# AN ASSESSMENT OF SELECT ANTHELMINTICS ON PARASITIC CONTROL AND HEALTH STATUS OF CAPTIVE CERVIDS

**DISSERTATION SUBMITTED TO SAURASTRA UNIVERSITY, RAJKOT, IN PARTIAL FULFILMENT OF THE MASTER'S DEGREE IN WILDLIFE SCIENCE**


BY

**GARGA MOHAN DAS**


UNDER THE SUPERVISION OF

**Dr. (Capt.) PARAG NIGAM**
**Sh. DEBASHISH CHKRABORTY, IFS**


भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

## *CERTIFICATE*

This is to certify that **Dr. Garga Mohan Das,** student of Wildlife Institute of India has carried out an original piece of research work entitled **"An assessment of select anthelmintics on parasitic control and health status of captive cervids"** for the partial fulfillment of the M.Sc. Degree in Wildlife Science from the Saurashtra University, Rajkot, India. These investigations were carried out under our supervision from November 2006 to June 2007. We also certify that this research has not been submitted for any other degree to any University.

**Dr. (Capt.) Parag Nigam**
Wildlife Health Management Deptt.

Dated: June 22, 2007
Place : Dehradun

**Sh. Debashish Chakraborty, IFS**
Population Management Deptt.

Post Box No. 18, Chandrabani, Dehradun - 248001. India
EPABX : +91-135-2640111 to 2640115 2640990 ; FAX : 2640117 GRAM : WILDLIFE;
E-Mail : wii@wii.gov.in

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# CONTENTS

# INTRODUCTION

## 1.1 Background to the study

Zoos function in a world of rapidly increasing environmental threat and declining biodiversity. Climate change, unsustainable exploitation of natural resources, impact of invasives and environmental degradation have all grown at an alarming rate at the expense of biodiversity. This has led to zoos to evolve from menageries of yesteryears to centers for conservation, research and education. They are repositories of populations of several endangered species and in some cases the only remaining populations, in this context the management of these populations assume great significance. These populations need management interventions not only at demographic and genetic levels but also in health care, so as to ensure their long term viability. One of the groups in captivity requiring attention are cervids. All zoos in the country have a considerable population of these animals and the need for scientific and professional management is the need of the hour. They suffer from viral, bacterial, fungal, metabolic, parasitic, and other diseases (Arora 2003).

In Indian conditions, helminthic infections are common amongst captive cervids owing to the relatively unhygienic conditions and poor health care existing within *ex situ* facilities. In such a situation of disequilibrium, parasites manifest their harmful effects on the host and it is often difficult to exterminate them given the confinement and changed environmental conditions of the hosts (Acharjyo 2001).

Parasites both endo-parasites and ecto-parasites reduce the general growth and body condition of the host. The presence of heavy parasitic infection causes various sub acute and acute clinical manifestations like dullness, weakness, emaciation, anorexia, vomiting, diarrhea, constipation, odema, icterus, anemia, prostrations, abdominal pain and hemorrhagic enteritis and may even lead to mortality. However, in chronic parasitic infections, animals show different abnormal behavior therefore affecting the survival, reproductive output and growth of the host either directly or indirectly (Williams 1982).

Experimental studies on captive animals clearly demonstrate an adverse effect of parasites on reproduction and survival of the host populations (Scott 1990). Parasites may also indirectly affect hosts by reducing their competitive fitness (Scott, 1988).Therefore, the impact of parasites will depend upon the level of pathogenicity and the resistance of the host to infection, which are influenced by malnutrition, overcrowding, stress and multiple parasitism that complicate the dynamics of host parasite interaction (Anderson and May 1978, Gulland 1992).

Among wild herbivores in captivity, sambar (*Cervus unicolor*) and chital (*Axis axis*) are more susceptible to parasitic infection due to reasons such as high densities, faulty management practices and defective enclosure design.

A variety of gastrointestinal parasites of sambar and chital are reported to be pathogenic in captive conditions. Studies examining parasitic loads among Indian cervids have been well documented. *Fasciola gigantica* in chital (Nandankanan Zoo; Acharjyo 1985 and Assam State Zoo cum Botanical Garden; Chakraborty *et al* 1994), *Paramphistomum spp* in chital (Nandankanan Zoo; Patnaik and Acharjyo 1970), *Gastrothylax crumenifer* of sambar (Jaipur Zoo; Agarwal and Ahluwalia 1980), *Coenorus gaigeri* of sambar (Delhi Zoo; Verma *et al.* 1994), *Ascaris vitulorum* in chital (Arora *et al* 1985). *Cysticercus tenuicolis* of chital (Nagpur Deer Park; Kolte *et al.* 1998). More over, some helminthic parasite like *Trichuris discolor, Gongyloma sp., Haemonchus contortus, Bunostomum spp, Trichstrongylus sp., Dicrocoelium sp., Mullerious capillaries, Fischederious elangatus, Onchocerca sp.* and *Homologaster polaniae* were reported more commonly in zoos (Patnaik and Acharjyao1970, Acharjyo 1985, Arora and Ramaswamy 1990, Chakraborty and Chaudhary 1993, Chakraborty *et al* 1994, Vardharajan *et al* 2002, Banarjee *et al* 2004). Helminthic infections have resulted in significant levels of morbidity and even mortality (14% to 43% in Nandankanan Zoo; Acharjyo and Rao, 1987) among chital and sambar. It is thus important to know basic parasitological diagnostic procedures, the anthelmintics available and their effect on parasitic load on body condition and behavior of animal in order to devise effective control programs.

## 1.2 Efficacy of anthelmintics on helminth parasites:

Ideal anthelmintics should be efficient against all parasitic stages of a particular species. It is also important that they should be non-toxic to the host, or at least have a wide safety margin and should also be rapidly metabolized and excreted by the host. Different chemical groups of anthelmintics are Benzimidazoles (Parbendazole, Mebendazole, Fenbendazole, Albendazole), Pyrazino-isoquinolines (Praziquantel) Thiabenzenedazole derivative (Trichlabendazole), Avermectine (Ivermectin), Imidazothiazoles (Tetramisole) and Organophosphates (Coumaphos, Trichlorfon).

Among anthelmintics, the broad spectrums of benzimidazole groups and avermectines are used predominantly for their high effectiveness and minimal side effects. The benzimidazoles group of drugs mainly comprises of mebendazole, fenbendazole, oxfendazole, oxibendazole, albendazole and phenothiazine. From amongst these anthelmintics, fenbendazole, ivermectin and albendazole are used more commonly (Melhorn, 1988).

## 1.3 Behavioral consequences of parasitism

Parasitized animals may respond differently from unparasitized individuals to the variety of environmental and physiological stimuli similarly conspecifics may also show altered behavior towards parasitized individuals. Females have a tendency to select the fittest males. Various studies have shown the negative effect of parasitism on body condition. Males which are heavily parasitized usually have poorly developed secondary sexual characters and are thus selected against. While males with greater parasite resistivity tend to have better body condition and better developed secondary sexual characters tend to be selected for in mating.

Various studies have also attempted to establish a link between parasitized animals and altered behavior. Marked changes have been observed in animals in their ability to avoid predators and forage. The effects of parasitism on social interactions have also been discussed by various workers, several of whom observed marked alterations in social hierarchy and other interactions between conspecifics. Moore (1995) suggested that their activity, appearance, size and foraging may be altered both qualitatively and quantitatively. Baylis and Nambiro (1993) deduced a decline in the defensive behavior due to lethargy induced by parasitism.

Hence, the study on assessment of different anthelmintics on parasitic load and their role on condition and behavior of animals become quite relevant.

# OBJECTIVES

1. Quantify the parasitic loads in cervids of selected deer parks
2. Assess the effectiveness of different anthelmintic regimes on parasitic loads.
3. Effect of various treatments on behavior and health status of cervids.

# REVIEW OF LITERATURE

Parasites can have a wide range of impact on the ecology of the host, in terms of health (Arme & Owen, 1967), behavior (Milinski, 1984; Moore, 1984), sexual selection (Howard and Minchella, 1990; Watve & Sukumar, 1997), and regulation of host populations (Freeland, 1983). It is interesting to study the parasitic diseases in ex-situ or in-situ condition and determine the potential factors responsible for the transmission of parasites. These factors include high stocking density, enclosure size, management practices, existing environmental conditions that affect the viability and behavior of parasites, feeding, movement, and defecation patterns of host, which determine the parasites encountered (Price *et al.* 1988; Watve, 1992).

Cervids in captivity are primarily affected by the gastrointestinal (GI) helminthes and protozoa. Helminth are the important group of parasites amongst all wild and captive animals. The main genera of helminthes recovered from cervids include *Fasciola* sp., *Paramphistomum* sp., *Strongyles* sp., *Strongyloides* sp., *Trichuris* sp., *Ascaris* sp., *Haemonchus* sp., *Ostertagia* sp., *Oesophagostomum* sp. (Arora, 2005). Major gastrointestinal helminth infections are reported to cause deterioration of health, reduce body condition, and lead to weight loss in young deer and reproductive disorders in older ones (Goosseens, 2005). Helminth infections have resulted in significant levels of morbidity and even mortality among chital (*Axis axis*) and sambar (*Cervus unicolor*) in Nandankanan Zoo (Acharjyo & Rao, 1987). However, several studies concluded that cervids and their gastrointestinal helminth are well adapted to each other; resulting mostly in sub-clinical infections (Goossens, 2005).

Although the prevalence of various GI parasites in cervids have been extensively reported in the country, studies on their impact on host species and control strategies are scanty. The review of literature is presented below.

### 3.1 Parasitic prevalence

Juana *et al.* (2006) carried out a coprological examination in 62 captive African gazelles including Mhorr's gazelles (*Gazella dama mhorri*), Cuvier's gazelles (*Gazella cuvieri*), and Dorcas gazelles (*Gazella dorcas neglecia*) over the course of a year. Nematode egg excretion showed a marked seasonal variation, with very low levels during the dry and hot period, a finding that is probably attributable to hypobiosis of the predominant species (*Camelostrongylus mentulatus*). Eggs of the *Nematodirus* sp., predominantly *Nematodirus spathiger*, were excreted throughout the year. No seasonal pattern was observed in *Trichuris* sp. egg excretion.

Varadharajan & Subramanian (2003) carried out a survey in Thrissur Zoo, Kerela, for a period of one year and screened 961 faecal samples of wild animals. Out of the total, 654 samples, (68.05%) were found positive for helminthic infection viz *Strongyles* sp., *Strongyloides* sp., *Amphistome* sp., *Fasciola* sp. and *Trichuris* sp.

Kashid *et al.* (2003) conducted studies on 10 species of wild animals at 6 locations viz Kanha National Park, Gemini circus, Deer Park at Nagpur, Maharaja Bag Zoo at Nagpur, Siddharth Zoo at Aurangabad, and Peshwe Park in Pune. A total of 501 faecal samples were screened and parasitic prevalence in tiger was 31.65%, Chital 96.13%, lions 35.72%, peacocks 88.33% and 2.42% in jackals, hyenas, sambar, nilgai and black buck.

