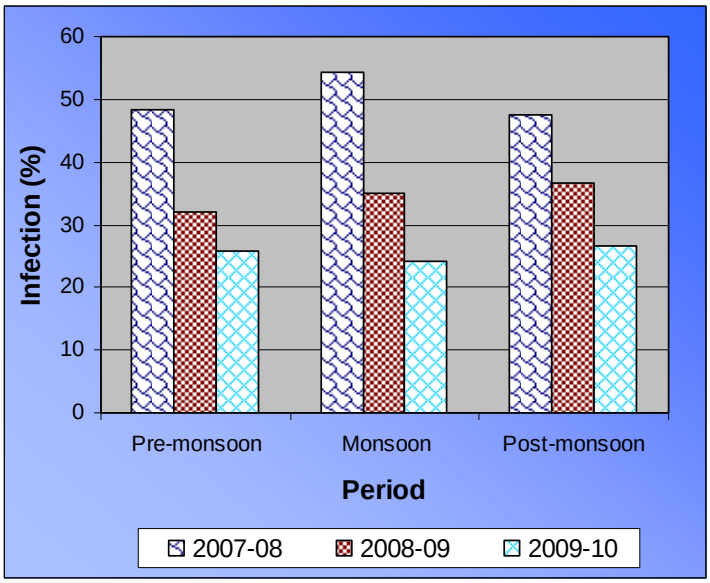
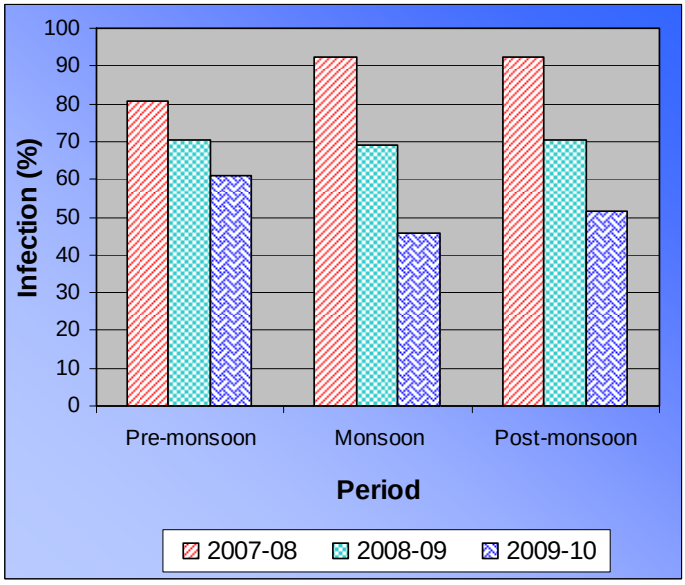


Fig 6. Season-wise prevalence of endoparasitic infection in Large Carnivores of Nandankanan Zoological Park during 2007-2010



Key observations

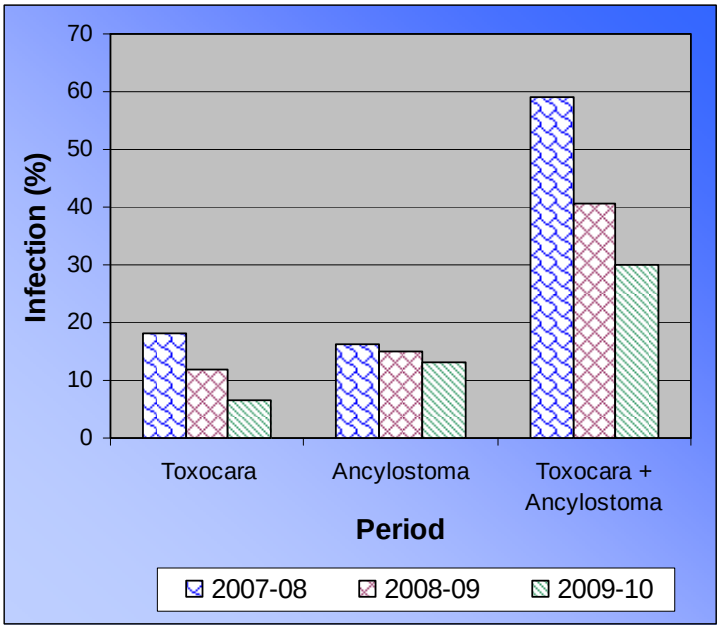
1. Prevalence of parasitic infection in mammals of Nandankanan Zoo during pre-monsoon season showed a declining trend from 2007-08 to 2009-10. Similar trend of infection was also noticed in other two seasons i.e., monsoon and post-monsoon.

2. The pattern of helminthic infection in carnivores was identical to that of mammals.

Table 5. Prevalence of nematode infection in large carnivores of Nandankanan Zoological Park during 2007-2010

Type of nematode infection	Prevalence rate of nematode infection in different years (%)		
	2007-08	2008-09	2009-10
***Toxocara* sp.**	18.0	12.0	6.5
***Ancylostoma* sp.**	16.4	15.0	13.0
***Toxocara* + *Ancylostoma* spp.**	59.0	40.6	30.1

Fig 7. Year-wise prevalence of nematode infection in large carnivores of Nandankanan Zoological Park during 2007-2010



Key points

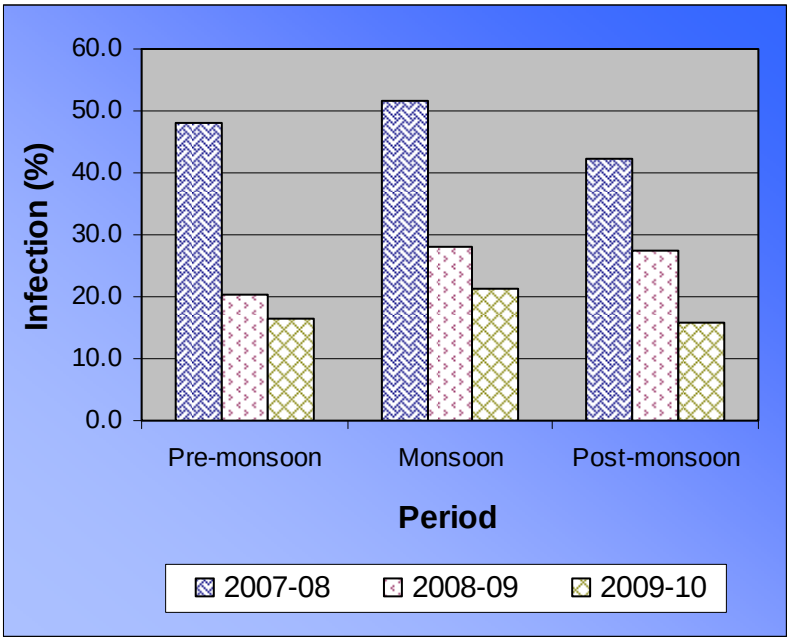
1. Mixed infection due to *Toxocara* and *Ancylostoma* spp. in large carnivores of Nandankanan Zoological Park was always in higher side (30.1-59.0%) during the period from 2007 to 2010 than the single infection due to either of the parasite which varied between 6.5 to18.0 per cent.

2. Prevalence rate of both single and mixed infection due to *Toxocara* and/or *Ancylostoma* spp. in carnivores of Nandankanan Zoological Park was reduced when compared to the rate of previous year.

Table 6. Prevalence of endoparasitic infection in large herbivores of Nandankanan Zoological Park during 2007-2010

Type of Endoparasites	Prevalence rate of nematode infection in different years (%)		
	2007-08	2008-09	2009-10
Trematodes	82.9	51.6	11.9
Nematodes	27.4	22.0	5.7

Fig 8. Season-wise prevalence of nematode infection in large herbivores of Nandankanan Zoological Park during 2007-2010



Key points

1. The prevalence of trematode (*Paramphistomum* sp.) infection recorded in large herbivores of Nandankanan Zoological Park during 2007-08, 08-09 and 09-10 were 82.9, 51.6 and 11.9 %, respectively which were remarkably in higher side as compared to the nematode infections of the corresponding year(5.7 -27.4%).
2. Maximum helminthic infection was noticed during monsoon of every year than the other two seasons.

RESULTS (Birds)

Table 7. Season-wise prevalence of helminth and coccidia infection in birds of Nandankanan Zoo during the year 2007-08.

Sl. No.	Name of the Birds	Type of parasitic infection		
		Pre-monsoon	Monsoon	Post-monsoon
1	Blossom Headed Parakeet	-	As	C, As
2	Alexandrine Parakeet	-	-	-
3	Indian Red Breasted Parakeet	As	As, C	As
4	Rosella Eastern Parakeet	-	-	-
5	Purple Capped Lorry	-	As, C	C
6	Yellow backed Lorry	-	C	-
7	Love birds	-	-	Cp
8	Brown winged Conure	-	As	-
9	Nandeya Conure	-	-	-
10	Zendya Conure	-	-	-
11	Cockatiel	-	-	Cp
12	Green winged Macaw	-	-	-
13	Green winged Macaw	-	-	-
14	Blue Yellow Macaw	-	-	-
15	Green winged Macaw	-		-
16	Silver Pheasant	-		Cp
17	Lesser Sulphur Crested Cockatoo	-	-	-
18	Budgerigar	As	As	C
19	Silver Pheasant	-	-	
20	Silver Pheasant	-		Cp, As
21	Budgerigar	-	-	-
22	Koel	-	Cp	Cp, C
23	Golden Pheasant	-	-	-
24	Silver Pheasant	-	As	-
25	Golden Pheasant	-		
26	Nicober Pigeon	-	-	-
27	Grey Bhutan Peacock Pheasant	-	Cp	-
28	Alexandrine Parakeet		-	-
29	Pariah Kite	As	As	Cp
30	Brahminy Kite	-	-	-
31	Alexandrine Parakeet			-
32	Nicober Pigeon	-		-
33	Vulture			-
34	Scavenger			As
35	White Scavenger Vulture	-	-	-
36	White Backed Vulture (Indian)	As	As	
37	Cassowary		-	-
38	Cassowary		-	-
39	Cassowary	-	-	-
44	Emu		-	-
45	Indian Peafowl White	-	-	

46	Indian Peafowl	-	Cp	
48	Black Swan	As, C	As, Cp, C	
49	Java Sparrow		-	-
50	Budgerigar	-	-	-
51	Zebra Finch		-	-
52	Diamond Dove	As, C	As, C	-
53	Bengal Finch		C	-
54	Munia	As	As, C	-
55	Rose Ringed Parakeet (Adm. Off.)		C	As
56	Shikra			-
57	Saras Crane		-	-
58	Dove (Children's Park)		Cp	-
59	Chinese White Dove	-	Cp	-
60	Common Indian Peacock	As	As	As
61	Peacock (Black - Chicks)		C	
62	Peacock (White)		As, C	Cp
63	Peacock (Black)	C	As, C	
64	Budgerigar (Children's Park)	-		-
66	Dove (Adm. Off.)			-
67	Budgerigar (Adm. Off.)			-
TOTAL				
Samples Collected		**43**	**49**	**53**
Samples found Negative		**34**	**26**	**39**
Samples found Positive		**9(21.0)**	**23(47.0)**	**14(26.4)**

As- Ascaridia: Cp-Capilaria: C- Coccidia

Figure in parenthesis indicates percentage of infection.

Key Points

1. Out of 43, 49 and 53 samples examined during the year 2007-08 in pre-monsoon, monsoon and post-monsoon seasons 9, 23 and 14 samples were found positive for nematode and/or protozoa infection indicating a prevalence rate of 21.0, 47.0 and 26.4%, respectively.
2. The nematode eggs identified in the faecal samples were *Ascaridia* and *Capillaria* spp.
3. Coccidia occysts were detected either alone or in combination with nematodes.

Table 8. Season-wise prevalence of helminth and coccidia infections in birds of Nandankanan zoo during the year 2008-09.

Sl. No.	Name	Type of parasitic infection		
		Pre-monsoon	Monsoon	Post-monsoon
1	Blossom Headed Parakeet	-	-	-
2	Alexandrine Parakeet	-	As	-
3	Indian Red Breasted Parakeet	As	As	As
4	Lesser Sulphur Crested Cockatoo			-
5	Rosella Eastern Parakeet	-	-	-
6	Purple Capped Lorry	As	C	-
7	Yellow backed Lorry	C	-	-
8	Love birds	-	C	-
9	Brown winged Conure	-	-	-
10	Nandeya Conure	-	-	-
11	Janday Conure	-	-	-
12	Budgerigar		C	C
13	Cockatiel	-	C	-
14	Green winged Macaw	-	-	-
15	Green winged Macaw	-	-	-
16	Blue Yellow Macaw	-	-	-
17	Green winged Macaw			
18	Silver Pheasant			
19	Lesser Sulphur Crested Cockatoo	-	-	-
20	Budgerigar	-		
21	Silver Pheasant	As	-	C
22	Silver Pheasant	-	-	-
23	Budgerigar			
24	Budgerigar	-	-	C
25	Budgerigar			-
26	Koel	Cp	As	Cp
27	Golden Pheasant	Cp	-	
28	Silver Pheasant	-	-	-
29	Golden Pheasant			
30	Rose Ringed Parakeet			
31	Nicober Pigeon		-	-
32	Grey Bhutan Peacock Pheasant	-	-	-
33	Alexandrine Parakeet	-	As	-
34	Pariah Kite	-	-	As
35	Brahminy Kite			-
36	Alexandrine Parakeet		-	-
37	Alexandrine Parakeet	-	-	
38	Nicober Pigeon	-	-	
39	Scavenger			
40	White Vulture	As	Cp	
41	White Scavenger Vulture			-
42	White Backed Vulture (Indian)		Cp	
43	Cassowary		-	-
44	Cassowary		-	-
45	Cassowary	-		-
50	Emu		-	-
51	Indian Peafowl White		-	C

52	Indian Peafowl		-	
53	Black Swan			-
55	Java Sparrow	-	-	-
56	Budgerigar			-
57	Zebra Finch	-	-	-
58	Diamond Dove	-	-	-
59	Bengal Finch		-	-
60	Red Munia	-	-	-
61	Budgerigar (Adm. Off.)	-		-
62	Rose Ringed Parakeet (Adm. Off.)		-	-
63	Shikra			
64	Budgerigar (Children's Park)			
65	Chinese White Dove			
66	Common Indian Peacock	As		-
67	Dove (Adm. Off.)		-	
68	Dove (Children's Park)			
70	Peacock (Black - Chicks)		-	-
71	Peacock (Black)	As	-	
72	Peacock (White)	C	-	Cp, C
73	Saras Crane		-	C
74	Eagle		-	-
TOTAL				
Collected		**43**	**54**	**55**
Negative		**27**	**38**	**40**
Positive		**16(37.2%)**	**16(29.6%)**	**15(27.2%)**

As- Ascaridia; Cp- Capilaria; C- Coccidia

Figure in parenthesis indicates percentage of Infection.