Mandal *et al.* (2002) examined faecal samples of free ranging chital in Mudumalai National Park and found that parasitic prevalence increased significantly in grazing areas used by cattle in pre-monsoon. The prevalence percentage of helminthic infection was of *Strongyles* sp. (41.67%), *Strongyloides* sp. (11.46%), *Ascaris* sp. (5.29%), *Amphistome* sp. (15.63%) and *Fasciola* sp. (13.54%).

Varadharajan & Kandasamy (2002) surveyed parasitic infection in wild animal in V.O.C Park and Mini zoo at Coimbatore and recorded an overall parasitic prevalence of 58% in captive animals. Among the infected animals, herbivores showed multiple infections with more than one helminth parasite. *Strongyles* sp., *Trichuris* sp. were the most commonly found parasites. Additionally infection with *Ascaris* sp., *Moniezia* sp., *Strongyloides* sp., *Coccidia* sp. and *Balantidium* sp. were also reported.

Kumar (2001) reported the overall parasitic prevalence of 18.23% in wild herbivores and domestic animals at Pench Tiger Reserve, Maharashtra in which highest prevalence was observed in Gaur (33.33%) and amongst the residential livestock population, bullock showed the highest prevalence of 21.05%.

Varadharajan and Pythal (1999) carried out coprological examination in wild animal in Zoological Garden Thrivanthapuram and reported that 76% (97/127) of the samples to be positive for parasitic infection. Among helminth infection, 66% animals were found to have single species infection while 34% animals had more than one species of infection. *Strongyle, Amphistome Strongyloides* and *Fasciola* were the major parasites reported in herbivores while *Ancylostoma, Toxascaris and Diphylobathrium* and *Paragonimus* infection were reported in carnivores. Of all the helminth infections in herbivores, Strongyle and Amphistoime infections were found to be higher in Bovidae and Cervidae. Other infections observed in order of prevalence in herbivores were ascarid, strongyloids, spirurid and Fasciola. The study showed that helminth and protozoans present in the wild animals were far less significant as manifesters of clinical disorder. The author also reported that though deworming was being carried out twice annually, it was apparent from the results that the efficacy of the same was not being ensured. Therefore, even low grade infections should not be neglected and conducting epizootiological surveys are necessary to study the prevalence of parasitic infections.

Modi *et al.* (1997a,b) studied the effect of seasonal influence and age on the prevalence of intestinal parasitism among zoo animals in Sanjay Gandhi Zoological Park Patna and Jawaharlal Nehru Bilogical Park, Bokaro steel city on 105 herbivorous and 80 carnivorous animals. 46.67% of herbivores were positive for protozoan and helminthic infections. These included *Ascaris* sp., *Ancylostoma* sp., *Oesophagostomum* sp., *Trichuris* sp., *Strongyloides* sp., *Fasciola* sp., *Paramphistomum* sp., *Coccidia* sp., and *Entamoeba* sp., whereas carnivores were infected with *Ascaris* sp., *Ancylostoma* sp., *Trichuris* sp., *Strongyloides* sp., *Taenia* sp., *Fasciola* sp., *Coccidia* sp., *Entamoeba* sp. and *Giardia* sp. The study revealed that age had more significant influence on parasitic loads, however it was also reported that maximum percentage of infection occurred during monsoon and minimum during summers

Chakraborty & Islam (1996) studied gastrointestinal parasitic infection in few herbivores at Kaziranga National Park. Out of a total of 171 samples, 40.35% were positive for one or mixed infections. Species-wise infection rate was found to be 22.85%, 21.85%, 49.31% and 58.06% in Hog deer (*Axis porcinus*), Swamp deer (*Cervus duvaceli*), Water Buffalo (*Bubalus bubalis*) and Elephant (*Elephas maximus*) respectively. Parasitic ova *of Paramphistomum* sp., *Fasciola* sp., *Stronglyes* sp., *Strongyloides* sp., *Trichuris* sp., *Oesophagostomum* sp. *and Ascaris* sp. were recorded along with oocyst of coccidia from swamp deer and water buffalo.

Chakraborty *et al.* (1994) reported the prevalence of parasitic infection in captive wild herbivores in Assam State Zoo cum Botanical Garden during the period of 1985 to 1989. Two hundred and fourteen captive wild herbivores were necropsied. Different nematodes recorded were *Haemonchus, Ascaris, Gongylonema, Trichostrongylus, Oesophagostomum, Seteria, Dictyophyma, Cooperia, Onchocerca, Trichuris, Kululima, Chabertia, Necator, Bunostomum, Dictyocaulus, Harbronema, Chonigium, Grammacephalus* and the trematode were *Fasciola, Paramphistomum, Gastrothylax, Fischoederius, Carmyerius, Cotylophoron, Gigantocotyle, Homologaster, Pseudodiscus, Pfenderius* and *Brumphtica.* The cestodes found in the study were *Moneizia, Anaplocephala, Hyadatid* cyst and *Cysticercus.* Protozoans recorded were *Sarcocystis, Eimeria and Balantidium coli.*

Bordoloi *et al.* (1991) reported on incidence of intestinal helminthic infection of deer in Assam State Zoo cum Botanical Garden. Coprological examination of 24 animals showed that 33.33% of deer were infected by helminth infection. The highest infection was recorded for Trichostrongylus 50% followed by Bunostomum and Dicrocoelium 25% respectively.

Gaur *et al.* (1979) studied prevalence of helminth infection in wild animals of Corbett National Park. Out of 122 faecal samples of Chital (*Axis axis*) and Barasinga (*Cervus duvauceli)*, 79 (64.75%) were positive for helminthic infections and included *Fasciola* sp.(16.46%), *Amphistomes* sp. (12.66%), *Strongyloides* sp. (15.19%) and *Strongyles* sp. (20.25%).

Prestwood (1975) investigated the helminth infections among free-ranging, intermingling populations of white-tailed deer (*Odocoileus virginianus*), cattle (*Bos taurus*), and swine (*Sus scrofa*) on an island off the Georgia coast. Helminthes recovered from ruminants were *Capillaria bovis, Cooperia punctata, Dictyocaulus viviparus, Gongylonema pulchrum, G. verrucosum, Haemonchus contortus, Moniezia benedeni,* and *Trichostrongylus axei,* occurred in both deer and cattle.

Patnaik *et al.* (1970) conducted a study on the helminth parasites of vertebrates in Baranga Zoo in Orrissa. Post –mortem examination of 15 mammal species revealed that out of 153 vertebrates, 127 of them were infected with 16 trematodes, 17 cestodes, 34 nematodes and 3 acanthocephalid species. Among the ungulates, Chital, Sambar, Barking deer and Nilgai were infected with *Fasciola gigantica, Cotylophoron cotylophoron, Fischoederius elongates, Homologaster poloniae, Trichuris discolor, Paramphistomum explanatum, Fishchoederius cobboldi and Ashworthius martinagliae.*

### 3.2 Factors affecting Parasites prevalence

Sanyal, 1996 during the study on reported that rainfall governs the severity of infection and favours the development and survival of pre-parasitic stages that ultimately infects the host

Goossens *et al.* (2006) incriminated high contamination for grassy pastures with infective larvae/eggs in the previous year or before the first treatment as reason for failure of the treatment regimes in some herds.

### 3.3 Parasites and their effect on animals

Stein *et al.* (2002) did an experimental and cross-sectional study on the impact of gastrointestinal nematodes on reindeer and found that gastrointestinal nematodes had a significant impact on the growth of farmed ruminants. The anthelmintics (Albendazole, Moxidectin and Ivermectin) treatment caused an increase in the body mass, back fat depth and fecundity of the reindeer. Treatment depressed the abundance of adult parasites of *Ostertagia gruehneri* for at least 6 months. More over experimental results showed for the first time in a natural ruminant host population that gastrointestinal nematodes can have a significant effect on host condition and fecundity.

Jana & Jana (2001) recorded fascioliasis in two captive spotted deer showing symptoms of anorexia, occasional colic and oily diarrhea tinged with mucous and blood in Kumari Khangabali Deer Park in West Bengal. Rafoximide at 25mg/kg body weight was given orally to manage fascioliasis.

Jayathangarajan (2000) reported occurrence of Bunostomiasis in captive black buck kept in Arignar Anna Zoological Park, Vandalur, Chennai. The animals were reported to be off feed and had weakness, persistent diarrhea, anemia and rough hair coat.

Andrews (1938), Sahoo & Singh (2002) reported parasitism in animals to reduce feed intake, increase loss of endogenous protein, reduce nitrogen balance, increase heat production and reduce the efficiency of conversion of food to weight gain.

### 3.4 Drug trials

Over the last 50 years, administration of anthelmintic has come to be the dominant form of nematode control in India (Sanyal, 1998).

Goossens *et al.* (2006) evaluated three parasite control programs in seven herds of captive wild ruminants viz. Arabian oryx, Scimitar-horned oryx, Slender-horned gazelle, Soay sheep, Ibex, Red deer, and Nelson's elk for three consecutive years. In the first year, a biannual spring-summer treatment regime with Fenbendazole at 7.5 mg/kg body weight p.o. for 3 days was applied. The next year, an early-season treatment program with three administrations of fenbendazole at the same dosage at 3 week intervals was used. In the third year, an early-season treatment program with Ivermectin (0.2 mg/kg p.o. for 3 days), applied three times at 5 weak intervals, was evaluated. Effectiveness of these control programs was assessed by faecal egg counts and by scores of body condition and faecal consistency at weekly interval. With the spring-summer regime, faecal egg counts remained low during the first 5 months, but from September onwards, they slowly increased to significant levels in all seven herds. The early-season program with Ivermectin resulted in very low to zero egg shedding in Gazelle, adult Soay sheep, Ibex, Red deer, and Nelson's elk during the entire grazing season, but failed to prevent high shedding in October in Arabian oryx and Scimitar-horned oryx.

Goossens *et al.* (2005) assessed the efficacy of Fenbendazole at a dose rate of 7.5 mg/kg bodyweight in 5 Arabian oryx (*Oryx leucoryx*), 6 Scimitar-horned oryx (*Oryx dammah*), 14 Slender-horned gazelles (*Gazella leptoceros*), 8 Soay sheep (*Ovis aries aries soay*), 13 Alpine ibex (*Capra ibex ibex*), 6 Red deer (*Cervus elaphus hippelaphus*) and 11 Nelson's elk (*Cervus elaphus nelsoni*) kept in five herds in a zoo. It was observed that Fenbendazole was highly effective against nematodes in five of the seven species, consistently reducing egg shedding by more than 90 per cent.

Foreyt *et al.* (2004) conducted a study on black tailed deer (*Odocoileus hemionus columbianus*) in Western Washington (USA) that had developed a hair loss syndrome that often preceded emaciation, debilitation, pneumonia, and death. Coprological examinations indicated infection with *Dictyocaulus viviparus, Parelaphostrongylus* sp., *Trichuris* sp., *Moniezia* sp., *Eimeria* sp., and gastrointestinal strongyles. Biting lice (*Tricholipeurus parallelus*) were also observed on all deer. Animals were given ivermectin to determine the effect of treatment. It was found that lice and all nematode eggs and larval stages in feces were eliminated or greatly reduced following treatment.

Williams *et al.* (1997) evaluated the efficacy of Albendazole, Oxfendazole and fenbendazole compared with Ivermectin pour-on (IVM-PO) against inhibited early fourth-stage larvae of *Ostertagia ostertagi*, other gastrointestinal nematodes and lungworm of cattle during spring in Louisiana. Efficacy of IVM-PO was greater ($P<0.05$) against all *O. ostertagi* stages than the Benzimidazole drugs, except for Albendazole. Efficacy of the Benzimidazole drugs against all other species was essentially similar to that of IVM-PO.

Yazwinski *et al.* (1995) evaluated the nematocidal effectiveness of the Ivermectin sustained-release bolus throughout its 135-day delivery period to Twenty-four naturally infected calves. Result showed that parasitic populations of *Haemonchus, Ostertagia, Trichostrongylus, Cooperia, Bunostomum*, and *Oesophagostomum sp.* were significantly reduced in cattle treated with the Ivermectin sustained-release bolus and the nematocidal activity of the Ivermectin sustained-release bolus proved highly effective, with > 98% efficacy for all nematode species present.

Teresa *et al.* (1995) studied the efficacy of Mebendazole and Ivermectin in controlling of gastrointestinal helminthiasis in three species of captive gazelles: *Gazella dama mhorri* , *G. cuvieri,* and *G. dorcas.* Ivermectin was given subcutaneously in a single 0.2-mg/kg live-weight dose and Mebendazole was given in three dosages based on species: *G. doras,* 14 mg/kg; *G. cuvieri,* 6 mg/kg; and *G. dama,* 3 mg/kg orally twice daily for 3 consecutive days. Each drug was tested in 13 individuals of each species; 13 additional individuals served as untreated controls. Helminths detected by faecal examination and culture were species of *Trichuris, Ostertagia, Cooperia, Trichostrongylus, Nematodirus* and *Strongyloides.* The prevalence among the total gazelle population was: *Trichuris,* 55%, *Nematodirus* 26% and other nematodes 84%. After treatment with Mebendazole, the nematode egg counts and the number of animals shedding eggs decreased moderately. However, following Ivermectin treatments, there was marked decreases in the amount of eggs shed and the number of animals shedding eggs of these nematodes.

Shahardar *et al.* (1995) studied the efficacy of Fenbendazole against gastrointestinal nematode in eight Kashmiri stag (*Cervus elephus hungul)* infected with *Strongyles* sp. and *Strongyloides* sp. Fenbendazole at a dose rate of 7.5 mg/kg body weight was administered to the animals. Pre treatment EPG in animals varied between 100 -500 for Strongyles ova and 100-1100 for Strongyloides ova. However, on second day post treatment the number of eggs was reduced to 100% in respect of Strongyles and 5.2% in respect of Stronglyloides. On day $4^{th}$ and $8^{th}$ post treatment, a number of Strongyloides eggs were reduced by 92.6 and 100% respectively. The animal did not reveal any parasitic ova on $28^{th}$ and $35^{th}$ day of post treatment.

Mukherjee *et al.* 1994 carried out comparative efficacy of tetramisole, fenbendazole and Ivermectin was studied against gastrointestinal nematodes in 45 Pashmina goats of 3 age groups <6, 6-9 and >9 months. Superiority of Ivermectin became evident from 3 days onwards post-treatment over the other two drugs. Efficacy of the compounds was finally assessed by EPG count of faecal samples on day 9 post-treatment as compared to pre-treatment EPG. Ivermectin was observed 100% effective against *Strongyloides, Trichuris* and *Nematodirus* and 94.16-100% effective against *Trichostrongyles,* the difference between these two drugs being marginal, Tetramisole was found 94.64-100% effective against trichostrongyles, 83.33%-100% effective against *Strongylodes* and 100% effective against *Trichuris* and *Nematodirus.* The overall efficiency were 100%, 95.78-100% and 95.31-98.85% with Ivermectin, fenbendazole and tetramisole respectively.

Andrea *et al.* (1994) examined efficacy of fenbendazole at the San Diego Wild Animal Park in nine species of the subfamilies Antilopinae and Hippotraginae over a 2-yr period. Two different doses (114 g/ton feed, 228 g/ton feed) of Fenbendazole milled in pelleted feed was given to the animals. Paired pre-treatment and post-treatment faecal samples were obtained at six treatment periods from individually identified animals for faecal egg counts. For 1 yr, Persian gazelles (*Gazalla subgutturosa)* were intensively monitored by performing egg counts and pasture larval counts at 3 wk intervals. Over all Fenbendazole treatment showed significant results (P>0.05). Time series analysis with cross-correlation indicated that faecal egg counts significantly influenced the larval counts 6 week later (r=0.613, P<0.05). Year-round presence of infective larvae on irrigated pasture made strategic parasite control difficult and necessitated frequent anthelmintic treatment (>3/yr) for adequate parasite control.

Stephen *et al.* (1993) examined the efficacy of Fenbendazole against gastrointestinal nematodes in captive (N-77) and free ranging White tailed deer (3 study areas) in Louisiana. Fenbendazole reduced gastrointestinal nematode burden. Mean egg per gram of feces from captive deer decreased $p<0.01$ and $p<0.01$ respectively. Doses approximating 0.42 – 0.46 g/ deer did not affect ($p=0.61$) eggs per gram of feces collected from free ranging deer. Mean eggs per gram of feces collected from free ranging deer was affected by fenbendazole treatment ($P=0.04$) and decreased an average 86% (SE = 1.9) on the 3 study area after provision of fenbendazole in doses approximating 1.67 to 1.82 gm per deer. They suggested that reduction in the cross transmission of gastrointestinal parasites common to deer and livestock might be possible through fenbendazole treatment of deer.

Loyacano *et al.* (2001) conducted a study to assess the effect of parenteral administration of Doramectin or a combination of Ivermectin and Closulon on control of gastrointestinal nematode and liver fluke infections and on growth performance in cattle. Result suggested that Doramectin had a greater impact on subclinical gastrointestinal tract parasitism in calves, as demonstrated by growth performance, than did Ivermectin and Closulon.

Andrews *et al.* (1993) did a study on the nematode egg output and plasma concentration of Ivermectin after its administration to red deer (*Cervus elaphus elaphus*) and found that Ivermectin when used at 400 micrograms/kg bodyweight, proved to be more efficient than 200 micrograms/kg bodyweight although positive worm egg counts together with the isolation of lungworm (*Dictyocaulus sp.*) larvae were recorded from hinds having received the anthelmintic at the higher dose.

Rahman *et al.* (1988) evaluated the efficacy of praziquantel against *Schistosoma nasale* infection in naturally infected cattle treated with a single oral dose of at 20mg/kg body weight and the result showed that the drug was highly effective causing a considerable reduction in egg counts.

Todd *et al.* (1985) experimentally infected four groups of five lambs each with mixed infections of *Haemonchus contortus, Ostertagia circumcincta, Trichostrongylus axei,* and *T. colubriformis*. One group (control) was given the propylene glycol, and the others were given 100, 200, or 300 micrograms of Ivermectin/kg of body weight orally. Twelve days after treatment, the sheep were necropsied. The compound was greater than 99% effective against immature stages of 4 nematode species at all dosages, except at the 100 micrograms/kg dosage, where efficacy was 96% against *Haemonchus contortus.*

Swan *et al.* (1985) evaluated the efficacy of Ivermectin administered at 200 micrograms/kg against induced infestations of 5 gastrointestinal nematode species in cattle by oral drench and subcutaneous injection of Ivermectin against the third and fourth larval and adult stages *of Bunostomum phlebotomum, C. pectinata, Haemonchus placei, Oesophagostomum radiatum* and *Ostertagia ostertagi*. Result showed that Ivermectin was 77.5-100% effective against naturally acquired infestations of *Trichuris* sp. and more than 80% effectiveness against other nematodes.

Janssen (1985) conducted an experimental study where 4% fenbendazole premix was milled into the feed of 55 nondomestic ruminants (37 antilopines, 12 hippotragines, and 6 caprines). Efficacy of the premix against endoparasites in the ruminants was determined by comparison of pre and post treatment faecal egg counts in which dosages greater than 5 mg/kg resulted in 98% to 100% reductions in faecal egg counts. Strongyloides and Nematodirus eggs were most sensitive to treatment, with 100% reductions in faecal egg counts. Strongyle and Trichuris egg counts were reduced 90% and 96%, respectively.

Theodorides *et al.* (1976) reported that Albendazole was highly efficacious in the removal of monospecific and mixed infection of *Haemonchus contortus, Nematodirus spathiger*, and *Dictyocaulus filaria* from sheep. A dose level of 5 mg/kg removed nearly all gastrointestinal nematodes, and 10 mg/kg removed all lungworms. Tapeworms of the genus Moniezia were completely removed by a dose level of 10 mg/kg

Kennedy & Todd (1975) conducted an experiment on lambs that were severely parasitized by Haemonchus, Ostertagia, Trichostrongylus, Cooperia, Oesophagostomum, and Nematodirus. The animals were treated with fenbendazole given at 3 dose levels: 3.5, 5.0, and 7.5 mg/kg of body weight. Efficacies against these genera, except Haemonchus and Nematodirus, were 100% at the 3 dose levels. . Efficacies for the 3 doses against Haemonchus were 93.4, 95.3, and 99.8%, respectively, and against Nematodirus, 99.5, 99.6, and 100%. Efficacies for the doses against Trichuris were 69.1, 83.6, and 98.2 %.

Tripathy *et al.* (1971) surveyed intestinal parasitic infections in zoo animals and birds of the Nandankannan Biological Park, Orissa. Coprological examination revealed helminthic infections viz Coccidiasis, Ascariasis, Toxacariasis and Fascioliasis and tape worm infection. Treatment with Codrinal (Hoechst), Bifuran soluble tablets (Smith, Kline and French), Cyanamide 12.5% reduced the intensity of helminthic ova and protozoan cyst. The results of the treatment were quite successful.

### 3.5 Impact of parasites and anthelmintic treatment on animal behavior

Parasites can so greatly alter a host's behavior that they change its ecological function (Moore, 1995). Parasitized animals may respond differently from uninfected animals. Their activity, appearance, size and foraging can be altered both qualitatively and quantitatively. Un-parasitized animals may exhibit behavioral alterations when trying to avoid parasites (Moore, 1995). In captivity, as the stocking density increases in a limited space; some species show more aggression than their free ranging conspecifics (Anon, 1999). Moreover in certain species, territoriality in a constricted space further leads to infighting (Stine *et al.* 1982). Hence the size of the enclosure for particular number of individuals of a single or variety of species needs thorough considerations. The management of species needs special attention to minimize the chances of aggression related injuries, disease prevalence, fight for accessibility to food, space and females (Pranjona, 2003).

Growing animals may suffer impaired growth rate and reproductive efficiency with levels of intestinal parasites that does not necessarily result in clinical signs of disease. The behavioral pattern involved in the avoidance of internal and external macro parasites include feeding, elimination, grooming, fly repelling, evasive behavior and grouping (Benjamin, 1992).