Key Points

1. Out of 43,54 and 55 feacal samples examined during the year 2008-09 in pre-monsoon, monsoon and post-monsoon seasons 16, 16 and 15 samples were found positive for nematode and/or protozoa infection indicating a prevalence rate of 37.2, 29.6 and 27.2%, respectively.
2. The eggs/oocysts identified in the faecal samples were *Ascaridia, Capillaria Eimeria* spp., either alone or in combination.

Table 9. Season-wise prevalence of helminth and coccidia infection in birds of Nandankanan Zoo during 09-10.

Sl. No.	Name	Type of parasitic infection		
		Pre-monsoon	Monsoon	Post-monsoon
1	Blossom Headed Parakeet	-	-	-
2	Alexandrine Parakeet	-	-	-
3	Indian Red Breasted Parakeet	-	As	-
4	Lesser Sulphur Crested Cockatoo			-
5	Rosella Eastern Parakeet		-	
6	Rosella Eastern Parakeet	-	-	-
7	Purple Capped Lorry	-	-	-
8	Yellow backed Lorry		-	
9	Yellow backed Lorry	-	-	-
10	Love birds			-
11	Love birds		-	-
12	Love birds		-	
13	Love birds	-		
14	Brown winged Conure		-	-
15	Nandeya Conure			
16	Janday Conure		-	-
17	Budgerigar	-	-	-
18	Cockatiel			
19	Cockatiel	-	-	-
20	Green winged Macaw	-	-	-
21	Green winged Macaw	-	-	-
22	Blue Yellow Macaw	-	-	-
23	Blue Yellow Macaw		-	
24	Green winged Macaw			
25	Silver Pheasant			
26	Lesser Sulphur Crested Cockatoo	-	-	
27	Budgerigar			
28	Silver Pheasant	-	-	-
29	Silver Pheasant		-	-
30	Budgerigar	-		
31	Budgerigar		-	-
32	Budgerigar			
33	Koel	-	-	-
34	Golden Pheasant	-	-	-
35	Silver Pheasant	-	-	-
36	Golden Pheasant			
37	Rose Ringed Parakeet	-		
38	Nicober Pigeon		-	
39	Nicober Pigeon	-	-	-
40	Grey Bhutan Peacock Pheasant	-	-	
41	Alexandrine Parakeet			
42	Pariah Kite	-	-	
43	Brahminy Kite	-	-	C
44	Alexandrine Parakeet	-	-	-
45	Alexandrine Parakeet			
46	Nicober Pigeon			
47	Scavenger	-	-	
48	White Vulture		-	
49	White Scavenger Vulture	-		-
50	White Backed Vulture (Indian)			

51	Cassowary	-	-	-
52	Cassowary	-	-	-
53	Cassowary		-	-
54	Pelican Rosy/ White			
55	Spot Bill Duck			
56	White Ibis			
57	White Necked Stork			
58	Emu	-	-	-
59	Indian Peafowl White			
60	Indian Peafowl			
61	Black Swan	-	L	C
62	Common Crane			
63	Java Sparrow	-	C	-
64	Budgerigar			-
65	Zebra Finch	-	-	-
66	Diamond Dove	-	-	-
67	Bengal Finch	-	-	-
68	Red Munia	-	-	-
69	Budgerigar (Adm. Off.)		-	
70	Rose Ringed Parakeet (Adm. Off.)		-	-
71	Shikra		-	As
72	Budgerigar (Children's Park)		As	Cp
73	Chinese White Dove		-	
74	Common Indian Peacock		-	-
75	Dove (Adm. Off.)			
76	Dove (Children's Park)		-	
77	Open bill stork (Aviary sec.)	-		-
78	Peacock (Black - Chicks)			
79	Peacock (Black)	As	As	As
80	Peacock (White)	As	As	As
81	Saras Crane	-	-	-
82	Eagle		As	
83	Water Aviary	-	-	-
84	Mandarin Duck	-	-	-
85	Peacock (New)		As, C	-
86	Peacock (New)		As, C, Cp	-
87	Ring Dove		-	
TOTAL				
Collected		**39**	**58**	**47**
Negative		**37**	**49**	**41**
Positive		**2(5.1%)**	**9(15.5%)**	**6(12.7%)**

As- Ascaridia; Ca- Capilaria; C- Coccidia

Figure in parenthesis indicates percentage of Infection.

Key Points

1. The prevalence rate of parasitic infection during the year 2009-10 in pre-monsoon, monsoon and post-monsoon seasons were 5.1%(2/39), 15.5%(9/58) and 12.7%(6/47) respectively.
2. Two nematode eggs i.e., *Ascaridia* and *Capillaria* spp. and one coccidian oocyst i.e., *Eimeria* sp., either single of mixed form, were detected in the faecal samples.

Fig 9. Season-wise prevalence of parasitic infection in birds at Nandankanan Zoological Park during 2007-10

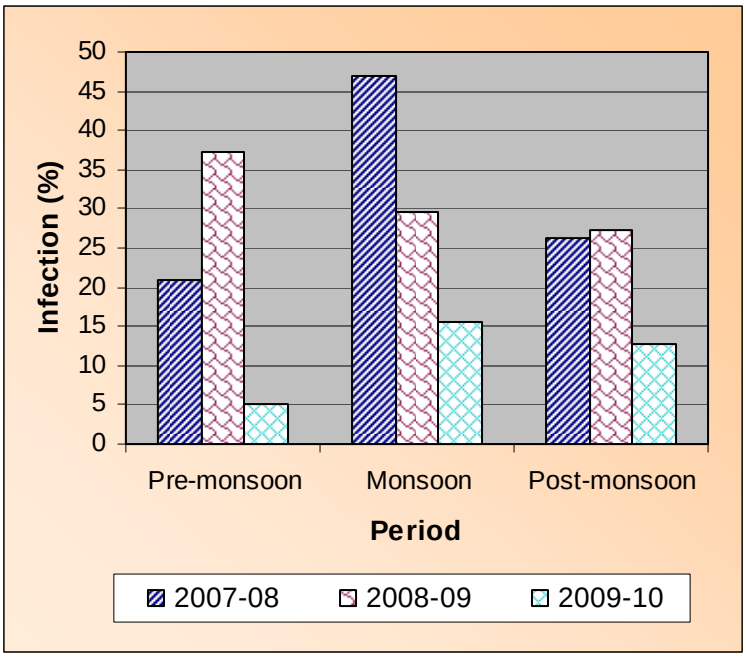
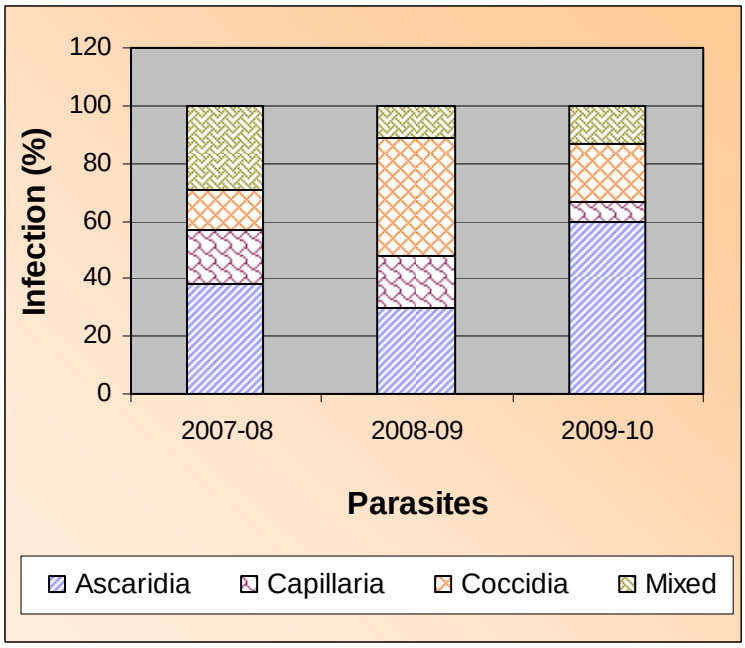


Fig 10. Prevalence of different parasitic infections in birds at Nandankanan Zoological Park during 2007-10



Key observations

1. Nematode and coccidia infection, either single or mixed, were prevalent in birds during different period under study i.e., 2007-2010.
2. No definite pattern of prevalence of parasitic diseases was recorded with respect to the seasons of the year.

RESULTS (Reptiles)

Table 10 . Season-wise prevalence of endoparasitic infection in different species of reptiles at Nandankanan Zoological Park during 2007-2010

Sl. No.	Periods	Season	No. of faecal samples examined	No. of samples positive for parasitic infection	Percentage of infection	Overall percentage of infection
1	2007-08	Pre-monsoon	16	2	12.5	**13.9**
		Monsoon	14	2	14.3	
		Post-monsoon	20	3	15.0	
2	2008-09	Pre-monsoon	19	2	10.5	**10.3**
		Monsoon	14	1	7.1	
		Post-monsoon	15	2	13.3	
3	2009-10	Pre-monsoon	20	1	5.0	**8.1**
		Monsoon	16	2	12.5	
		Post-monsoon	15	1	6.7	
Total		**Pre-monsoon**	**55**	**5**	**9.1**	**10.8**
		Monsoon	**44**	**5**	**11.4**	
		Post-monsoon	**50**	**6**	**12.0**	

Key Points

1. Prevalence of endoparasitic infection during the year 2007-08 was highest (13.9%) in Reptiles followed by 2008-09 (10.3%) and 2009-10 (8.1%).

2. Maximum prevalence of endoparasitic infection was recorded in post-monsoon (12.0%) followed by monsoon (11.4%) and pre-monsoon (9.1%) with an overall percentage of 10.8.

Fig 11. Season-wise parasitic infection in reptiles of Nandankanan Zoological Park during 2007-10.

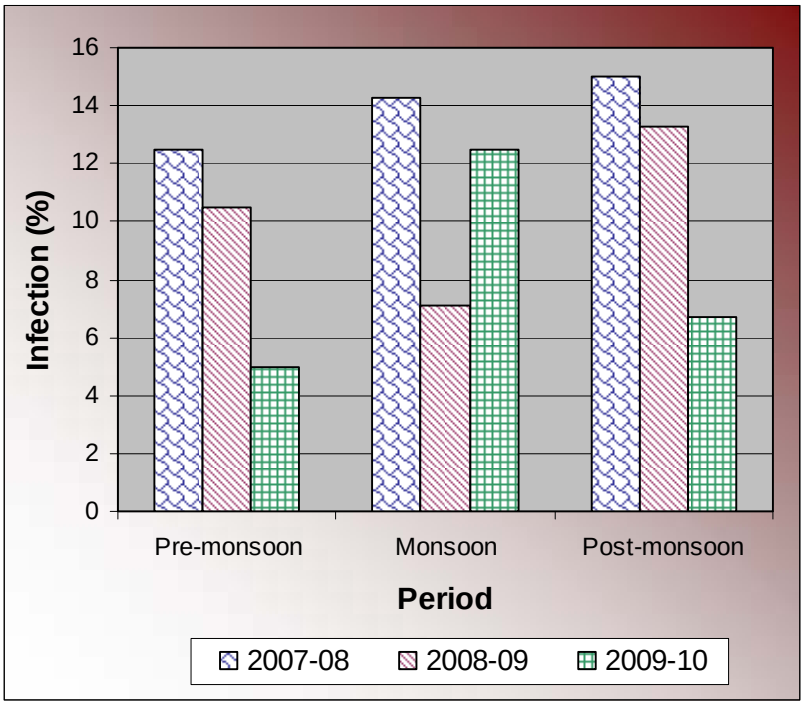
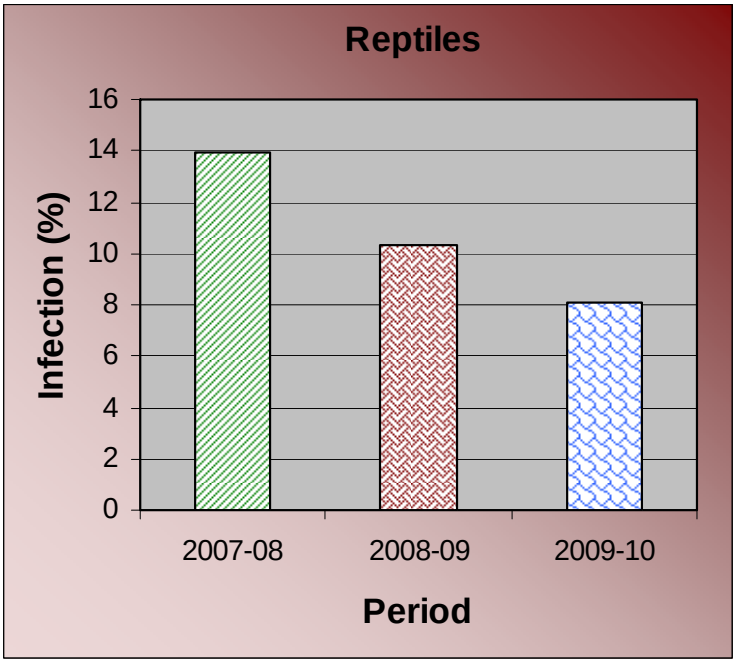


Fig 12. Prevalence of endoparasitic infections in different species of reptiles at Nandankanan Zoological Park during 2007 to 2010



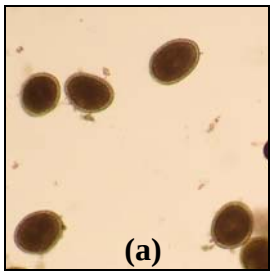
Key Points

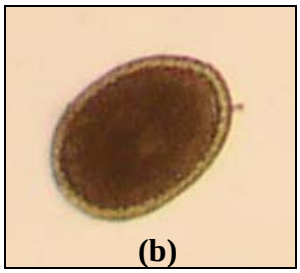
1. Prevalence of endoparasitic infection in reptiles showed a declining trend from initial study period (2007-08) upto the end (2009-10).