The behavioral consequences of parasitic infections in various animals were studies by Plateux (1972), Combes (1991), Moore and Goteli (1990), Hetchel *et al.* (1993). According to Moore (1995) the behavior of infected animals does not often differ from rest of the uninfected conspecific. Hetchel *et al.* (1993) reported that infected isopods spent significantly more time on foraging activity compared to their uninfected counterparts. The other study on copepods by Poulin *et al.* (1992) found increased swimming in case of cestode infection. However, on other side, not all parasites or all developmental stages of a parasite alter host behavior. Moore and Gotelli (1990) found no behavioral changes when infected with cestodes. They also reported that behavioral change is critical for survival from predators in wild conditions. Baylis and Nambiro (1993) inferred a reduction in defensive behavior as a consequence of lethargic condition. However, according to Hart (1990), the lethargy more benefits a host striving to eliminate a pathogen. The effect and magnitude of parasitic infection on the social behavior is reported by Moller *et al.* (1993). On the other side, host social behavior is recognized as having significant effect on the transmission of contagious parasites (Freeland, 1976). For instance, increased grouping of host individuals is correlated with both increased prevalence and intensity of contagious parasites across a wide range of taxa (Cote & Poulin 1995). Freeland (1979) and Ranta (1992) found a correlation between grouping behavior of host and multi-species infection.

Animals adopt some behavioral strategies to avoid infections, it doesn't mean that individuals remain free from parasites or never succumb to parasitism. Animal may carry a parasites load that does not affect its health, but when there are intense demands on body resources such as a seasonal nutritional stress or over stocking, even a moderate to light parasite load may play a role in the animal's survival. (Benjamin 1992)

Shahardar *et al.* (1995) reported marked improvement in the clinical signs exhibited by eight Kashmiri deer (*Curvus elephus hungal)* dewormed with single dose treatment of

Fenbendazole @ 7.5 mg/kg body weight. The author reported that the animals were alert healthy with normal appetite and passed pelleted feces of normal consistency on 28th and 35th days of post treatment.

Muraleedharan et al 1990 stated that helminthic or sub-clinical coocidial infections might not cause any immediate alarming signs of disease but in the long course, they might produce ill effects such as emaciation and general weakness which would in due course be responsible for inviting other pathogens.

Irwine *et al.* 2006 examined evidence for parasite impacts in 285 red deer (*Cervus elephus)* harvested during 1991 and 1992 on the Isle of Rum and reported presence of *Nemotodirus* sp, *Capillaria* spp., *Cooperia* spp., *Monieza expanza, Oesophagostomum venulosum* and *Trichuris ovis.* Lungworm (*Dictyocaulus* spp.) and tissue worm *(Elaphostrongylus cervi)* larvae were also observed in faecal samples. Despite low levels of infection, both adult male and female deer showed significant negative corelation between indices of condition (kidney fat index, dressed carcass weight and larder weight) and intensity of *Ostertagia* spp. infection. The apparent subclinical effects of low-level parasite infection on red deer performance would alternatively be due to animals in poorer nutritional state being more susceptible to infection. The results suggested that further studies of wild populations are justified, in particular where high local host densities exist or alternative ungulates hosts are present and, where experimental treatments are tractable.

# MATERIAL AND METHODS

The study was carried out for a period of six months between November 2006 to May 2007. The reconnaissance survey was carried out at seven deer Parks in the states of Uttarankhand, Haryana, Punjab and Himachal Pradesh during November 2006. Based on the initial survey three deer Parks were selected and intensive sampling was carried out to assess the parasitic load, carry out anthelmintic trials and study impact of anthelmintic treatment on behavior and condition of animal between December 2006 to May 2007.

## 4.1. Reconnaissance survey

The reconnaissance survey included rapid questionnaire survey at all the seven deer Parks . The survey was carried out with the aim of assessing the existing practices, animal densities, topography and to find out the feasibility of the present study. Additionally, faecal samples were collected randomly and analyzed for presence of parasitic ova. The detailed results of questionnaire survey and coprological examination are presented in section 4 (Table 4.1).

## 4.2 Selection of study site

For the intensive study three deer Parks, namely Deer Park Hisar in the state of Haryana, Deer Park Bir Moti Bagh, Patiala in the state of Punjab and Deer Park Rampur Mandi, Dehradun in the state of Uttarankhand were selected. The description and husbandry details are provided as Table 4.1

**Table 4.1 Description of Selected Deer Parks in which intensive study was carried out.**

| Name of Deer Park | Description | Husbandry practices: |
|---|---|---|
| **Deer Park, Bir Moti Bagh, Patiala:** | Deer Park,Patiala located inside the Bir Moti Bagh Wildlife Sanctuary at 5 km from the main city patiala, Punjab. The total area of the Park is 30 acre where the sanctuary extends over 1616.034 acre. The enclosure size of all deer species is equal viz: 2904 sq meter or 0.8 acre. The area is dominated by dry deciduous forest and falls in the semi arid region with maximum rainfall of 730mm and experiences extreme summer and winter temperatures. | Animals are fed the green fodder at the rate of 15 kg per animal per day Black grams is fed at the rate of 250 gm per animal per day as concentrate supplement. The green fodder supplied from outside the Park on contractual basis. Jaggery and salt are given in a weekly interval. Animals are fed at morning and at evening. Dung removal and animal waste disposal practices are not followed regularly. Ad libitum drinking water supply is provided to the animals from nearby bore wells. De-worming of animals in the Park is done but irregular. Routine parasitological examinations of animals are not followed. |
| **Hissar Deer Park, Haryana.** | The Park is located on the outskirts of Hissar, 10 km from main town on the Dhansu road and is spread over 42 acres or 170016 sq meters of area, The main vegetation of the Park and surrounding areas are *Prosopis* spp. *Acacia* spp, *Sheeshom* spp, *Ficus* spp, and plantation of *Eucalyptus* spp. The Park has six acres area for cultivation of green fodder. The Park has three shelters and two cemented waterholes. The Park is situated on the bank of a reservoir and is surrounded by various species of trees. The maximum day temperature during the summer varies between 40 to 48 °C. During winter it ranges between 1.5 °C to 4 °C. There are 4 feeding troughs and 2 cemented water holes with two shelter houses in the exhibit area of the Park. Most of the Park is covered by thick thorny shrubs and trees; animals primarily inside the forest. | Animals are fed with the mixture of chopped green fodder and concentrate pelleted cattle feed·at morning and evening at the rate of 15 kg per day per animal for chital. The daily dung removal and animal waste disposal practices are not regular. Sometimes, the leaf litter and dung are burned. Drinking water is supplied from the nearby drainage system at regular intervals. Animals are housed on sandy to hard substrate without any vegetation in exhibit area except *Eucalyptus* plantation. Veterinary intervention is minimal. No routine parasitological examination and routine check up of the animals is performed. The general health and body condition of the animals inside the Parks was average to poor. |
| **Assan barrage (Rampur mandi), Dehradun.** | The Park is situated near the confluence of Yamuna river and the Assan River, 40 kms west of Dehradun on the Dehradun-Paonta Road. Temperature in summer maximum 38°C and minimum 14°C and in winter maximum 21°C and minimum 2°C. Average rainfall is 250 cm and occurs during June to September. The Park houses a total of 9 individual of chital. The enclosure size extends 0.75 acre or 3000 sq meter. There is one feeding trough and one water trough with two bamboo thatch shelter houses. The ground of the exhibit area is covered by grass. | Animals are fed with green leaves and fodder two times daily with concentrate feed in morning and evening. The amount for green fodder is 15 kg per animal per day and 250 gm concentrate feed per animal per day daily. Daily dung removal and animal waste disposal are not practiced but burning is sometimes carried out. There is a 24 hour drinking water supply from a bore well. Routine veterinary checkup and routine parasitological examination are not followed. The general health and body condition of the animals was found to be average to poor. |

### 4.3. Study animal: Chital (Axis *axis*)

The chital (*Axis axis*) is an endemic medium sized cervid distributed through out the forested parts of Indian subcontinent. Chital constitutes major prey biomass of large carnivores like tiger, lion, leopard, dhole etc. in most of the protected areas in the country. The information on endoparasites and their behavioural consequences in cervids in general and chital in particular in wild conditions as well as captivity is scanty.

During reconnaissance study, four species of cervids were found namely chital (*Axis axis*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjac*) and hog deer (*Axis porcinus*). Among all cervids, sambar, barking deer and hog deer were not present on all sites and the numbers of individuals were also less. Chital was selected for the detailed study as the number of individuals on different Parks was enough for required sample size. The details of chital population and the number of animals sampled in various deer Parks are provided table 3.2.

**Table 4.2 Percentage of number of chital sampled in three different Parks**

| Deer Parks | Population | Sampled | % animal sampled |
|---|---|---|---|
| Deer Park Hissar | 30 | 24 | 80% |
| Deer Park Bir Moti Bagh, Patiala | 24 | 16 | 66.66% |
| Assan Barrage (Rampur Mandi) Dehradun | 9 | 9 | 100% |

### 4.4. Parasitological Investigations

#### 4.4.1 Sample collection

Fresh faecal samples were collected at random on alternate days on three occasions between 0600 hrs to 0700 hrs prior to anthelmintic trial. Post treatment faecal sample collection was carried out at three day intervals on $3^{rd}$ day, $7^{th}$ day, $11^{th}$, $15^{th}$ day $19^{th}$ day and $21^{st}$ day post anthelmintic treatment. The anthelmintic treatment was repeated on $22^{nd}$ day following initial administration. The samples were again collected and tested for parasitic load on $26^{th}$ Day.

### 4.4.2 Faecal examination

Faecal samples were observed qualitatively for consistency, color, odor, presence of mucous, blood and parasite segments and observations made for each sample were recorded. Pellets showing different consistency encountered during the study as presented as Plate 1.

Field laboratory was established at different sites for preliminary analysis of the samples as well as for processing the samples for transfer to laboratory (Plate 2). For qualitative and quantitative analysis of parasitic load, fresh faecal samples weighing 20 gm to 30 gms were collected in sample collection vials. The samples were preserved in 10% formalin saline and appropriately labeled till further examination. Coprological examination included both qualitative test employing floatation and sedimentation techniques and quantitative test employing Modified Mc master technique to assess the Eggs per grams (EPG) as described by Coles, (1986). Briefly the techniques are described as follows

#### 4.4.2.1 . Sedimentation method

As most operculated trematode eggs and a few nematode eggs are difficult or impossible to recover by floatation techniques, sedimentation procedures are more appropriate (Coles, 1986). Briefly the techniques includes mixing 1 gm of feces with 40 ml of water or saline in a beaker, sieving it through a sieve having 40 meshes per sq. inch, pouring the mixture into centrifuge tube and spinning at moderate rate of speed for 5 minutes. The supernatant is then discarded and a small quantity of the sediments are put on glass microscopic slide and examined under microscope after putting a cover slip.