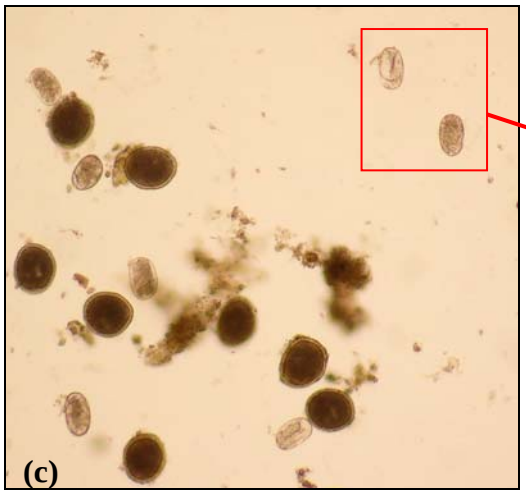
2. Maximum rate of prevalence was recorded either during the post-monsoon period (2007-08 and 2008-09) or monsoon season (2009-10).

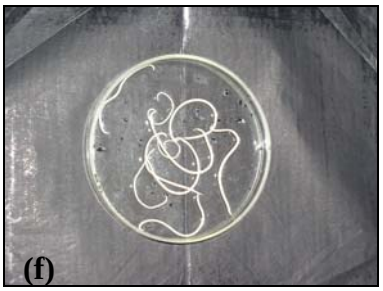
ENDOPARASITES RECOVERED FROM MAMMALS, BIRDS AND REPTILES OF NANDANKANAN ZOO

Tiger (*Panthera tigris*)









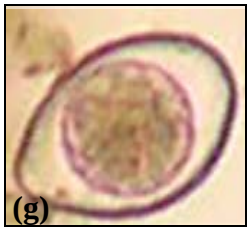
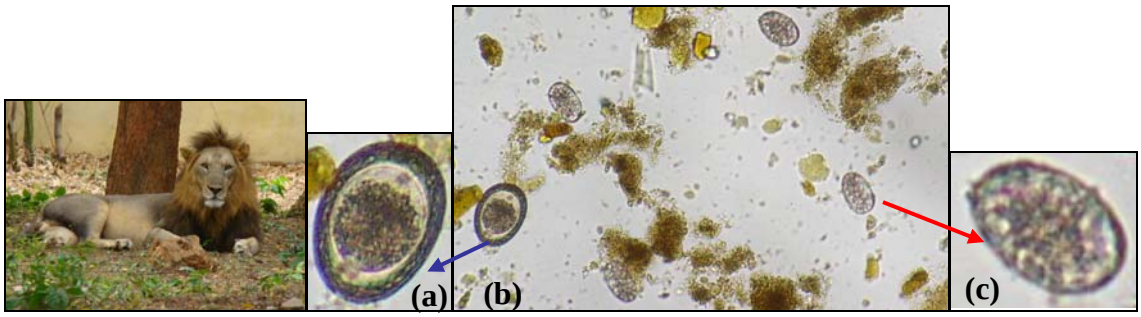
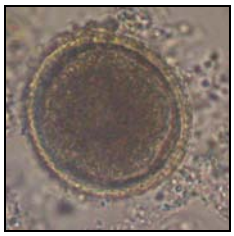


Fig 13 (a-g). (a) *Toxocara cati* eggs [X100], (b) magnified view of *Toxocara cati* egg, (c) *Toxocara cati, Ancylostoma* spp. and *Strongyloides* spp. eggs [X100], (d) magnified form of *Strongyloides* spp. and *Ancylostoma* spp. eggs, (e) *Ancylostoma* sp. egg [X400], (f) *Toxocara cati* adult parasites and (g) *Isospora felis* oocyst [X400].



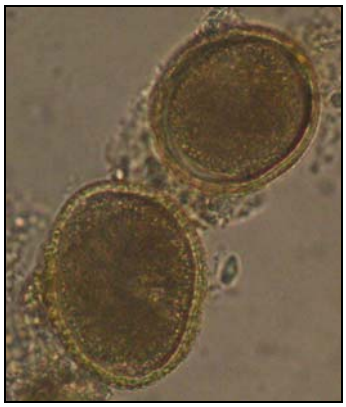
Lion (*Panthera leo*)

Fig 14 (a-c). (a) Magnified view of *Toxascaris leonina* egg (b) *Toxascaris leonina* and *Ancylostoma* spp. eggs [X100] and (c) magnified form of *Ancylostoma* spp. egg recovered from lion (*Panthera leo*)



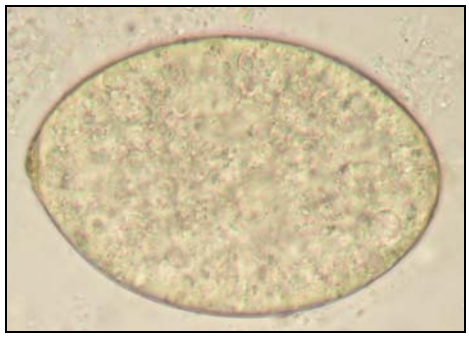
Leopard (*Panthera pardus*)

Fig 15. *Toxocara* sp. egg recovered from leopard [X400].



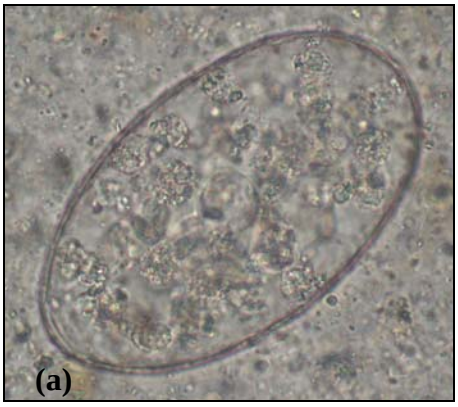
Jaguar (*Panthera onca*)

Fig 16.*Toxocara* sp. eggs recovered from jaguar [X400].



Sloth bear (*Melursus ursinus*)

Fig 17. Magnified view of *Paragonimus* sp. egg recovered from sloth bear.

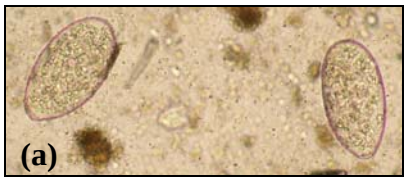


Nilgai (*Boselaphus tragocamelus*)

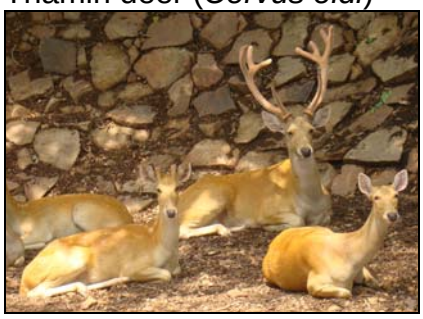
Fig 18 (a and b). (a) *Paramphistomum* sp. egg [X400] and (b) *Strongyloides* sp. egg [X400] recovered from Nilgai.

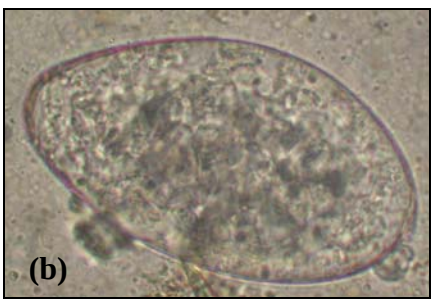
Sambar (*Cervus unicolor)*

Fig 19. Magnified form of *Paramphistomum* sp. egg recovered from Sambar



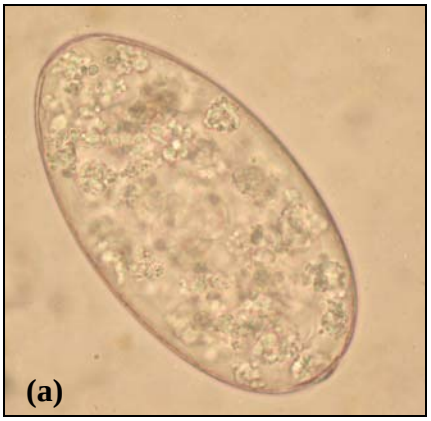
Thamin deer (*Cervus eldi*)





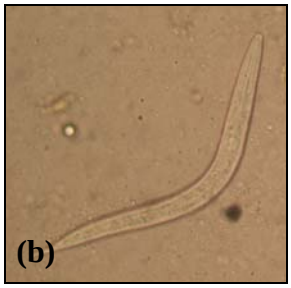
Swamp deer (*Cervus duvauceli duvauceli / randari*)

Fig 20 (a and b). (a) *Paramphistomum* sp. eggs [X100] and magnified view of *Paramphistomum* sp. egg recovered from Thamin deer and Swamp deer, respectively.



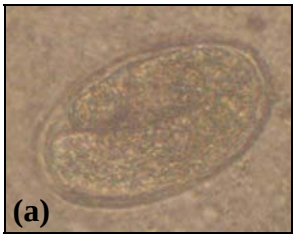
Mithun (*Bos frontalis*)

Fig 21 (a & b). (a) *Paramphistomum* sp. [X400] egg and (b) Strongyle sp. egg [X400] recovered from Mithun.

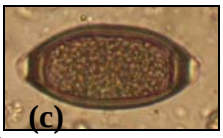


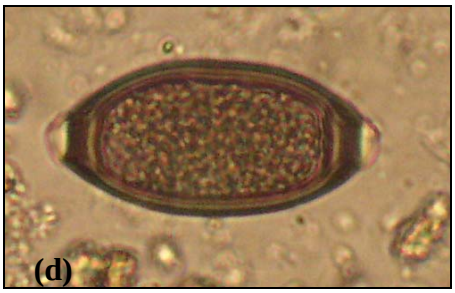
Hippopotamus (*Hippopotamus amphibious*)

Fig 22 (a & b). (a) *Strongyloides* sp. egg and *Strongyloides* sp. larva recovered from hippopotamus.



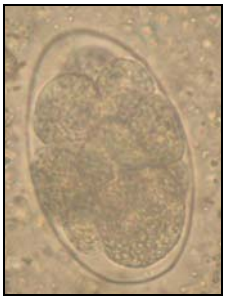
Hog deer (*Axis porcinus*)





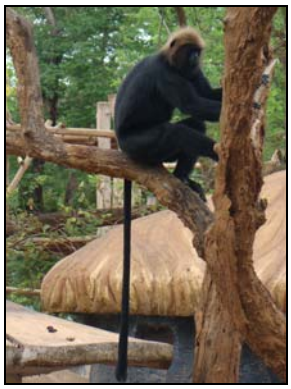
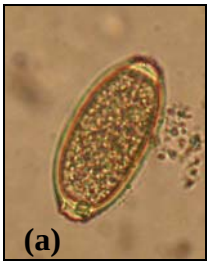
Barking deer (*Muntiacus muntjak*)

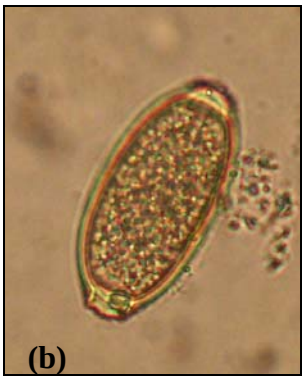
Fig 23 (a-d). (a) *Strongyloides* sp. egg [X400], (b) magnified view of *Strongyloides* sp. egg, (c and d) *Trichuris* sp. egg [X400] and magnified form of *Trichuris* sp. egg recovered from hog deer and barking deer respectively.

Elephant (*Elephas maximus*)

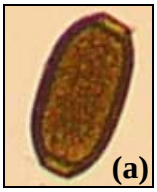
Fig 24. Strongyle sp. egg [X400] recovered from Indian elephant.

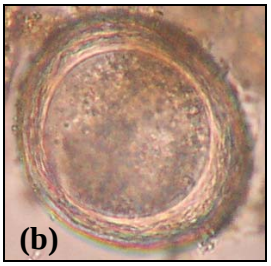





Nilgiri langur (*Presbytis johnii*)

Fig 25 (a and b). *Trichuris* sp. egg [X400] and magnified form of *Trichuris* sp. egg recovered from langur.

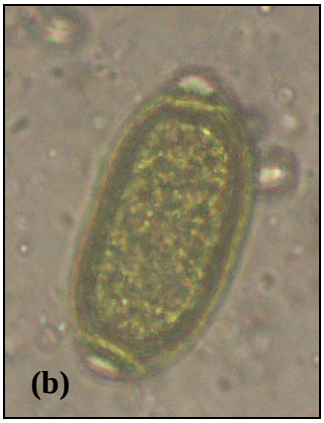


Hamadryas baboon (*Papio* sp.)

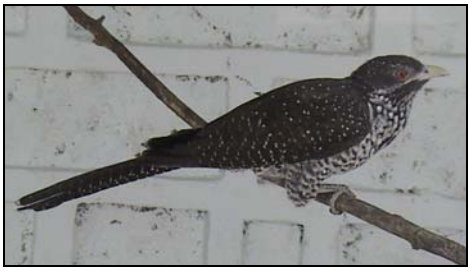
Fig 26 (a and b). (a) *Trichuris* sp. egg [X400] and (b) Ascaris egg [X400] recovered from baboon

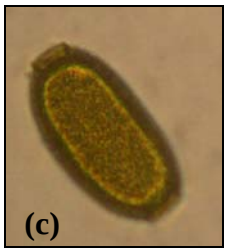

Rhesus monkey (*Macaca mulatta*)

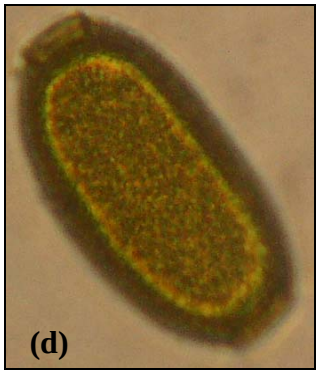
Fig 27. *Trichuris* sp. egg [X400] recovered from monkey.



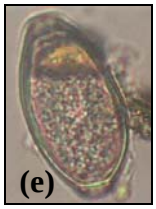
Budgerigar (*Melopsittacus undulates*)



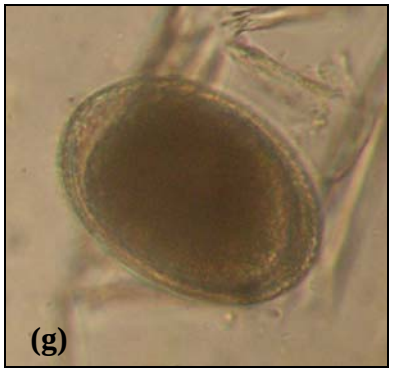




Koel (*Eudynamys scolopacea)*

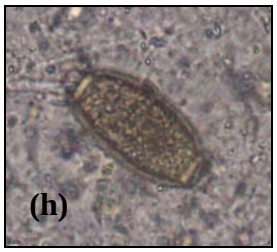


Black Swan (*Cygnus atratus*)

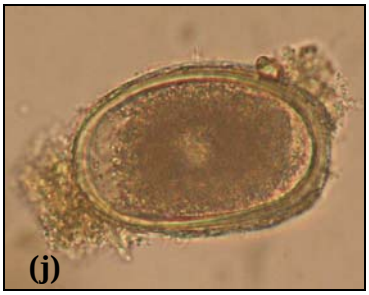


Shikra *(Accipiter badius)*

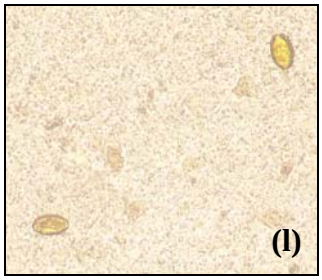
Fig 28 (a-g). (a to f) *Capillaria* sp. egg [X400] and its magnified view against each recovered from Budgerigar, koel and black swan respectively and (g) *Ascaridia* sp. egg [X400] recovered from Shikra.

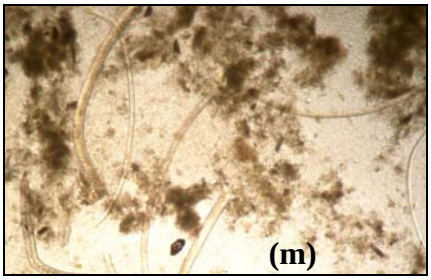


White peafowl (*Pavo cristatus*)

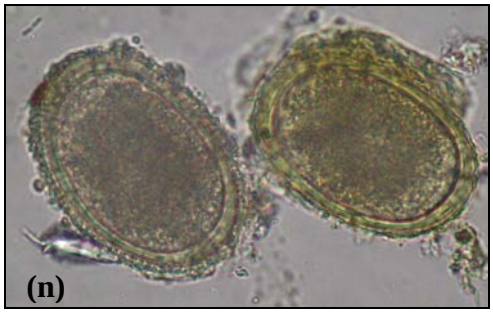


Peafowl (*Pavo cristatus*)

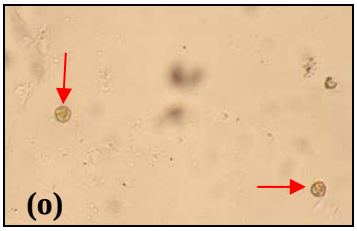




Love bird (*Agapornis fischeri*)

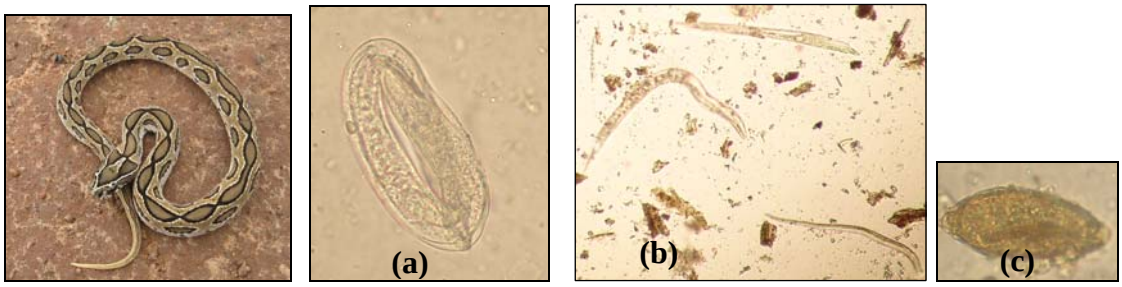


Red-breasted parakeet (*Psittacula alexandri)*

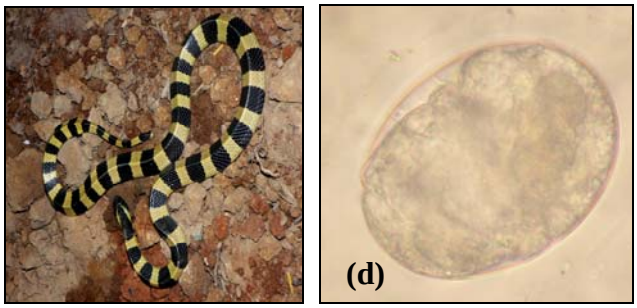


Java Sparrow (*Padda oryzivora)*

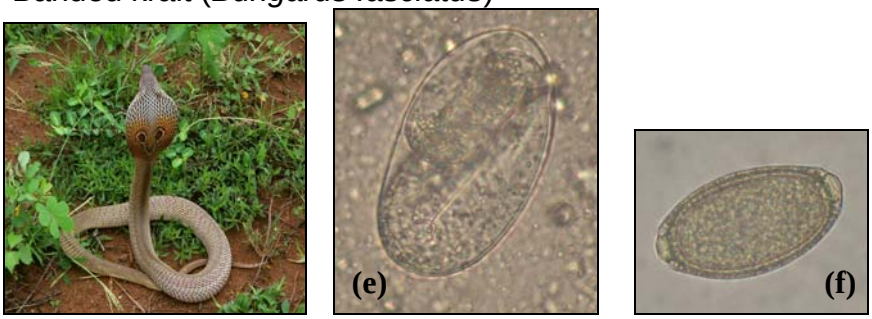
Fig 29 (h-o). (h and i) *Capillaria* sp. egg [X400] and *Strongyloides* sp. egg [X400] respectively recovered from white peafowl, (j and k) *Ascaridia* sp. Egg [X400], and *Strongyloides* sp. egg [400] respectively recovered from peafowl, (l and m) *Capillaria* sp. egg [X100] and larva [X100] respectively, recovered from Love bird (n) *Ascaridia* sp. eggs [X400] recovered from Red-breased parakeet and (o) *Eimeria* sp. oocysts [X100] recovered from Java sparrow.



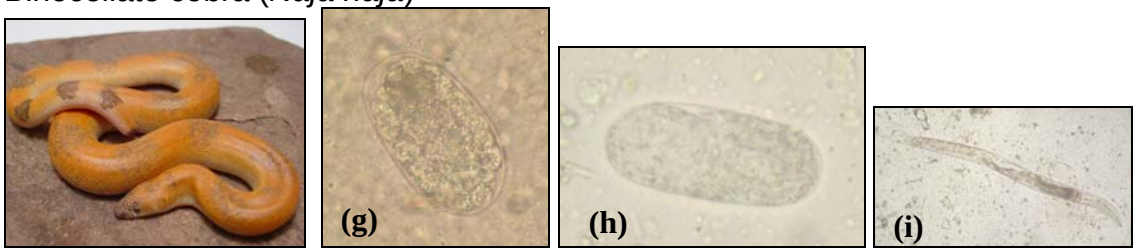
Viper, Russel's (*Vipera ruselli*)



Banded krait (*Bungarus fasciatus*)



Binocellate cobra (*Naja naja*)



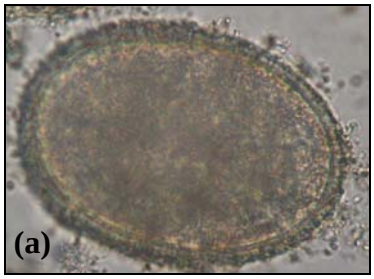
Sand boa (*Eryx johni*)

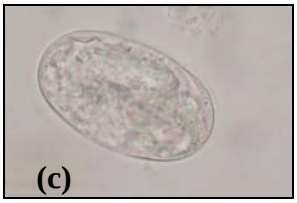
Star tortoise (*Geochelone elegans*)

Fig 30 (a-j). (a to c) *Strongyloides* sp. egg [X400], *Strongyloides* sp. larva [X100], and *Trichuris* sp. egg [X400] respectively, recovered from Russel's viper; (d) Strongyle egg [X400] recovered from Banded krait; (e and f) *Strongyloides* sp. egg [X400] and *Trichuris* sp. egg [X400] respectively, recovered from Binocellate cobra; (g to i) Strongyle spp. egg, *Strongyloides* sp. egg [X400] and larva respectively are recovered from Sand boa and (j) Magnified view of *Strongyloides* sp. larva recovered from Star tortoise.

ENDOPARASITES RECOVERED FROM PANGOLIN OF NANDANKANAN ZOO

Pangolin (*Manis crassicaudata*)





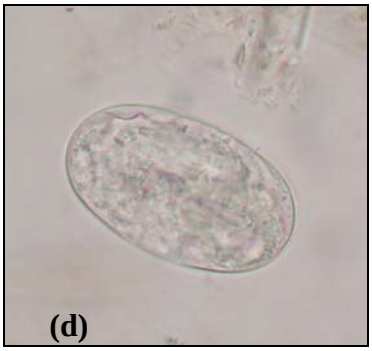


Fig 31 (a-d). (a) Magnified view of Ascaris egg, (b) Magnified view of *Strongyloides* sp. egg and larva and (c and d) Strongyle egg [X100] and [X400] respectively, recovered from Pangolin.

OBJECTIVE – II

To study the prevalence of ectoparasitic infestation in different species of captive animals and birds

The ectoparasites in different species of captive animals and birds include ticks, lice, fleas and mites. The infestation can be diagnosed by naked eye examination of the body coat and/or microscopic examination of skin scraping. It is not out of way to mention here that there are some inherent bottlenecks in the regular examination of body coat in different species of captive wild mammals, reptiles and birds for isolation of ectoparasites which in turn may invite health hazards. However, no opportunity was missed to record the presence of ectoparasite(s), if any, especially during post-mortem examination and restraint of the animal.

METHODOLOGY

2.1 Examination of skin for identification of ectoparasites

The body coats of the restrained/ dead mammals, reptiles and birds were examined for presence of ectoparasites like ticks, lice, mites and fleas.

2.2 Fixation procedure

Ectoparasites like ticks, mites and fleas were preserved in 70% alcohol. The preserved specimen was transferred to water by passing through descending grades of alcohol and washed thoroughly. For removal of the internal parts or blood from the ectoparasite, its body was punctured at 2 to 3 points. The washed material was kept in 10% KOH solution for 24 hours. Then the specimen was transferred to water in a watch glass and pressed with needle to expel the dissolved internal parts. After thorough washing in water, the specimen was dehydrated in ascending grades of alcohol i.e., 50, 70, 90, 95 and 100%, allowing 15-30 minutes for each concentration. Finally, it was transferred to cedar wood oil for clearing followed by mounting in D.P.X. on a glass slide with a cover glass over it.

RESULTS

The parasites recovered from different species of mammals and reptiles were brought to the laboratory for identification of the species. Based on the source as well as the morphological characteristics, the ectoparasites isolated from tiger, pangolin, python and swamp deer were identified as *Boophilus* and *Rhipicephalus* spp. (Ticks) , *Ophionyssus* sp.(Mites) and *Vermipsylla* sp.(Flea) which were described below .

***Boophilus* sp.**

- Ticks recovered from one tiger
- Anal groove absent in female, faint in male and surrounding the anus posteriorly.
- Inornate and eyes present
- Festoons absent
- Palps and hypostome short
- Coxa I bifid
- Spiracles circular or oval
- Legs ordinary size

***Rhipicephalus* sp.**

- Ticks were recovered from the pangolin
- Usually inornate
- Eyes and festoons present
- Hypostome and palpi short
- Basis capituli hexagonal dorsally
- Coxa I with two strong spurs
- Spiracles comma shaped.

***Ophionyssus* sp.**

- Mites were recovered from the skin or under the scales of a python
- Adult mites measure 0.8-1.2 mm
- Dark red or black in colour (Engorged)
- Two dorsal plates were present

***Vermipsylla* sp.**

- Fleas were recovered from Swamp deer
- Insects were wingless with Laterally compressed bodies
- Approximate length: 2.5 mm
- Chitinous covering was thick and dark brown
- Abdomen had 10 segments
- Legs were long

Table 11. Isolation of ectoparasites from different species of mammals, birds and reptiles of Nandankanan Zoological Park at the time of post mortem examination or restraint during 2007-10.