#### 4.4.2.2 . Floatation Method

The presence of majority of nematode eggs can be confirmed employing this technique. **Briefly the techniques includes mixing 5 gm of feces with adequate volume of water or saline in** a mortar and pestle, **sieving it through a sieve (40 meshes per sq. inch) and pouring the mixture into flat** bottom glass tube of 7.5 cm length and 2.5 cm internal diameter. The tubes are allowed to stand for 15 – 20 minutes and excess supernatant is discarded without disturbing the sediments. Later the flotation tube was filled up to brim with saturated salt solution (1.2 specific gravity). The saturated solution can be made by dissolving 434 gm of sodium chloride in 1000 ml distilled water. The floatation tube is then covered with a glass microscopic slide so that it touches the fluid. The tube is left undisturbed for 20-25 min. The slide is then removed and cover slip placed and examined under microscope.

#### 4.4.2.3. Modified McMaster technique

Modified McMaster technique is used for counting the number of parasitic eggs per gram (EPG) of feces (Coles, 1986). Basic technique as described by Coles, 1986 was used with slight modification. Briefly the technique included homogenizing 3 gm of fecal sample with 42 ml of distilled water, sieving it through a sieve in a beaker and allowing it to stand for 20 – 30 minutes. The supernatant is then discarded without disturbing the sediments. The sediments were reconstituted in saturated salt solution and the original volume was restored. Thereafter 0.15 ml of the mixture is immediately transferred to a McMaster slide so as to fill both the chambers in the slide. The chambers are then examined under microscope and number of eggs counted. EPG is calculated by multiplying number of eggs by 50.

#### 4.4.2.4. Identification of Eggs:

The identification of parasitic eggs was based on morphological studies as described by Soulsby (1982). Assistance from parasitologists at Hissar and Ludhiana Veterinary Collages were taken for confirmations of the parasitic ova detections.

## 4.5. Drug Trial

### 4.5.1 Animal Habituation and drug trial

The animals were habituated to eat concentrates from earthen pots only for a period of 10 days prior to initiation of anthelmintic treatment (Plate 3). A day prior to anthelmintic treatment the animals were fasted. The required quantity of drug was mixed with grounded pelleted feed and jaggery and delivered in individual containers to the animal in limited quantities (Plate 4). Once consumed, the animals were provided full concentrate ration alongwith green fodder. It was assumed that 80% of the total population consumed the food mixed with the drugs.

### 4.5.2 Anthelmintic trial

A total of three anthelmintic (singly and in combination) were tried at different Deer Parks. The drugs used for the trials are given in Table 4.3

**Table 4.3: Drug trials at different deer Parks**

| Name of Deer Park | Drug used | Dose rate | Dosing |
|---|---|---|---|
| Deer Park, Hissar | Fenbendazole *(Panacure® VET, Inervet, Pune, India)* | 7.5mg/kg | Day 1 and repeated at day 22 |
| Bir Moti Bagh Deer Park, Patiala | Praziquantel+Fenbendazole *(Fentas plus™, Intas pharmaceuticals, Dehradun India)* | 10 mg/kg+ 7.5 mg/kg | Day 1 and repeated at day 22 |
| Rampur Mandi Deer Park | Ivermectin *Neomec, Intas harmaceuticals, Ahemdabad, India* | 200µg/kg | Day 1 and repeated at day 22 |

All the preparations were administered orally mixed with concentrate feed and chopped green fodder. Mode of action for different drugs used is given below

**Mode of action of Benzimidazoles**

These drugs generally act on the intestinal cells of the helminthes preventing glucose uptake, thus starving the parasites which causes the death of the parasites. Stephen *et al* (1993) reported that fenbendazole was effective for reducing gastro intestinal nematode burden in captive and free ranging white tailed deer as reflected by fecal eggs per gram. Milkon *et al* (1994) also reported that fenbendazole treatment was associated with significant reduction of egg count for all the exotic ungulate spp. Goossens *et al* (2005) conducted a survey of gastrointestinal helminth infections of cervids kept in zoo in Belgium found that fenbendazole treatment have a effect on the parasitic loads. Qureshi *et al* (1986) used triclabendazole and albendazole to control *Fasciola magna* in white- tailed deer. Schultz *et al* (1993) used fenbendazole against gastrointestinal nematodes in white tailed deer.

**Mode of action of Ivermectin**

Ivermectin acts by potentiating the release and binding of gamma- aminobutyric acid (GABA) in certain nerve synapses. In nematodes, GABA acts as a neurotransmitter sending signals between interneurons and motor neurons; thus, when these signals are disrupted by ivermectin, paralysis of the nematode eventually take place. This drug has been shown to have excellent activity at very low dose rates, not only against a wide range of nematodes, but also against a wide range of ectoparasites. Teresa *et al* (1995) reported that ivermectin treatment greatly reduced fecal egg count and in the genus *Trichuris*, FEC was reduced by over 97% in gazelles sampled.

**Mode of action of praziquantel**

These groups of compounds are effective against wide range of adult and larval cestodes and nematodes. The action of the drugs result in a rapid vacuolization of tegumental layer in the growth zone of neck region of cestodes which leads to disruption of parasite musculature causing death to the parasites (Melhorn 1998).

## 4.6 Body Condition Evaluation (BCE) of Chital:

Health assessment of the Chital was carried out by assessing the body condition. The body condition indices as developed by Riney, (1960) and modified by Ashraf, (1992) were used to give score to each individual based on physical appearance. The criteria and point scores used to assess body condition is provided in Table 4.4 and presented as Plate 5

**TABLE 4.4 : Body region/score and Criteria**

| Body part | Point=0 | Point=1 | Point=2 | Scores |
|---|---|---|---|---|
| **Flank Area** | Depression is barely visible. Outline of flank area is not visible | Outline of flank area is slightly visible. | Flank depression is concave and tucked in | |
| **Ribs** | Thoracic surface is smooth and ribs are difficult to see. | Ribs are slightly visible | Ribs are distinct with inter-costal region. | |
| **Pelvic Girdle** | Bony Projections of pelvic girdle are barely visible | Pelvic girdle outline slightly visible | Clearly visible | |
| **Vertebral Column** | Laterally, it seems smooth. | Lumber vertebrae are visible but not prominent | Lateral and dorsal processes of lumber vertebrae are prominent and distinct. | |
| **Lumbar Shelf** | No depression in shelf.Appears almost round from behind. | Slight depression on either side. | Depression deep and concave. | |

**Interpretations: 0-1=Excellent, 2-4: Good, 5-7: Fair and 8 -10: Poor.**

The method used visual assessment to assign numerical scores to five different regions of the body, which are totaled to give a numerical index ranging from 0 to 10.

The targeted individuals chital were evaluated for the body condition at all three sites in a pretreatment and post treatment framework. The exercise was carried out twice in the pretreatment phase. Post treatment body condition was assessed twice at fifteen days interval on 15$^{th}$ and 30$^{th}$ day.

### 4.7 Behavioral sampling:

The behavioural observations were recorded using focal animal sampling (Altmann 1974; Lehner 1996; Lehner & Philip 1996). The individual animal was selected randomly from 6 identified individuals at each location based on visual perceptions with specific morphological characteristics viz antler size (in case of males), body colour, size, age and specific natural identification marks if present. The behavioral observations were categorized into broad behavioral states that included feeding, resting, movement and rumination. as described by Altmann 1974. The behavioural states noted during the study are presented as Plate 6.

The time frame for focal animal sampling was divided into pre-treatment and post- treatment regimes. The data were collected from early morning 7:00 hr to late evening 6:00 hr with one hour break during 13:00 to 14:00 hr. Sampling was carried out by one minute continuous observation followed by a break of 2 minutes. The observations were recorded in terms of time spent in each behavioural state. If an individual was observed spending less than two seconds in any specific state then it was considered as continuation of previous behavioural state only.

Pre treatment focal animal sampling was done by selecting two identified individuals amongst the pre-identified six individuals for 1st day of sampling. The sampling was done for 6 days alternatively so that all the six animals were sampled. Efforts were made to ensure that each individual got equal sampling time and frequencies of their behaviors without repetitions.

Post treatment behavioural sampling followed the interval of anthelmintic treatment regime Sampling was carried out on the gaps of collection of faecal samples up to the interval of $2^{nd}$ treatment.

## 4.8 Statistical analysis

### 4.8.1 Assessing the prevalence percentage

Prevalence of Parasitic infection was calculated in the Chital population as number of individuals infected in the total individuals sampled in a given park and calculated as follows:

*Prevalence percentage = (Number of positive sample (Individuals)/Number of animal tested) X 100*

The species wise parasitic prevalence in total Chital population was derived as follows:

*Species-wise parasitic prevalence = (Individuals infected with particular parasite/ Total Chital population sampled) X 100*

*Species-wise parasitic detections = (Number of individual parasite ova detected of particular species/ total number of parasitic ova detected) X 100*

### 4.8.2 Testing efficacy of different anthelmintic

The Independent sample T test (Zar, 2005) was employed to assess the efficacy of different anthelmintics on EPG (pre and post treatment).

Efficacy of different anthelmintic on EPG at 11 days and 21 days post treatment was assessed using Chi- square test

### 4.8.3 Linear regression

Linear regression slope was plotted between EpG and No of days for which EPG was estimated. Linear regression coefficients were calculated from these slopes.

### 4.8.4 Behavioural sampling

1. Two sample (One tailed) T test was employed to calculate the difference between pre and post treatment behavioral changes in three different parks. ($p < 0.05$).

### 4.8.5 Body condition evaluation

Chi- square test was employed to assess the body condition prior to and post anthelmintic treatment

# RESULT

## 5.1 Reconnaissance survey

The results of the reconnaissance survey carried out at seven deer parks in the states of Harayana, Punjab, Himachal Pradesh and Uttarakhand are presented as Table (5.1).

The deer parks were to be selected based on the animal density, topography, and those with similar management and veterinary practices, however there was no much difference among these. For the study Deer park at Hissar, Patiala and Rampur Mandi were selected. The basis of selection for these parks included availability of enough sample population, similar topography (plain levelled terrain) optimum for behavioural studies and proximity to reputed laboratories and expertise availability. Deer park at Neelon was rejected as the park had only one Chital whereas Bir Talab Bhatinda Deer Park had a very high density of animals. Additionally the laboratory and expertise availability for Bir Talab Deer Park were located far and were logistically not appropriate. Malsi Deer Park and Renukaji Lion Safari & WLS were rejected as the terrain was undulating thereby making behavioral observations difficult.

## 5.2 Assessment of Parasitic load

The overall pretreatment parasitic prevalence in Chital at different deer parks was 87.59% in Hissar and 100% in, Patiala and Rampur Mandi (Fig 5.1). The overall incidence of infection in various deer park is represented as Table 5.2.