Period of examination	Status of ecto-parasitic infestations				
	Character	Mammals	Birds	Reptiles	Total
2007- 08	No. of heads examined	34	21	05	60
	No. of heads positive for ectoparasites	09	0	01	10
2008- 09	No. of heads examined	27	14	03	44
	No. of heads positive for ectoparasites	07	0	01	08
2009-10	No. of heads examined	18	08	02	28
	No. of heads positive for ectoparasites	07	0	0	07

a. Out of 60, 44 and 28 heads of examined 10, 8 and 7 heads were of found positive for ectoparasitic infestation during the period 2007-08, 2008-09 and 2009-10, respectively.

b. The mammals were the dominating host for ectoparasites. Tigers constituted the major species of mammals where *Boophilus* sp. of ticks were isolated/identified.

c. None of the birds showed presence of ectoparasites during the period under study.

d. Besides tigers, ectoparasites have also been isolated/identified from the swamp deer and pangolin.

e. Among reptiles python was the only species identified to be affected with an ectoparasite i. e. *Ophionyssus* sp.

OBJECTIVE – III

To compare the efficacy of available drugs against endo and ecto-parasites in different species of animals and birds.

METHODOLOGY (Endoparasites)

The results of the prevalence studies revealed that Ascarids (*Toxocara* and *Toxascaris* sp.) and *Ancylostoma* spp., either single or mixed, in lions and tigers were common during different seasons of the year under study. This fact stimulated to undertake comparative efficacy studies of available drugs against such parasites. Besides, anthelmintics were evaluated against *Paramphistomum* sp. infection in herbivores.

3.1 Quantitative examination of faecal sample

Quantitative examination of the faecal samples was performed to evaluate the comparative efficacy of anthelmintics used against different parasitic infections. The eggs per gram of faeces (EPG) for nematode and trematode infection were undertaken using Willi's Technique and Stoll's dilution method, respectively. The EPG was carried out during pretreatment and on day 3, 7 and 10 post-treatment to assess the efficacy of the drugs used in the study.

3.1.1 Willi's Technique

An even suspension was made by taking 1 gm of faeces and 10-15 ml of water. The suspension was strained and centrifuged at 1500 rpm for 3 minutes. The sediment was transferred to a glass tube of 7.5 cm long and 2 cm diameter. Then saturated solution of magnesium sulphate was poured into the glass tube and mixed well. A glass slide was placed over the tube keeping it in standing position undisturbed for 20 to 30 minutes. The slide was removed by covering with a cover slip and examined under the low power objective (10X) of research microscope. The number of parasitic eggs present in the sample taken was counted. Three such observations were made and the average numbers of nematode eggs per gram of faeces were calculated.

3.1.2 Stoll's dilution method

Three grams of faeces were taken in a 45 ml graduated test tube. Deci-normal caustic soda was added up to 45 ml mark. The tube was closed with rubber

stopper by putting 10-12 glass beads into it and was shaken vigorously to make a homogenous suspension. Then the suspension was strained to remove the faecal debris. With the help of graduated pipette, 0.15 ml of the suspension was put into a slide and examined under the microscope by putting a cover slip on it. The total number of trematode eggs per gram of faeces was calculated by multiplying the total no. of eggs present in 0.15 ml of fluid with 100.

3.2 Comparative efficacy of the anthelmintics

The comparative efficacy of the anthelmintics was carried out against the prevalent nematode infection in tigers and lions. Different drugs i.e., Pyrental pamoate (Nemocid[1]), Levamisole (Dewormis[2]), Albendazole (Valbazen[3]) and Ivermectin (Neomec[4] Tablet or Hitek injection[5]) were administered @ 20.0 mg, 4.4 mg, 25.0 mg and 200 mcg per kg b.wt. along with the meat to the lions and tigers. Ivermectin Injection was administered through subcutaneous route where difficulty was experienced in giving the drug through oral route. Turmeric (*Curcuma longa*) powder was administered @ 5.0 gram daily orally for seven days.

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[1] Manufactured by M/S Ipca Laboratories Ltd, 63-E, Ipca House, Kandivili West, Mumbai.,Each tablet contain 250mg pyrantel pamoate

[2] Manufactured by M/S GlaxoSmithkline Ltd, Dr Annie Besant Road, Worli, Mumbai.,Each tablet contain 150mg of Levamisole.

[3] Manufactured by M/S Pfizer Animal Health Division Limited. Each tablet contains 600mg of Albendazole

[4]Manufactured by M/S Intas Pharmaceuticals Ltd, Matoda 382210, Ahmedabad, India. Each tablet contains 10mg of ivermectin.

[5] Marketed by M/S Agrivet Farm Care, Virbac Animal Health India Pvt. Ltd., Mumbai, each 10ml vial contains 1.0% W/V ivermectin solution

The anthelmintic efficacy of Oxyclozanide (Tolzan F[6]) and Albendazole (Analgon[7]) was carried out in ruminants having trematode i.e., *Paramphistomum* sp. infection where the drugs were administered @ 10mg/kg b.w. each orally.

The efficacy of the drug was calculated using the following formula on 3rd, 7th and 10th day of post-administration of drugs/herbal preparation:

$$\text{Efficacy \%} = \frac{\text{Pretreatment EPG - Post-treatment EPG}}{\text{Pretreatment EPG}} \times 100$$

The untreated animals considered as control group were subsequently treated with effective drug.

Methodology (Ectoparasites)

As per the information available during the course of investigation, tick infestation was found to be a common problem among the tigers. On getting the evidence of ectoparasitic infestation on the body of the tigers or in its enclosures, cypermethrin (Clinar[8]) or deltamethrin (Butox[9]) in the form of spray or ivermectin (Hitek[10]) as subcutaneous injection was prescribed. But, it was not possible to carry out systematic efficacy study of acaricidal drugs against such ectoparasites. However, attempt was made to detect the presence of ticks on the body or enclosures through physical examination or close inspection of different body regions during the post-treatment periods.

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[6] Manufactured by M/S Intervet India Private Limited, Briahnagar, Off. Pune – Nagar Road, Wagholi, Pune. The product contains 3.4% suspension of Oxyclozanide.

[7] Manufatured by M/S Wockhardt Limited, Wockhardt Towers, Bandra-Kurla Complex, Mumbai-400 051. The product contains Albendazole 25 mg/ml.

[8] Manufatured by M/S GlaxoSmithKline Pharmaceuticals Limited, Dr. Annie Besant Road, Mumbai - 400 030. The product contains Cypermethrin High Cis - 10 % w/v.

[9] Manufactured by M/S Intervet India Private Limited, Briahnagar, Off. Pune – Nagar Road, Wagholi, Pune. The product contains 12.5% EC deltamethrin.

[10] Marketed by M/S Agrivet Farm Care, Virbac Animal Health India Pvt. Ltd., Mumbai, each 10ml vial contains 1.0% W/V ivermectin solution.

RESULTS (Endoparasites)

The results of the comparative studies on the basis of epg count of different available anthelmintics and an indigenous herbal preparation were depicted with the corresponding interpretations in the following tables and figures.

Table 12. Comparative efficacy of anthelmintics on the basis of epg count in tigers of Nandankanan Zoo having *Toxocara* sp. infection

Drugs used	Average epg			
	Pre-treatment	Post-treatment		
		3rd	7th	10th
Dewormis	403	10 (97.5)	1 (99.7)	0 (100)
Valbazen	590	9 (98.4)	2 (99.6)	0 (100)
Nemocid	710	21 (97.0)	4 (99.4)	0 (100)
Control	670	720	783	754

Figures in parentheses indicate percentage of efficacy.

Table 13. Anthelmintic efficacy in tigers having *Ancylostoma* sp. infection in Nandankanan Zoo

Drugs used	Average epg			
	Pre-treatment	Post-treatment		
		3rd	7th	10th
Neomec	103	0 (100)	0 (100)	0 (100)
Nemocid	128	6 (95.3)	2 (98.4)	2 (98.4)
Dewormis	137	23 (83.2)	5 (96.3)	3 (97.8)
Control	141	162	160	179

Figures within parentheses indicate percentage of efficacy.

Key points

1. All the anthelmintics were found cent per cent effective in eliminating *Ascaris* infection in tigers.
2. Efficacy of Neomec, Nemocid and Dewormis against *Ancylostoma* sp. infection in tigers on 10th day post-treatment was 100, 98.4, and 97.8 %, respectively.
3. The rate of elimination of eggs was almost identical in all the groups.

Table 14. Comparative efficacy of anthelmintics in tigers of Nandankanan Zoo having mixed infection of *Toxocara* and *Ancylostoma* sp.

Drugs used	Type of infection	Average epg			
		Pre-treatment	Post-treatment		
			3rd	7th	10th
Dewormis	*Toxocara*	501	3 (99.4)	1 (99.8)	0 (100)
	Ancylostoma	30	2 (93.3)	1 (96.6)	1 (96.6)
Total		**531**	**5 (99.0)**	**2 (99.6)**	**1 (99.8)**
Valbazen	*Toxocara*	459	12 (97.3)	3 (99.3)	0 (100)
	Ancylostoma	23	5 (77.7)	3 (86.6)	1 (95.5)
Total		**482**	**17 (96.4)**	**6 (98.7)**	**1 (99.7)**
Nemocid	*Toxocara*	435	6 (98.6)	2 (99.5)	0 (100)
	Ancylostoma	21	2 (90.4)	1 (95.2)	1 (95.2)
Total		**456**	**8 (98.2)**	**3 (99.3)**	**1 (99.7)**
Control	*Toxocara*	441	425	431	469
	Ancylostoma	21	20	27	31
Total		**462**	**445**	**458**	**500**

Figures within parentheses indicate percentage of efficacy.

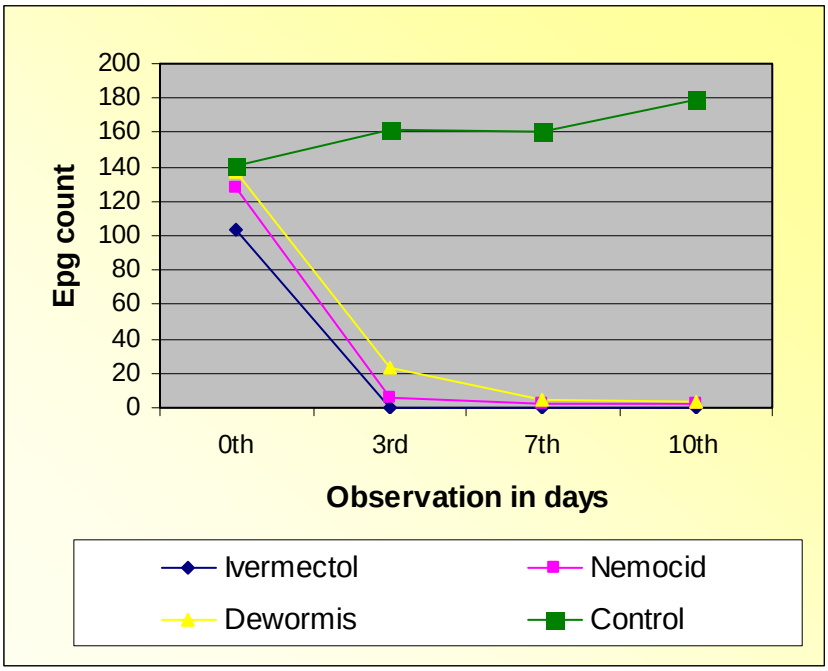
Key points

1. Anthelmintic efficacy of all the three drugs i.e., Dewormis, Valbazen and Nemocid on 10th day post-treatment was 100% against *Toxocara* infection whereas it was 96.6, 95.5 and 95.2% against *Ancylostoma* infection in tigers, respectively.

Table 15. Efficacy of anthelmintics against *Toxascaris* sp. infection in lions of Nandankanan Zoo on the basis of epg count

Drugs used	Average epg			
	Pre-treatment	Post-treatment		
		3rd	7th	10th
Neomec	249	0 (100)	0 (100)	0 (100)
Nemocid	287	86 (70.0)	3 (98.9)	0 (100)
Dewormis	270	15 (94.4)	3 (98.8)	0 (100.0)
Control	281	290	313	310

Fig 32. Comparative efficacy of different drugs against *Ancylostoma* sp. infection in lions of Nandankanan Zoo



Key points

1. All the three drugs used in the trial were found almost equally effective (100%) in eliminating the eggs of *Toxascaris* sp. from the naturally infected lions.

2. Neomec was found superior in terms of rate and degree of eliminating the *Ancylostoma* infection from the lion.

3. Untreated control animals continued to excrete eggs in their faeces.

Table 16. Comparative efficacy of anthelmintics in lions of Nandankanan Zoo having mixed infection of *Toxocara* and *Ancylostoma* spp.

Drugs used	Type of infection	Average EPG			
		Pre-treatment	Post-treatment		
			3rd	7th	10th
Neomec	*Toxocara*	83	0 (100)	0 (100)	0 (100)
	Ancylostoma	34	1 (97.0)	0 (100)	0 (100)
Total		**117**	**1 (99.1)**	**0 (100)**	**0 (100)**
Nemocid	*Toxocara*	72	29 (59.7)	1 (98.6)	0 (100)
	Ancylostoma	32	6 (81.2)	1 (96.8)	1 (96.8)
Total		**104**	**35 (66.3)**	**2 (98.0)**	**1 (99.0)**
Dewormis	*Toxocara*	81	0 (100)	5 (93.8)	0 (100)
	Ancylostoma	37	10 (72.9)	5 (86.4)	3 (91.8)
Total		**118**	**10 (91.5)**	**10 (91.5)**	**3 (97.4)**
Control	*Toxocara*	86	100	94	130
	Ancylostoma	30	33	38	42
Total		**116**	**133**	**132**	**172**

Figures within parentheses indicate percentage of efficacy.

Key points

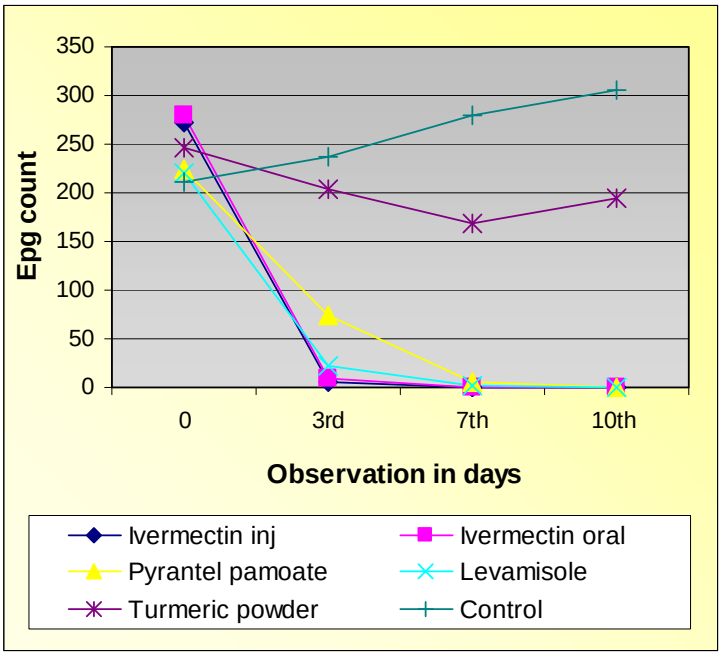
1. Based on EPG, the efficacy of Neomec, Nemocid and Dewormis against *Ancylostoma* infection were 100, 96.8 and 91.8%, respectively.

2. The efficacy of the drugs against *Toxocara* was cent per cent. However, the rate of elimination of the eggs was highest in the animals treated with Neomec followed by Dewormis and Nemocid.

Table 17. Efficacy of Turmeric and allopathic drugs against *Toxocara* sp. infection in tigers of Nandankanan Zoo

Drugs used	Average EPG			
	Pre-treatment	Post-treatment		
		3rd	7th	10th
Ivermectin Inj.	272	5 (98.1)	0 (100)	0 (100)
Ivermectin Tab.	280	9 (96.7)	0 (100)	0 (100)
Pyrantel pamoate	224	75 (66.5)	6 (99.1)	0 (100)
Levamisole	221	22 (90.4)	2 (99.1)	0 (100)
Albendazole	255	8 (96.8)	0 (100)	0 (100)
Turmeric powder	247	203 (18.0)	169 (31.5)	195 (64.0)
Control	212	237	280	306

Fig 33. Comparative efficacy of allopathic drugs and Turmeric against *Toxascaris leonina* infection in lions of Nandankanan Zoo



Key points:

1. Turmeric powder reduced the epg count by 64% by 10th day post-treatment as against 100% in allopathic drugs (Ivermectin, pyrantel pamoate, levamisole and albendazole) in tigers having *Toxocara* sp. infection.

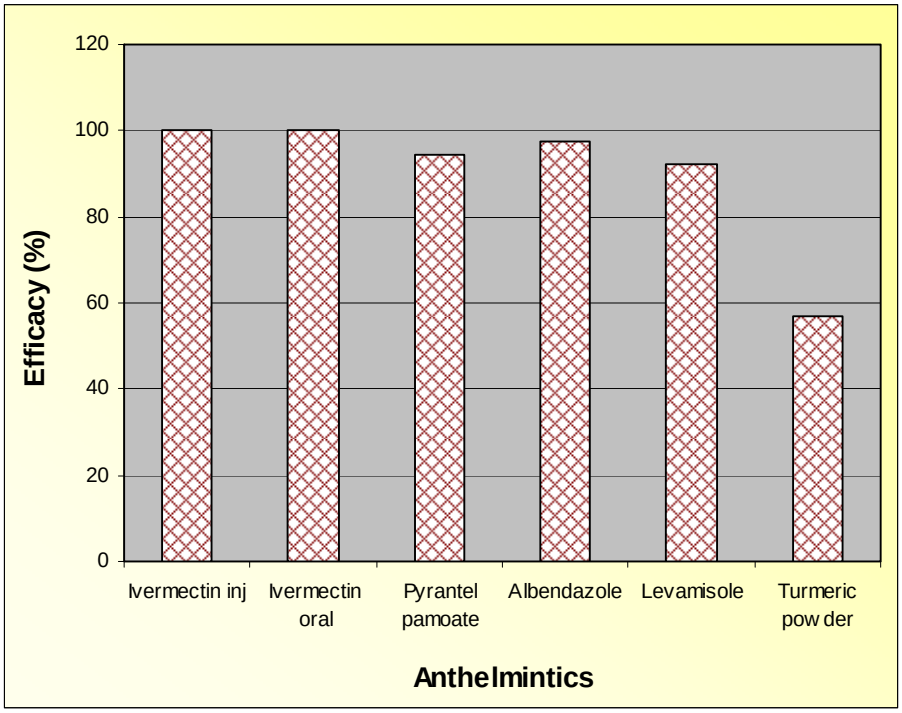
2. The degree as well as pattern of efficacy of Tumeric powder and allopathic drugs against *Toxascaris leonina* infection in lions were identical to that of tigers.

Table 18. Anthelmintic efficacy of Turmeric against *Ancylostoma* sp. Infection in tiger of Nandankanan Zoo

Drugs used	Average epg			
	Pre-treatment	Post-treatment		
		3rd	7th	10th
Ivermectin Inj	64	0 (100)	0 (100)	0 (100)
Ivermectin Tab	55	12 (78.1)	2 (96.3)	0 (100)
Levamisole	45	10 (77.7)	3 (93.3)	3 (93.3)
Albendazole	53	18 (77.7)	6 (88.6)	1 (98.1)
Pyrantel pamoate	42	15 (64.2)	5 (88.0)	1 (97.6)
Turmeric powder	37	21 (43.2)	17 (54.0)	12 (67.5)
Control	61	92	194	278

Figures within parentheses indicate percentage of efficacy.

Fig 34. Efficacy of Turmeric and allopathic drugs against *Ancylostoma* sp. Infection in lions of Nandankanan Zoo on 10th day post-treatment.



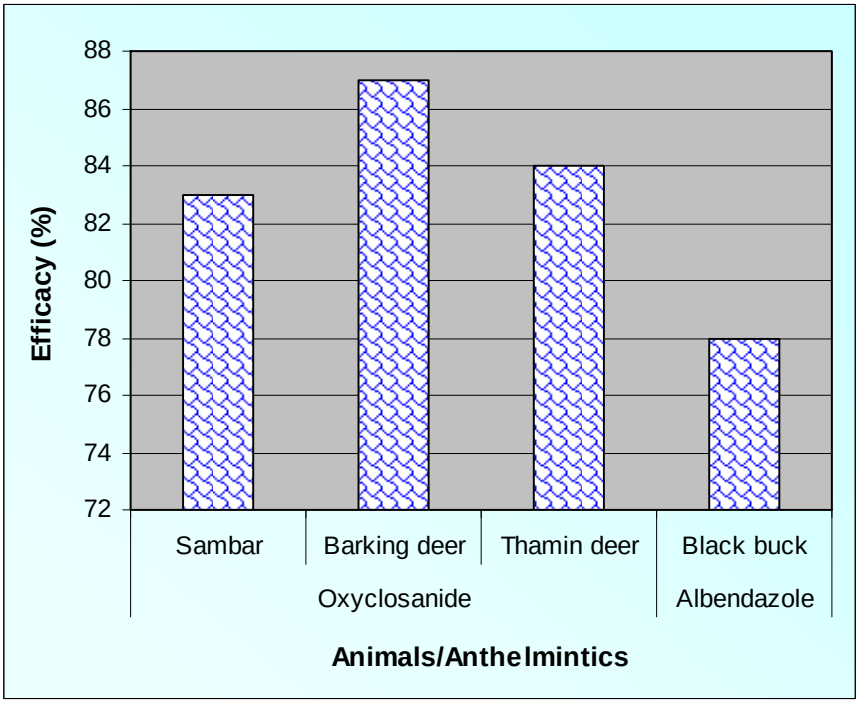
Key points:

1. Turmeric powder reduced the epg count by 67.5% by 10th day post-treatment as against 100, 98,97 and in Ivermectin, albendazole, pyrantel pamoate and levamisole in tigers having *Ancylostoma* sp. infection, respectively.
2. The efficacy of Tumeric powder and allopathic drugs against *Ancylostoma* sp infection in lions followed the similar trend to that of tigers.

Table 19. Comparative efficacy of different drugs against *Paramphistomum* sp. infection in herbivores of Nandankanan Zoo

Species of the animals treated	Drugs used	Average epg			
		Pre-treatment	Post-treatment		
			3rd	7th	10th
Sambar	Oxyclozanide	54	18 (67)	9 (83)	9 (83)
Barking deer	Oxyclozanide	61	24 (61)	13 (79)	8 (87)
Thamin deer	Oxyclozanide	69	21 (70)	11 (84)	11 (84)
Black buck	Albendazole	55	24 (56)	14 (75)	12 (78)
Control		56	54	60	59

Fig 35. Efficacy of oxyclozanide and albendazole against *Paramphistomum* sp. infection in different large and small herbivores of Nandankanan Zoo on 10th day post-treatment.



Key points

1. The efficacy of Oxyclozanide (Tolzan F) against *Paramphistomum* sp. infection in herbivores varied between 83 - 87% on 10th day of post-treatment.
2. The epg count was reduced by 78 % on 10th day after administration of albendazole (Analgon) against *Paramphistomum* sp. infection in herbivores.
3. Significant reduction of epg count was recorded on 3rd day post-treatment.

RESULTS (Ectoparasites)

Tigers administered with Ivermectin injection (Hitek) against endoparasites did not exhibit presence of ticks on their body coat for a considerable period which varied from 21 to 68 days. Reappearance of ticks was recorded as early as 15 days post-application and certain cases that was extended up to 42 days. Ivermectin could be considered as the drug of choice for parenteral use against the mixed infection of endoparasites and ectoparasites. Cypermethrin or Deltamethrin, used in the form of spray in the enclosures were found effective against tick infestations. There was disappearance of live ticks in the enclosures within 24hours of medication/application.

In addition to the use of cleaning and/or burning of bushes at regular interval is a regular practice for the control of the ectoparasites.

CONTROL OF NEMATODE INFECTION IN TIGERS

Prevalence study conducted on the mammals, reptiles and birds during 2007-10 revealed presence of single or mixed gastro-intestinal helminthic infection with variations in rate among three seasons i.e., pre-monsoon, monsoon and post-monsoon. Results of comparative anthelmintic efficacy study in lions and tigers indicated that faecal samples became negative of parasitic ova within 3 to 10 days after administration of effective drug. But there was reappearance of helminthic eggs in the faecal sample as less as three weeks after administration of drug. Regular administration of anthelmintic at three months intervals as practiced earlier did not eliminate infection especially in lions and tigers. This hinted at the in-situ source of re-infection.

A pilot study was carried out to assess the control of nematode infection in tigers through change of top soils in the enclosures. The purpose of removing top soil up to a depth of six inches was to disrupt the life cycle by destroying the developmental stages of the parasite which was supposed to be perpetuating in the top soil of the enclosure. Further, the effects of daily oral administration of turmeric powder along with meat were evaluated in certain enclosure.

METHODOLOGY

Four tiger enclosures i.e., 30C, 20, 28, 33C and having an area of 357, 208, 35 and 66 sq mt, respectively were selected for the study. In enclosure No 30C, the entire top soil upto six inches depth was dug out of the tiger enclosure. In the enclosure No.20, the top soil upto the similar depth was removed in the area upto 5ft from the periphery of the enclosure where the animals usually defecate. Due attention was given to the proper disposal of removed soil with a view to avoid possibility of contamination to the adjacent areas. The gap in the enclosure was filled with river sand. The expenditure incurred towards removal of top soil and refilling with sand varied from Rs.19/- to 53/- per sq mt.

Basing on the results of earlier study relating to the efficacy of turmeric, a known herbal preparation used in case of human beings for its anthelmintic property, was given @ 5.0 g orally daily with meat in powder form to the tigers in

the enclosure with replacement of top soil with sand upto 5 ft width and 6 inches depth (No.28) and without change of top soil (No.33C).

The tiger in the enclosure No. 21C under regular deworming practice at three months interval was included in the study as control for comparison.

The faecal samples were examined on monthly basis up to 10 months after initiation of control program to assess/compare the impact on epg count.

RESULTS

The results of the study have been presented in the following figure and table.