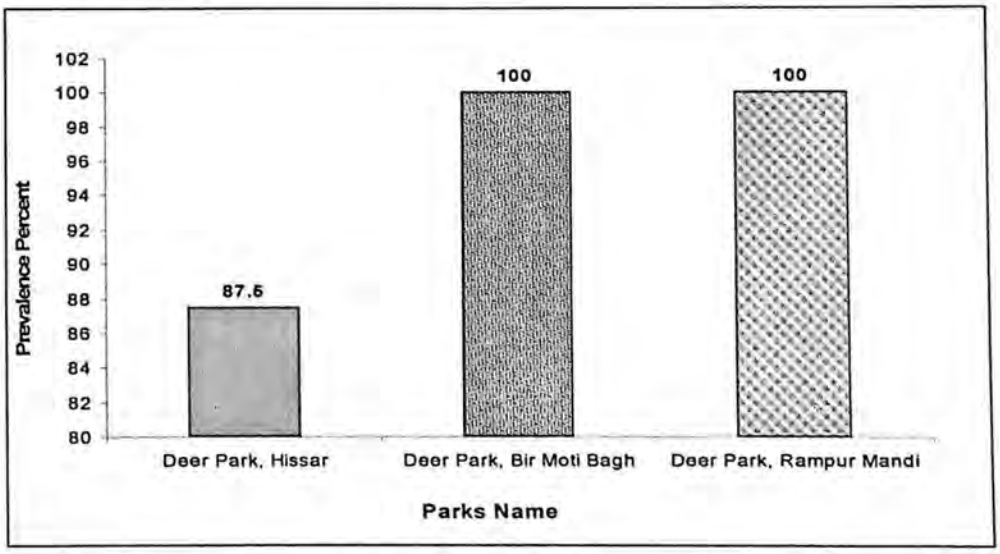


**Fig: 5.1. Over all prevalence of parasitic infections in chital in three deer parks**

**Table 5.1 Summary results of Reconnaissance survey of seven deer parks**

| Name of Deer Parks | Location | Chital population | Area in Acres | Animal Density | Management/husbandry practices | | Veterinary practices | | | Parasitic ova encountered during Recce. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Feeding & water source | Disinfection and sanitation practices | Veterinary cover | Routine parasitological examination | Deworming /vaccination | |
| Deer Park, Hissar | Outskirts of Hissar (Harayana)/ Semi natural flat ground Mixed species enclosure | 30 | 42 | 1.407 | Green fodder and concentrates fed<br>Water lifted from near by lake and drained through *kucha nalas* | Occasional disinfection and no regular dung removal or waste disposal | SOS | Not carried out | Not carried out | Detected (Strongyle spp., Strongyloides spp., Trichuris spp.) |
| Deer Park, Bir Moti Bagh | Outskirts of Patiala (Punjab)/Individual species enclosure | 24 | 0.8 | 30 | Green fodder and concentrates fed<br>Ground water pumped and provided to individual enclosure through *kucha nalas* | Occasional disinfection and no regular dung removal or waste disposal | SOS | On demand | Deworming carried out every six month, no vaccination carried out | Detected (Strongyle spp., Trichuris spp.) |
| Deer Park, Rampur Mandi | Rampur Mandi, Dehradun/ Individual species enclosure | 9 | 0.75 | 12 | Green fodder and concentrates fed<br>Water trough filled from Tap water | Occasional disinfection and no regular dung removal or waste disposal | SOS | Not carried out | Not carried out | Detected (Strongyle spp.) |
| Deer Park, Neelon | Outskirts of Ludhiana(Punjab)/ Mixed species enclosure | 1 | 0.3395 | 0.34 | Green fodder and concentrates fed<br>Ground water pumped and provided to individual enclosure | Regular disinfection and dung removal and waste disposal followed | SOS | Not carried out | Not carried out | Not detected |
| Deer Park, Bir Talab, | Outskirts of Bathinda (Punjab)/Individual species enclosure | 14 | 0.294 | 47,62 | Green fodder and concentrates fed<br>Ground water pumped and provided to individual enclosure through *kucha nalas* | Occasional disinfection/daily dung removal and waste disposal facility available | Weekly | On demand | Deworming carried out every six month, no vaccination carried out | Detected (Strongyle spp., Strongyloides spp.) |
| Malsi Deer Park | Outskirts of Dehradun, U.A/ Semi-natural condition with hilly slopes Mixed species enclosure | 57 | 61.8 | 0.922 | Green fodder and concentrates fed<br>Water trough filled from Tap water | Occasional disinfection and no regular dung removal or waste disposal | SOS | Not carried out | Not carried out | Detected (Strongyle spp.) |
| Renukaji Lion Safari & WLS | Sirmaur district of H.P./ Semi-natural condition with hilly slopes /Mixed species enclosure | 2 | 3.933 | 0.509 | Green fodder and concentrates fed<br>Ground water pumped out from the nearby Renukaji Lake and provided | Occasional disinfection and no regular dung removal or waste disposal | Monthly | Not carried out | Not carried out | Detected (Strongyle spp.) |

It was observed that mixed or multi-species infections were dominant compared to single species infection and ranged from 65.27% at Hissar to 100% at Bir Moti Bagh. At Rampur Mandi Deer Park mixed species infection was observed in 88% of population. 12.5% of the animals at Hissar tested negative for parasitic ova whereas none of the animals were negative for parasitic infection at Bir Moti Bagh and Rampur Mandi Deer Parks. The details are provided in Table 4.2

**Table 5.2.: Population Infected at different deer parks**

| **Name of Deer Park** | **Single parasitic ova detected** | **Mixed infection with more than one parasitic ova** | **Animal negative for parasitic ova** |
|---|---|---|---|
| Deer park, Hissar | 22.23% | 65.27% | 12.5% |
| Deer park, Bir Moti Bagh | - | 100% | - |
| Deer Park, Rampur Mandi | 11.11% | 88.88% | - |

## 5.3 Species wise parasitic prevalence

Species wise parasitic prevalence in total chital population at different deer parks is presented as table 5.3. *Strongyles* sp showed maximum prevalence of 73.61 % followed by *Strongyloides* sp. 34.72%, *Trichuris* sp. 15.27%, *Ascaris* sp. 15.27%, *Moniezia* sp 15.27%, and *Coccidia* sp 13.88% at deer Park Hissar. 65.27% of chital population showed mixed infection with more than one parasite. Hissar deer park was the only deer park among the three that showed incidence of *Moneizia sp.* and *Coccidia sp.*

Species wise parasitic prevalence of Deer Park, Bir Moti Bagh, Patiala were *Trichuris* sp 87.5%, *Strongyles* sp 68.75%, *Strongyloides* sp 50 % and *Ascaris* sp 37.5%. 100% of animals showed mixed infection 100%.

At Deer Park, Rampur Mandi *Trichuris* sp was found in 100% of chital population however *Strongyloides* sp and *Strongyles* sp was found to be 29.62% and 88.88 % respectively. 100% of animals showed mixed infection.

*Strongyles sp.* was the dominant parasite at Hissar while *Trichuris sp.* was the dominant parasite at Bir Moti Bagh and Rampur Mandi respectively.

**Table-5.3.: Species wise parasitic prevalence in chital population in different deer parks.**

| Parks Name | Parasites detected | | | | | |
|---|---|---|---|---|---|---|
| | *Strongylus sp.* (%) | *Strongyloides sp.* (%) | *Trichuris sp.* (%) | *Ascaris sp.* (%) | *Moniezia sp.* (%) | *Coccidia sp.* (%) |
| **Deer park, Hissar** | 73.61 | 34.72 | 15.27 | 15.27 | 15.27 | 13.88 |
| **Deer park, Bir Moti Bagh** | 68.75 | 50 | 87.5 | 37.5 | No ova detected | No ova detected |
| **Deer Park, Rampur Mandi** | 88.88 | 29.62 | 100 | PND | No ova detected | No ova detected |

## 5.4 Species wise parasitic prevalence from the total parasitic ova detected

Analysis of species –wise parasitic prevalence from the total parasitic ova detected in chital at different deer parks is tabulated as Table 5.4. Different parasitic ovas encountered during the study as presented as Plate 7.

**Table 5.4. Species – wise parasitic prevalence across the three deer parks in chital.**

| Parks Name | *Strongyles* sp (%) | *Strongyloides* sp ( %) | *Moniezia* sp (%) | *Ascaris* sp ( %) | *Trichuris* sp ( %) | *Coccidia* sp (%) |
|---|---|---|---|---|---|---|
| Deer Park, Hissar | 43.80 | 20.66 | 9.09 | 9.09 | 9.09 | 8.26 |
| Deer Park, Bir Moti Bagh | 28.21 | 20.51 | 0.00 | 15.38 | 35.90 | 0.00 |
| Deer Park, Rampur Mandi | 40.00 | 15.00 | 0.00 | 0.00 | 45.00 | 0.00 |

Of a total of 121 parasitic ova encountered at Deer Park, Hissar(Pre Treatment) *Strongyles* sp contributed maximum( 43.80%), followed by *Strongyloides* sp (20.66%), *Moniezia* sp, *Trichuris* sp, *Ascaris* sp(9.09% each), and *Coccidia* sp (8.26%).

Of a total of 117 parasitic ova encountered at deer park, Bir Moti Bagh, *Trichuris* sp contributed maximum (35.90%), followed by *Strongyles* sp (28.21%), *Strongyloides* sp (20.51%), and *Ascaris* sp (15.38%).

Of a total of 60 parasitic ova encounterd at deer Park, Rampur Mandi ( Pre Treatment) *Strongyles* sp(40%), *Strongyloides* sp (20.51%), and *Trichuris* sp (45%).

### 5.5 Anthelmintic trial

### 5.5.1 Effect of anthelmintic on parasitic prevalence

Anthelmintic trials were conducted in the three deer parks using different drugs either singly or in combination. The mean prevalence of parasites detected across three deer parks (day wise) pre and post treatment up to 26 days is represented in Fig. 5.2 .

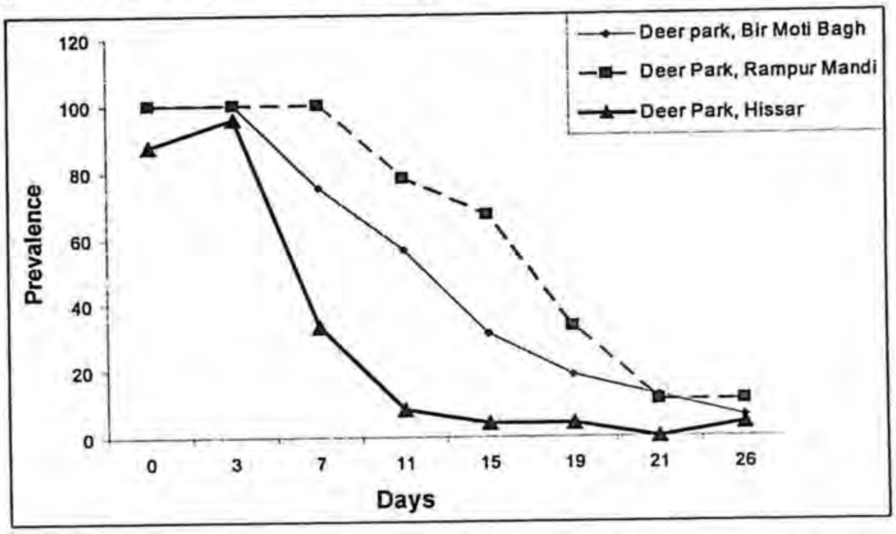


**Figure- 5.2: Day wise mean parasitic prevalence across three deer parks.**

At deer park, Hissar the mean prevalence of helminthic infections prior to treatment was found to be 87.5%. However, on 3rd days post treatment there was increase in prevalence percentage (95%). Subsequently the prevalence decreased on 7th day, 11th day, 15th and 19th day with parasitic prevalence at 33.33%, 8.33%, 4.1% and 4.1% respectively. Most importantly, it was observed that on the day of 21st day, no infections were found. The animals were again treated on 22nd day and showed a mild reoccurrence (4.17%) on the 26th day.

At deer park, Bir Moti Bagh, prior to treatment, the parasitic prevalence was 100% and did not show any change 3 days post treatment. Subsequently the parasitic prevalence decreased to 75%, 56.2%, 31.25%, 18.75% and 12.5% on 7th, 11th, 15th, 19th and 21st day respectively. Following second treatment the parasitic prevalence was 6.25% on the 26th day.

At Deer Park, Rampur Mandi, prior to the anthelmintic treatment, the prevalence was 100% and remained same on 3rd and 7th day post treatment. The prevalence was found to decrease on 11th, 15th, 19th, and 21st day with prevalence percentage of 77.78%, 66.67%, 33.33%, and 11.12% respectively. Following 2nd treatment however the parasite prevalence remain same at 11.12% (26th day post treatment).

Deer Park Hissar showed a drastic decline in parasitic prevalence by the 7th day and then gradually declined to 0 on the 21st day. A marginal prevalence was detected on the 26th day while the deer parks at Bir Moti Bag and Rampur Mandi showed remarkable declines by the 11th and 19th day respectively and then tapered of to extremely low levels of parasitic prevalence by the 21st day. However parasites were not completely eliminated at Bir Moti Bagh and Rampur Mandi. The differences in prevalence of parasites post-treatment is probably due to the composition of the species infecting the deer and also the possibility of re-infection occurring post treatment.

Accordingly, the efficacy of three different anthelmintic trials on parasitic prevalence carried out at different deer park pre treatment and 11th and 21st day post treatment is presented. (Fig.5.3).

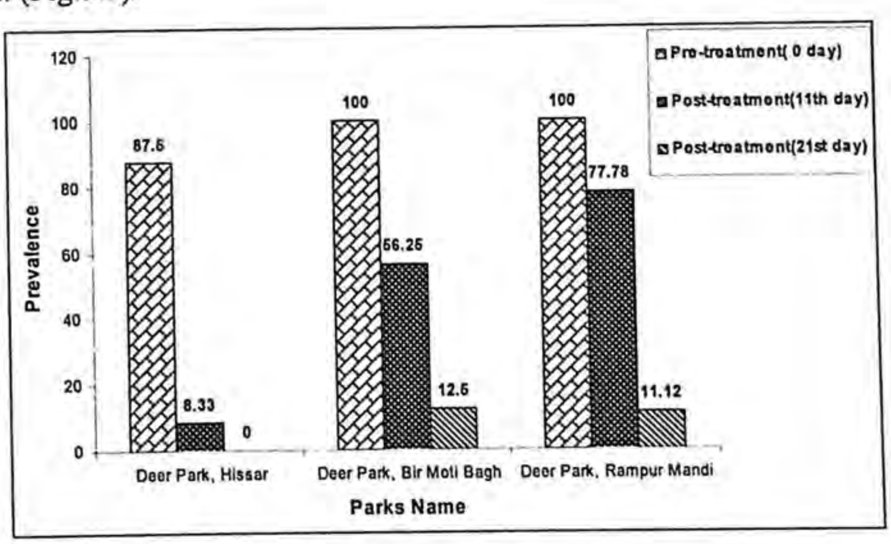


**Fig 5.3: Prevalence percentage of parasitic infection in pre treatment and at 11 and 21 days post treatment**

Pre-treatment prevalence percentage of parasitic infections in 3 different parks were 87.50 % in Deer park Hissar, 100% in Bir Moti bagh, Patiala and 100% Deer Park, Rampur Mandi. whereas it showed a significant reduction ($p = 0.001$) in all the three Deer parks, on 11th and 21st day post treatment. Though no parasitic ova were detected at Hissar on 21st day, the deer park at Patiala and Rampur Mandi showed 11.11% and 12.5% parasitic prevalence on 21st day.

### 5.5.2 Effect of anthelmintic on EPG of Feces

The parasitic load was also quantified using modified Mc Master Technique. The Eggs Per Grams (EPG) prior to initiation of anthelmintic trial and subsequently on 3rd, 7th, 11th, 15th, 19th, & 21st days post 1st treatment and then on 26th day is tabulated as (Table 5.5) and represented as Fig 5.4

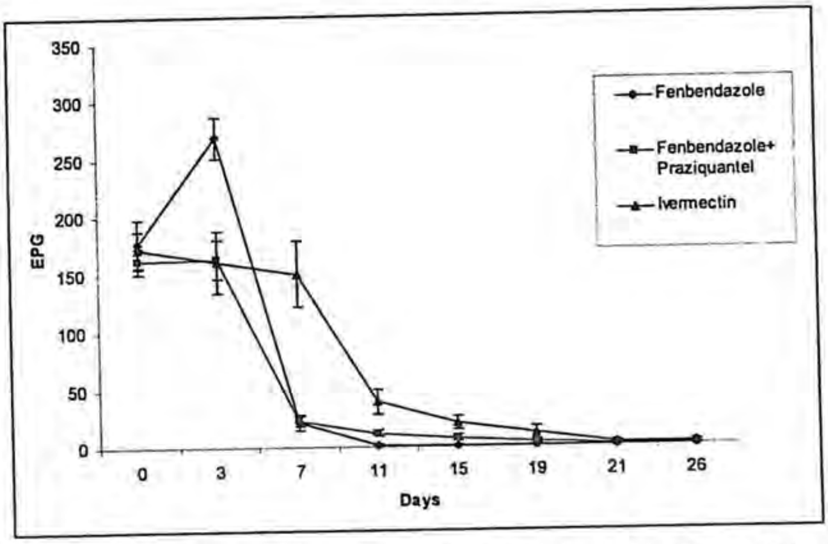


**Figure- 5.4: Day wise efficacy of anthelmintic on EPG in three different parks.**

**Table 5.5. Day wise mean EPG count from 0 day to 26th day at three Deer Parks.**

| | 0 day | 3 Day | 7 day | 11 day | 15 day | 19 day | 21day | 26 day |
|---|---|---|---|---|---|---|---|---|
| Hissar | 177.11± 20.597 | 268.75±18.05 | 21.25±6.71 | 1.25±0.91 | 0.41±0.41 | 0.41±0.41 | 0 | 0.41±0.41 |
| Patiala | 162.03± 11.51 | 163.28± 16.59 | 22.65± 4.87 | 11.71± 3.118 | 7.03± 3.01 | 3.90± 2.20 | 1.56± 1.06 | 1.56± 1.56 |
| Rampur Mandi | 171.83± 16.62 | 161.11± 26.64 | 150± 28.73 | 38.88± 10.78 | 20.37± 6.07 | 11.11± 6.21 | 1.85± 11.85 | 1.85± 1.85 |

Following the anthelmintic treatment with Fenbendazole at Deer Park Hissar, the mean EPG increased on 3rd day post treatment and then reduced on 7th day up to 26th day. At Deer Park Rampur Mandi, the EPG reduced on the 7th day and showed decreasing trend up to 26th day. Following anthelmintic treatment with Ivermectin at Deer Park, Rampur Mandi, EPG was significantly reduced on 11th day and showed downward trend subsequently up to 26th day.

### 5.5.3 Efficacy of anthelmintic on individual parasite species

The common species at three different Deer Parks encountered were *Strongyle* sp., *Ascaris* sp., *Trichuris* sp. and *Strongyloides* sp. Efficacy of various anthelmintics on these individual parasitic species at different deer parks is provided as Fig. 5.5

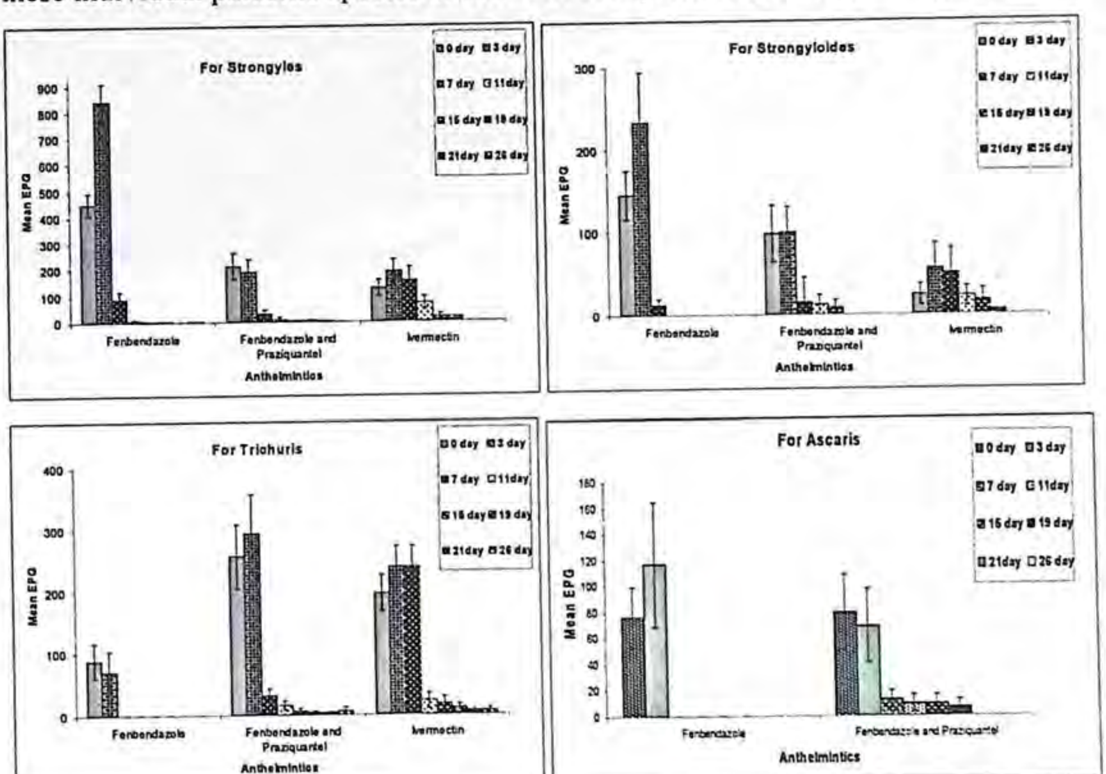


**Fig 5.5: Efficacy of Anthelmintic on common parasitic species at three different Parks.**

#### 5.5.3.1 Efficacy of anthelmintic on *Strongyles* sp.

The effect of various anthelmintics on the EPG for *Strongyles* sp. showed an increase on 3rd day post treatment at Hissar and Rampur Mandi deer park. However, there was a decrease noted at Bir Moti Bagh deer park. Subsequently the EPG at Hissar and

Rampur Mandi deer parks gradually started reducing and no Strongyle ova were recovered on 21st day. There was a marginal recovery of strongyle ova on the 26th day at Hissar though Bir Moti Bagh and Rampur Mandi tested negative for Strongyle ova (26th day).