Fig 36. Effects of control measures on epg count in Tigers of Nandankanan zoo

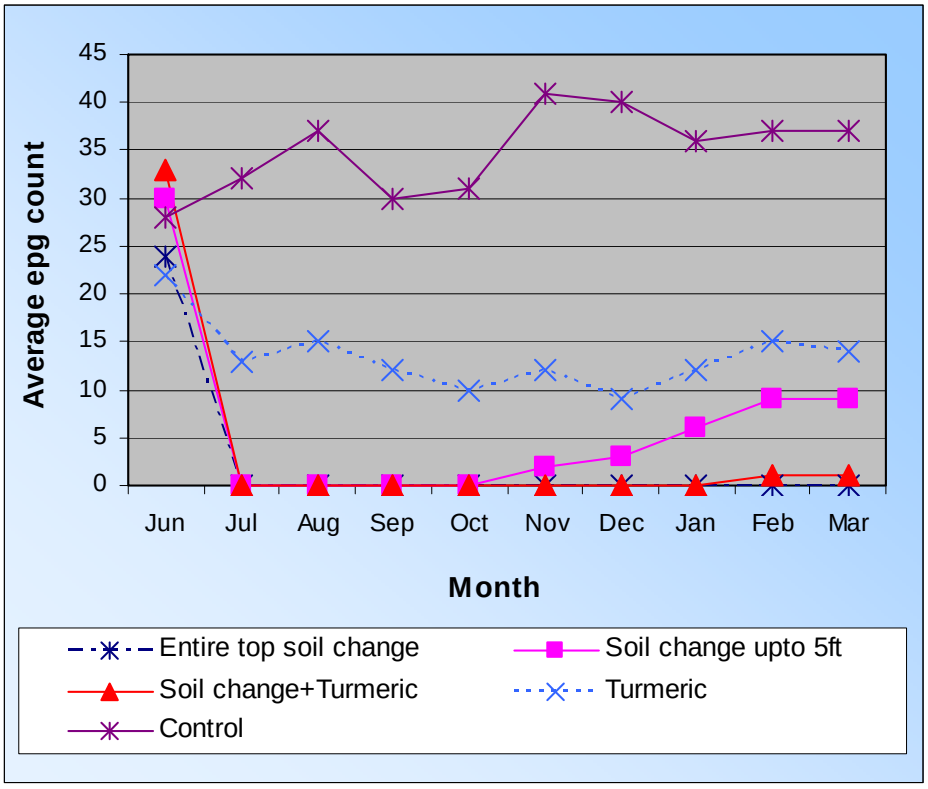


Table 20. Impact of control measures on epg count in different tiger enclosures at Nandankanan Zoo

Control measures	Average epg counts in tigers in different months									
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Change of entire top soils (Encl No 30C)	24	-	-	-	-	-	-	-	-	-
Change of top soil upto5 ft from the periphery (Encl No 20)	30	-	-	-	-	2	3	6	9	9
Change of top soils upto 5ft and administration of turmeric (Encl No 28)	33	-	-	-	-	-	-	-	1	1
Administration of turmeric (Encl No 33C)	22	13	15	12	10	12	9	12	15	14
Anthelminthic adminstartion at 3 months interval as control (Encl No.21C)	28	32	37	30	31	41	40	36	37	37

Key observations

- The faecal sample from the enclosure where the entire top soils was changed became negative for presence of helminthic ova during the entire observation period of 10 months.
- The faecal sample from the enclosure where the top soils was changed partly (upto 5ft from the periphery) became negative for presence of helminthic ova. The epg count ranging from 2-9 was recorded during the subsequent period as against 30 before implementation of control measure.
- When compared to control group, the epg count was reduced after administration of turmeric alone. However, the reduction was less when compared to that of the groups reared in the enclosures where top soil was changed.
- Reappearance of eggs in certain enclosures may be attributed to the possibility of re-infection arising out of the left over soil.

OBJECTIVE – IV

Recommendations for management of parasitic (ectoparasites and endoparasites) infections in wild animals in captivity.

Parasitic diseases are quite common in zoos because the closed environment facilitate the perpetuation of the infection. Available literatures especially on Indian zoos are testimony of the facts. A number of factors such as climatic conditions, design and dimension of animal enclosures, resistance/susceptibility of host, plane of nutrition and concurrent disease in the host play a significant role on the incidence and severity of infection. In order to prevent/minimize the uptake of infective stage larvae by the host, the measure means of the transmission of the infection, it is essential to reduce/eliminate contamination of the environment in general and the enclosures in particular. Control programs are aimed at achieving such goal. The choice and intensity of control measures are usually area or region specific. A thorough knowledge on the life cycle of the parasite, epidemiology of the disease, health management practices of the zoo and behavior of the host are prerequisites for designing successful control program. A number measures were experimentally adopted to control such diseases in the Nandankanan Zoo and as such recommended for better management of parasitic (Ectoparasites and endoparasites) infections among wild animals in captivity .

Endo- parasites

- Appearance of clinical signs suggestive of parasitism in the host was not a regular feature in the wild mammals though faecal samples were found positive for eggs/larvae of endoparasites. Further to it, eggs of *Toxocara, Toxascaris* and *Anyclostoma* spp. reappeared in the faeces of lions and tigers as early as 22 days post-administration of anthelmintics Keeping such facts back drop, it is suggested to examine the faecal sample through concentration method at least at 3-4 weeks interval even if the animal found apparently healthy.

- Oral administration of effective anthelmintic as per recommended dose against the infection ascertained through examination of faecal sample

and/or adult parasites. Mass medication is prefered especially to the animals reared in groups or flocks. As an ideal practice, a particular anthelmintic or any anthelmintic of that chemical group should never be used for more than a year in order to avoid the possibility of drug resistance.

- In absence of immature *Paramphistomum* sp. infection, anti-trematodal drugs can be given against mature worms with a view to minimize the number of infected snails.

- Proper disposal of the dung/contaminated soil/refusals/excreta to suitable pits preferably having earthen embankment.

- The cultivation of fodder in snail inhabited swampy fields may facilitate transmission of trematode infective stage through ingestion of grass blades. In order to prevent such infection, either the fodder cultivated in snail free zones should be supplied or practice of sun drying for about six hours before ingestion of green fodder by the animals may be adopted. As an alternative, the lower portion of the forage plants should not be fed to the animals because the infective stages usually concentrate on these parts.

- Administration of effective herbal preparation especially turmeric powder would be considered as an alternate choice to reduce the worm burden.

- Examination of faecal samples especially from pregnant, aged or young animals at monthly interval to ascertain the type of gastro-intestinal helminthic infection would be an ideal practice.

- On the event of repeated exposures to a particular infection it is advisable to remove the entire top soil or three meter distance from the periphery of the enclosure upto a depth of 6 inches following seven days from the day of deworming.

- Supply of clean drinking water from a dependable source and periodic cleaning of moats including the bottom deposits with application of lime.

- Facilitate intake of food on the clean floor or in other words discourage contamination of food materials with soil/sand. The feeding and watering troughs were kept at higher level with a view to avoid faecal contamination
- Maintaining animals with proper nutrition defends animals from becoming easy prey to parasitic diseases.
- The floors of the enclosures should be free from cracks and crevices having provision for proper drainage system to prevent water logging or dampness.
- Identify location specific problems with respect to the season or climate and accordingly administer anthelmintic as prophylactic treatment well in advancer to avoid possibility of future risk which usually falls during monsoon and post monsoon period.
- Newly received species should be kept in the quarantine and screened for endoparasites (including ectoparasites) and if found positive, suitable treatment is advisable.
- Proper disposal of the carcasses after necropsy must be ensured.
- The number of snails, the intermediate hosts for trematodes, could be reduced either by restricting the size of the habitat or proper drainage of low lying areas.
- An integrated strategic approach consisting of the measures directly or indirectly linked with reducing parasitic burden in the hosts and minimizing environmental contamination would be more beneficial than relying upon any one practice.

Ecto- parasites

- Periodic examination of body coat, enclosures especially the walls and floors would facilitate identification of the problem.
- Controlled burning of dry leaves inside the enclosures during early summer when the trees shed the leaves.

- Application of acaricidal agents on the body coat as well as walls in the form of spray and use of blow lamps on the walls need to be applied every 2-3 months especially in the enclosures adjacent to the safari where the infestation would be a common problem.

Above all, the zoo personnel directly or indirectly associated with health related issues of the captive animals need to be educated on life cycle, pathogenesis, clinical signs and the benefits of control measures against prevalent parasitic diseases. Further, as recorded in the study, degree of infection was highest in large carnivores; hence special attention was focused especially during monsoon and post-monsoon period. Undoubtedly, implementation of those measures would keep the exhibits in optimum health which in turn would facilitate to fulfill the objectives of the zoo.

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ANNEXURES

Annexure-I

LIST OF MAMMALS AT NANDANKANAN ZOOLOGICAL PARK

Sl. No.	Common Name	Zoological Name
1	Assamese macaque	*Macaca assamensis*
2	Barking deer	*Muntiacus muntjak*
3	Black buck or Indian antelope	*Antilope cervicapra*
4	Bonnet macaque	*Macaca radiata*
5	Chital or spotted deer	*Axis axis*
6	Common langur or Hanuman langur	*Presbytis entellus*
7	Common mongoose	*Herpestus edwardsi*
8	Common palm civet or Toddy cat	*Paradoxurus hermaphroditus*
9	Fishing cat	*Felis viverrina*
10	Four horned antelope or Chowshingha	*Tetracerus quadricornis*
11	Great Indian one horned rhinoceros	*Rhinocerus unicornis*
12	Himalayan black bear	*Selenarctos thibetanus*
13	Hippopotamus	*Hippopotamus amphibius*
14	Hog deer	*Axis porcinus*
15	Indian Chevrotain or Mouse deer	*Tragulus meminna*
16	Indian Elephant	*Elephas maximus*
17	Indian hare	*Lepus nigricollis*
18	Indian porcupine	*Hystrix indica*
19	Indian wild boar	*Sus scrofa*
20	Jackal	*Canis aureus*
21	Jungle cat	*Felis chaus*
22	Leopard or panther	*Panthera pardus*
23	Lion	*Panthera leo*
24	Lion tailed macaque	*Macaca silenus*
25	Nilgai or Bluebull	*Boselaphus tragocamelus*
26	Nilgiri langur	*Presbytis johnii*
27	Pangolin	*Manis crassicaudata*
28	Ratel or Honey badger	*Mellivora capensis*
29	Rhesus macaque	*Macaca mulatta*
30	Sambar	*Cervus unicolor*
31	Sloth bear	*Melursus ursinus*
32	Small Indian civet	*Viverricula indica*
33	Striped hyena	*Hyaena hyaena*
34	Swamp deer or Barasingha	*Cervus duvauceli duvauceli / randari*
35	Thamin or Brow-antilered deer	*Cervus eldi*
36	Tiger	*Panthera tigris*

Annexure-II

LIST OF BIRDS AT NANDANKANAN ZOOLOGICAL PARK

SL. No.	Common Name of Species	Zoological Name
1	Budgerigar	*Melopsittacus undulates*
2	Cassowary	*Casuarius casuarius*
3	Cockatiel white	*Nymphicus hollandicus*
4	Cockatoo, Lesser Sulphur Crested	*Cacatua slphurea*
5	Cockatoo, Greater Sulphur Creasted	*Cacatua galerita*
6	Connure Brown Eared	*Aratinga patagonus*
7	Connure Jandaya	*Aratinga jandaya*
8	Connure Nanday	*Nandayus nenday*
9	Crane Sarus	*Grus antigone*
10	Dove	*Zenaida zenaida*
11	Dove, Diamond	*Geopelia cuneata*
12	Dove, White Chinese	*Streptopelia risoria*
13	Duck, Common Muscovy	***Cairina moschata***
14	Duck, Mandarin	*Aix galericulata*
15	Egret, Little	*Egretta garzetta*
16	Egret, Median	*Egretta intermedia*
17	Emu	*Dromaius novaehollandiae*
18	Finch, Bengali	*Lonchura striata*
19	Finch, Long Tailed	*Peophila cincta*
20	Finch, Star	*Peophila ruficauda*
21	Finch, Zebra	*Peophila quttata*
22	Heron, Grey	*Ardea cinerea*
23	Heron, Night	*Nycticorax nycticorax*
24	Ibis, Black	*Pseudibis papillosa*
25	Ibis, White	*Threskiornis aethiopica*
26	Kite, Brahminy	*Haliastur indus*
27	Kite, Pariah	*Milvus migrans*
28	Koel	*Eudynamys scolopacea*
29	Lorry Purple Capped	*Lorius domicellus*
30	Lorry Yellow backed	*Lorius qarrulus flavopalliatus*
31	Love bird, Fischers	*Agapornis fischeri*
32	Macaw, Blue & Yellow	*Ara ararauna*
33	Macaw, Green Winged	*Ara chloroptera*
34	Munia, Blackheaded	*Lonchura malacca*
35	Munia, Spotted/Nutmeg Mannikin	*Lonchura punctulata*
36	Owl, Barn	*Tylo alba*
37	Parakeet, Mostach/Indian Red Breasted	*Psittacula alexandri*
38	Parakeet, Alexandrine	*Psittacula eupatria*

39	Parakeet, Blossom Headed	*Psittacula cyanocephala*
40	Parakeet, Rose Ring	*Psittacula krameri*
41	Peafowl, Indian	*Pavo cristatus*
42	Peafowl, Indian white	*Pavo cristatus*
43	Pelican Grey	*Pelecanus philippensis*
44	Pelican Rosy/White	*Pelecanus onocrotalus*
45	Pheasant, Bhutan Grey Peacock	*Polypectron thibetanus*
46	Pheasant, Golden	*Crysolophus pictus*
47	Pheasant, Silver	*Lophura nycthemera*
48	Pigeon Nicobar	*Caloenas nicobarica*
49	Rosella, Eastern	*Platycercus eximius*
50	Sparrow Java	*Padda oryzivora*
51	Spoonbill white eurasian	*Platalea leucorodia*
52	Stork Lesser Adjutant	*Leptoptilos javanicus*
53	Stork Painted	*Mycteria leucocephala*
54	Stork Open Billed	*Anastomus oscitans*
55	Stork White Neck	*Ciconia episcopus*
56	Swan Black	*Cygnus atratus*
57	Vulture Scavenger	*Neophron percnopterus*

Annexure-III

LIST OF REPTILES AT NANDANKANAN ZOOLOGICAL PARK

Sl. No.	Common Name	Zoological Name
1	Boa, Common sand	*Eryx johni*
2	Boa, Red sand	*Eryx conicus*
3	Caiman spectacled	*Caiman sclerops*
4	Cobra, King	*Ophiophagus hannah*
5	Cobra, Monocellate	*Naja naja kouthia*
6	Cobra, Binocellate	*Naja naja*
7	Crocodile, Long snouted/Gharial	*Gavialis gangeticus*
8	Crocodile, Morelet's	*Crocodylus moreletii*
9	Crocodile, Mugger	*Crocodilus palustris*
10	Crocodile, Salt water	*Crocodylus porosus*
11	Crocodile, Siamese	*Crocodylus siamensis*
12	Indian Chameleon	*Chameleon zeylanicus*
13	Krait, Banded	*Bungarus fasciatus*
14	Krait, Common Indian	*Bungarus caeruleus*
15	Monitor Lizard, Common Indian	*Varanus bengalensis*
16	Monitor Lizard, Water	*Varanus salvator*
17	Python, Burmese Rock	*Python molurus bivistatus*
18	Python, Indian Rock	*Python molurus molurus*
19	Python, Reticulated	*Python reticulatus*
20	Snake, Rat	*Ptyas mucosus*
21	Tortoise Star Indian	*Geochelone elegans*
22	Turtle, Fresh Water/ Indian Soft/Shelled	*Lissemys punctata punctata*
23	Turtle, Ganges Soft Shelled	*Trionyx gangeticus*
24	Viper, Russel's	*Vipera ruselli*

Annexure-IV

INFORMATIONS ON TAXONOMIC POSITION, IDENTIFICATION, BASIC BIOLOGY, PREY SPECIES AND CONTROL OF ENDOPARASITES

A. NEMATODES

Toxascaris spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class - Cotyloda
Subclass – Secernentea
Order – Ascaridida
Superfamily – Ascaridoidea
Family – Ascarididae
Genus – *Toxascaris*
Species - *leonina*

(ii) Identification

- Male up to 7 cm long.
- Tail is simple and spicules are 0.07 to 0.15 mm long.
- Female up to 10 cm long and the genital organs lie behind the level of vulva.

(iii) Basic biology

- Adult parasites present in small intestine.
- Infective stage the egg containing a second-stage larva.
- Fifth stage larvae are produced about six weeks after infection and eggs are produced from 74 days onwards.
- No migration of larvae occurs.

(iv) Prey species

Wild Felidae and canidae.

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises.
- Prompt disposal of refusals and excreta.
- Regular examination of faecal sample followed by deworming, if required.
- Periodic removal of top soil preferably upto three meter distance from the periphery of the enclosure.

Toxocara spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class - Cotyloda
Subclass – Secernentea
Order – Ascaridida
Superfamily – Ascaridoidea
Family – Ascarididae
Genus – *Toxocara*
Species – *cati*

(ii) Identification

- Cervical alae are very broad and are striated.
- Male up to 3-6 cm long.
- Spicules are 1.63 to 2.08 mm long.
- Female up to 4-10 cm long.

(iii) Basic biology

Infective stage the egg containing a second-stage larva.

- Larvae are found in stomach wall for first two days.
- Majority of third-stage larvae occur in stomach wall while fourth-stage larvae occur in stomach contents.
- Migration of larvae occurs at second stage.
- Third-stage migration occurs only after returning of larvae to the digestive tract.

(iv) Prey species

Wild Felidae.

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises.
- Prompt disposal of refusals and excreta.
- Regular examination of faecal sample followed by deworming, if required.
- Periodic removal of top soil preferably upto three meter distance from the periphery of the enclosure.

Ancylostoma spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class - Cotyloda
Subclass – Secernentea
Order - Strongylida
Superfamily – Ancylostomatoidea
Family – Ancylostomatidae
Subfamily – Ancylostominae
Genus – *Ancylostoma*
Species – *caninum, braziliense, ceylanicum, duodenale.*

(ii) Identification

- *A.caninum*
  - Males 10 to 12 mm long and female 14 to 16 mm long.
  - Worms fairly rigid and grey and reddish in colour.
  - Buccal capsule deep.
  - Ventral margin of buccal capsule bears three teeth on either side.
  - Male bursa well developed and spicules 0.8 to 0.95 mm long.
- *A. braziliense*
  - Males 6 to 7.75 mm and females 7 to 10 mm.
  - Ventral teeth consist of a large and a small one on either side.
- *A. ceylanicum*
  - Inner pair of ventral teeth in the mouth larger than *A. braziliense*.
  - Origin and direction of rays of bursa differ.
- *A. doudenale*
  - Ventral teeth consist of two large and one small on either side.

(iii) Basic biology

- Infection occurs by ingestion of third stage infective larvae or by skin penetration by them.
- Prenatal infection by fetus by intrauterine infection.
- Colostral or lactogenic infection by passage of larva through milk.
- Third stage larvae moults to fourth stage then immature and adult worms develop in the small intestine.

(iv) Prey species: Wild carnivores

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises.
- Prompt disposal of refusals and excreta.
- Regular examination of faecal sample followed by deworming, if required.
- Periodic removal of top soil preferably upto three meter distance from the periphery of the enclosure.

Strongyloides spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class - Cotyloda
Subclass – Secernentea
Order - Rhabditida
Superfamily - Rhabditoidea
Family – Strongyloididae
Genus – *Strongyloides*
Species – *papillosus, westeri, stercoralis, avium*

(ii) Identification

- Rhabditiform oesophagus in free living generation and filariform oesophagus in parasitic generation.
- Adult worms characterized by their female genital organs and relatively long oesophagus.
- Vulva is near the middle of the body, eggs are few but large and thin shells.
- Adults of *S. papillosus, S. westeri* and *S. stercoralis are* 3.5 to 6 mm, 9 mm and 2.2 mm long, respectively.

(iii) Basic biology

- Completely parasitic or completely free living or combination of both life cycles can occur.
- Parthenogenetic female present in the mucosa of small intestine produces eggs which are passed in faeces.
- Eggs may gives rise, outside the host, directly to third stage infective larvae or develop to free living males or females which may subsequently produce infective larvae.
- Infective larvae penetrate through skin of host and pass with blood to lungs, thence up the trachea to pharynx and on to the intestine.

(iv) Prey species

S. papillosus: Wild ruminants
S. westeri: Zebra
S. stercoralis: Primates and wild carnivores
S. avium : Wild birds

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises.
- Prompt disposal of refusals and excreta.
- Regular examination of faecal sample followed by deworming, if required.
- Periodic removal of top soil preferably upto three meter distance from the periphery of the enclosure.

Strongylus spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class - Cotyloda
Subclass – Secernentea
Order – Strongylida
Superfamily – Strongyloidea
Family – Strongylidae
Genus – *Strongylus*

(ii) Identification

- Well-developed globoid buccal capsule on the dorsal wall of which there may be a median thickening, called the dorsal gutter, carries the duct of the dorsal oesophageal gland.
- Anterior margin of the buccal capsule usually bears leaf-crowns or corona radiate.
- Male bursa is strongly developed and has typical rays.
- Male is 26 to 35 mm long and the female 38 to 47 mm by about 2 mm thick in *S. equines.*
- In *S. equines* vulva lies 12-14 mm from the posterior extremity and male having two simple and slender spicules.

(iii) Basic biology

- *S. equines* exsheathed infective larvae after reaching subserosa cause the formation of nodules.
- Fourth-stage larvae occur in the nodules and migrate to the peripheral cavity and then to the liver.
- Between two and four months after infection larvae leave the liver and pass to the peritoneal cavity.
- After infection the moult to the fifth larval stage occurs about 118 days and a permanent buccal capsule is produced.

(iv) Prey species

S. equines: Zebra

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises with prompt disposal of refusals and excreta.
- Regular examination of faecal samples followed by deworming, if required, with effective anthelmintics.
- Periodic removal of top soil from the enclosure.

Trichuris spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class - Cotyloda
Subclass – Adenophorea
Order – Enoplida
Superfamily – Trichuroidea
Family – Trichuridae
Genus – *Trichuris*
Species – *ovis, discolor, globulosa, vulpis, suis, trichiura*

(ii) Identification

- Anterior part of the body is long and slender, while posterior part much thicker.
- Hind end of the male is curled and the only spicule surrounded by a protrusible sheath usually armed with fine cuticular spines.
- Vulva is situated at the beginning of the wide part of the body.

➢ *T. ovis*
- Male 50 to 80 mm long and anterior end constitutes three-quarters of the length whereas female is 35 to 70 mm long and anterior end forms two-third of four-fifths.

➢ *T*. *discolor*
- Females are orange-yellow in colour.

➢ *T*. *globulosa*
- Male is 40 to 70 mm long and the female 42 to 60 mm and anterior part constituting about two-thirds to three-quarters of the length.
- Spicules measures 4.2 to 4.8 mm and its sheath bears a terminal, spherical expansion on which the spines are larger than on the remaining portion.

➢ *T. vulpis*
- Worms 45 to 75 mm long and anterior portion constitute about three-quarter of it.
- Specule is 9 to 11 mm long and sheath bears small spines only on the proximal portion.

➢ *T. suis*
- Male is 30 to 50 mm long and the female 35 to 50 mm.
- Anterior portion forms about two-thirds of the total length.
- Spicule is 2 to 3.35 mm long, with a blunt tip, and its sheath is variable in shape and in the extent of its spinous armature.

(iii) Basic biology

- Life cycle is direct.
- Egg having infective larva upon ingestion by suitable host will hatch and develop to a mature adult parasite in about 7 to 20 weeks.
- The eggs are very resistant to external environmental conditions.

(iv) Prey species

T. ovis: Ruminants
T. *discolor*: Zebra
T. *globulosa*: Ruminants
T. vulpis: Wild carnivores
T. suis : Wild pigs/boars
T. trichiura: Simian primates

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises.
- Prompt disposal of refusals and excreta.
- Regular examination of faecal sample followed by deworming, if required, with effective anthelmintics.
- Periodic removal of top soil from the enclosure.

Capillaria spp.

(i) Taxonomic position

Phylum – Platyhelminths
Class – Cotyloda
Subclass – Adenophorea
Order – Enoplida
Superfamily – Trichuroidea
Family – Capillariidae
Genus – *Capillaria*
Species – *caudinflata*, *obsignata*, *contorta*, *entomelas*, *plica*, *aerophila*.

(ii) Identification

- Worms are small and slender.
- Posterior part of the body is not conspicuously thicker than the anterior part.

➢ *C. caudinflata*
- Males are 9 to 14 mm long and females 14 to 25 mm.
- Oesophagus is almost half as long as the body in the male and one-third as long in the female.
- Tail of the female is cylindrical up to the end.
- Vulva has a conspicuous projecting appendage.

➢ *C. obsignata*
- Males are 9.5 to 11.5 mm long and females 10.5 to 14.5 mm.
- In male the oesophagus is more than half as long as the body where as in female it is shorter.
- Tail of the female tapers posteriorly.

➢ *C. contorta*
- Males are 12 to 17 mm long and females 27 to 38 mm.

➢ *C. plica*
- Male is 13 to 30 mm long and the female 30 to 60 mm.

➢ *C. aerophila*
- Male is 24.5 mm long and the female 32 mm.
- There is one spicule and a spicule sheath armed with spines.

(iii) Basic biology

➢ *C. plica*
- The larvae entering the connective tissue of earthworms and foxes infecting themselves by eating infected earthworms.

➢ *C. aerophila*
- Eggs are laid in the lungs, coughed up and shallowed, and are therefore passed in the faeces.
- They develop in the open, attains infective stage after five to seven weeks, and may remain viable for over a year under favourable conditions.
- Infective lavae hatch out of the egg when shallowed by a suitable host.
- Then eggs hatch in the intestine and larvae migrate to the lungs in seven to ten days, reaching maturity 40 days after infection.

(iv) Prey species

C. caudinflatum: Wild birds
C. obsignata: Wild birds
C. contorta: Wild birds
C. entomelas: Wild animals
C. plica: Wild carnivores
C. aerophila: Wild carnivores

(v) Ways on control or strategies

- Good hygienic measures.
- Proper cleansing of the premises.
- Prompt disposal of refusals and excreta.
- Regular examination of faecal sample followed by deworming, if required.
- Periodic removal of top soil from the enclosure.

B. TREMATODES

Paragonimus spp.

(i) Taxonomic position

Phylum – Platyhelminthes
Class – Trematoda
Subclass – Digenea
Family – Paragonimidae
Genera – *Paragonimus*
Species – *westermanii,*

(ii) Identification

- Ovoid, plump distomes with a spiny tegument and are parasitic in the lungs.
- Oral sucker is ventro-terminal.
- Ventral sucker is near the mid-body and the genital pore is immediately behind this.
- Testes in the posterior half of the body and the ovary is pre-testicular.

(iii) Basic biology

- Eggs are coughed up, swallowed, and passed out with the droppings.
- The cercariea develop in snails and afterwards escape and encyst on fresh water crabs or cray-fish.
- Upon ingestion, the adult flukes develop in the body.

(iv) Prey species

P. westermanii: Wild carnivores

(v) Ways on control or strategies

- Avoid ingestion of raw fresh water crustacea.
- Steps to eliminate fresh water snails inside the enclosures and drinking water sources.

Paramphistomum spp.

(i) Taxonomic position

Phylum – Platyhelminthes
Class – Trematoda
Subclass – Digenea
Family – Paramphistomatidae
Genus – *Paramphistomum*,
Species – *gotoi, cervi, gracile*, *explanatum*

(ii) Identification

- Usually thick and circular in transverse section.
- Posterior sucker is situated close to the posterior extremity and may be very strongly developed.
- A large ventral pouch may be present.
- Anterior sucker sometimes has a pair of posterior pockets.
- Pharynx is absent; esophagus present and the intestinal caeca are simple.
- Tegument is spineless.
- Genital pore opens ventrally, median, in the anterior third.
- Testes are frequently lobed and usually anterior to the small ovary.
- Vitelline glands are lateral andstrongly developed.
- Coiled uterus runs forwards in the dorsal part of the body.

(iii) Basic biology

- Adult parasites present in rumen and reticulum in the wild ruminants.
- Life cycle is indirect.
- The planorbid snails, aquatic in nature, act as intermediate host.
- The period required for maturation varies from 6 weeks to 4 months.
- Animals grazing on areas contaminated with metacercaria near water bodies are likely to be affected.

(iv) Prey species

Wild ruminants

(v) Ways on control or strategies

- Periodic treatment of the affected animal during the seasonal peaks.
- Avoid assess of the animals to the contaminated areas.
- Restrict the supply of contaminated product.
- Destruction of host snails by the use of molluscicides.

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