#### 5.5.3.2 Efficacy of anthelmintic on *Strongyloides* sp.

The effect of various anthelmintics on the EPG for *Strongyloides sp.* showed an increase by 3rd day post treatment at all the parks and gradually were eliminated by 11th day, 19th day and 21st day at Hissar, Patiala and Rampur Mandi respectively.

#### *5.5.3.3 Efficacy of anthelmintic on Trichuris sp.*

The effect of various anthelmintics on the EPG for T*richuris sp.* showed an increase by 3rd day post treatment at Bir Moti Bagh and Rampur Mandi deer park. However there was a decrease noted at Hissar deer park by 3rd day. The parasite was eliminated at Hissar by 7th day itself though the parasite existed both on 21st day and 26th day at Bir Moti bagh and Rampur Mandi Deer park.

#### 5.5.3.4 Efficacy of anthelmintic on *Ascaris* sp.

*Ascaris* sp. was reported only at Hissar and Bir Moti Bagh deer Park. EPG for *Ascaris* sp. showed an increase by 3rd day post treatment at Hissar Deer park and got eliminated by 7th day post treatment. However at Bir Moti Bagh deer park the EPG showed a decreasing trend and the parasite was eliminated by 21st day. No parasite was detected on 26th day

### 5.6 Efficacy of anthelmintics:

The efficacies of different anthelmintics were assessed at 11th day and 21st day post treatment at different deer parks. SPSS 14 version 2004 was used to analyse the results and the values of t, p, df at $\alpha \leq 0.05$ were calculated and are presented as Table 5.5.

**Table 5.5.: Efficacy of different anthelmintics assessed at 11th day and 21st day post treatment using SPSS 14 version 2004 at $\alpha \leq 0.05$**

| | | | | | | |
|---|---|---|---|---|---|---|
| At Deer Park, Hissar: | | | | | | |
| | At 11 days post treatment | | | At 21 days post treatment | | |
| | t value | p value | df | t value | p value | df value |
| *Trichuris* sp | 3.183 | 0.003 | 46 | 3.183 | 0.003 | 46 |
| *Strongyles* sp | 10.526 | 0.0001 | 46 | 10.738 | 0.0001 | 46 |
| *Ascaris* sp | 3.375 | 0.002 | 46 | 3.375 | 0.002 | 46 |
| *Strongyloides* sp | 4.939 | 0.0001 | 46 | 4.939 | 0.0001 | |
| *Moniezia* sp | 2.704 | 0.010 | 46 | 2.704 | 0.010 | 46 |
| *Coccidia sp* | -.763 | 0.449 | 46 | -.332 | 0.742 | 46 |
| At Deer Park, Bir Moti Bagh | | | | | | |
| *Trichuris* sp | 4.788 | 0.0001 | 30 | 5.043 | .0001 | 30 |
| *Strongyles* sp | 4.087 | 0.0001 | 30 | 4.230 | .0001 | 30 |
| *Ascaris* sp | 2.294 | 0.029 | 30 | 2.650 | 0.013 | 30 |
| *Strongyloides* sp | 2.400 | 0.023 | 30 | 2.783 | 0.0009 | 30 |
| At Deer Park, Rampur Mandi | | | | | | |
| *Trichuris* sp | 5.544 | 0.0001 | 16 | 6.466 | .0001 | 16 |
| *Strongyles* sp | 1.414 | 0.176 | 16 | 4.235 | .001 | 16 |
| *Strongyloides* sp | 0.105 | 0.917 | 16 | 1.886 | 0.078 | 16 |
| At Deer Park Rampur Mandi | | | | | | |
| *Trichuris* sp | 5.544 | 0.0001 | 16 | 6.466 | .0001 | 16 |
| *Strongyles* sp | 1.414 | 0.176 | 16 | 4.235 | .001 | 16 |
| *Strongyloides* sp | 0.105 | 0.917 | 16 | 1.886 | 0.078 | 16 |

Fenbendazole significantly reduced EPG of Strongyles sp, *Strongyloides* sp, *Ascaris* sp and *Moniezia* sp, *Trichuris* sp. Hoe ever *Coccidia* sp did not show significant reduction (p=0.001).

The anthelmintic combination of Fenbendazole and Praziquantel showed significant reduction of EPG 11 days and 21 days post treatment.

Ivermectin showed significant reduction of EPG for *Strongyles* sp and *Trichuris* sp at 11 and 21 days post treatment (p=0.0001) where as had no significant difference in out put of *Strongyloides* sp (p=0.917 at 11 days and 0.078 at 21 days).

## 5.7 Body condition evaluation in Chital:

Body condition evaluation in chital at three different parks prior to and 30 days post treatment was carried out. The percent scores of various parameters viz. poor, fair, good and excellent were compared. And the results of body condition evaluation carried out prior to treatment and 15 and 30 days post treatment are provided as Fig 5.6. The $\chi 2$ test at $\alpha \leq 0.05$ at 15th days and 30th days post treatment was carried out to assess the significant differences between pre and post treatment. The Chi-square values are presented on table Table 5.6. Body condition evaluation after treatment was found to be significantly different (p: 0.001) following the administration of drugs at all three parks.

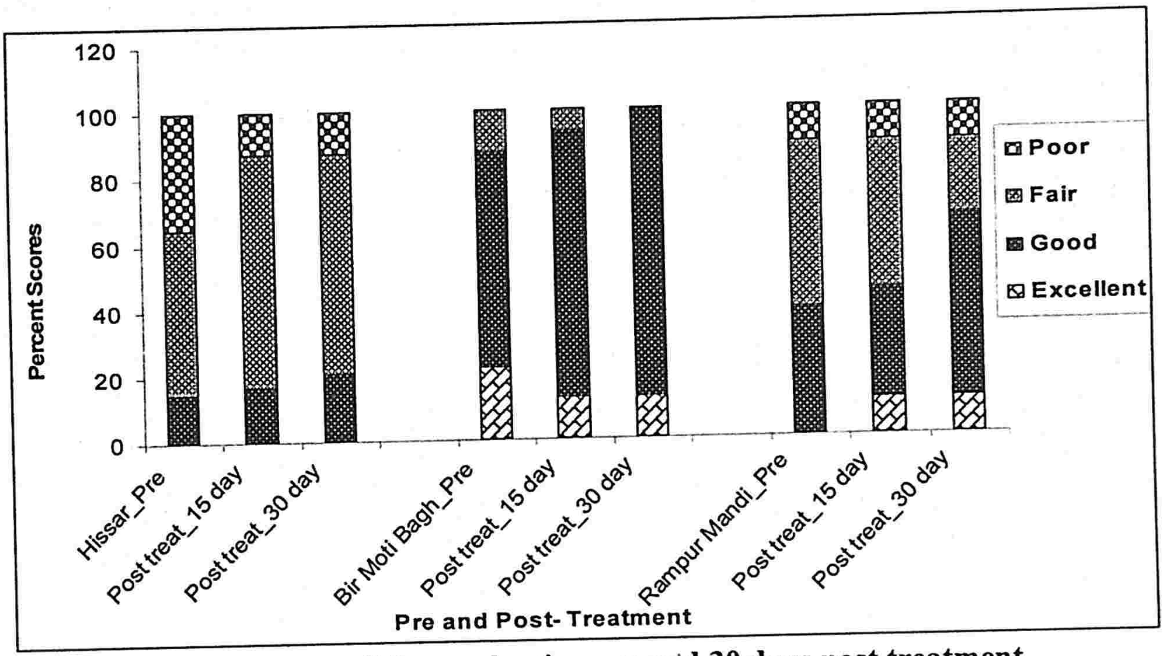


**Fig 5.6: Body condition evaluation pre and 30 days post treatment**

**Table 5.6: Pre and post treatment $\chi 2$ values of each parameter in three parks (df = 3) at 15th day and 30th day**

| | Deer park, Hissar | | Deer Park, Patiala | | Deer Park, Rampur Mandi | |
|---|---|---|---|---|---|---|
| | At 15 day | At 30 day | At 15 day | At 30 day | At 15 day | At 30 day |
| Poor | 42 | 42.03 | 0 | 0.00 | 0 | 0.00 |
| Fair | 6.17 | 4.168 | 6.25 | 0.00 | 0.69 | 34.72 |
| Good | 0.264 | 1.875 | 3.004 | 5.46 | 0.925 | 5.00 |
| Excellence | 0 | 0.00 | 7.031 | 7.03 | 11.11 | 11.11 |
| $\sum\chi 2$ | 48.391 | 48.06 | 16.285 | 12.5 | 12.725 | 50.83 |
| Significant value(p) | 0.001 | 0.001 | 0.001 | 0.005 | 0.005 | 0.001 |

## 5.8 Behavioural study

The different behavioural patterns observed in three deer parks were assessed in pre and post treatment framework. The major behaviours recorded were resting, feeding, movement and rumination.

In Deer Park, Hissar, movement (0.48 ± 0.01) was most frequent activity followed by feeding (0.23 ± 0.02) and resting (0.22 ± 0.01). The least observed activity was rumination (0.07 ± 0.02). Feeding and resting showed significant difference between pre treatment and post treatment phase. However there is no remarkable changed in movement (0.47 ± 0.02) and rumination (0.07 ± 0.01). During post treatment phase resting was significantly ($t = 1.33$, $p = 0.05$) decreased while feeding increased significantly ($t = -1.495$, $p = 0.05$).

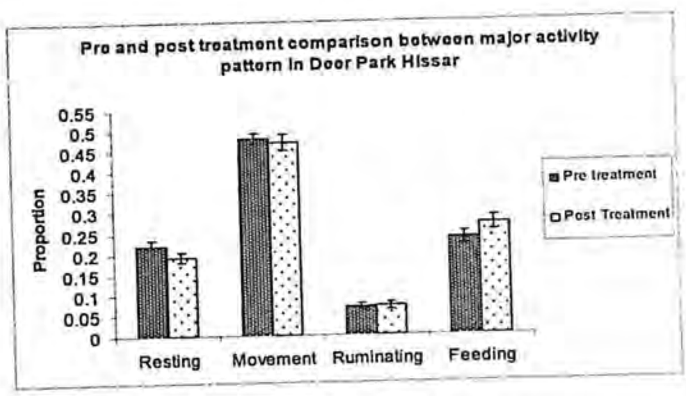


**Fig. 5.7 Comparison of major behaviroual activities at Deer Park Hissar**

In Bir Moti Bagh Deer Park, movement (0.44 ± 0.5) was most frequently observed activity followed by resting (0.26 ± 0.01) and feeding (0.26 ± 0.23) is almost equal proportions. Movement ($t = 1.9$ $p = 0.03$) and feeding ($t = 1.25$, $p = 0.011$) were found significantly different between pre-treatment and post treatment phase. However resting did not show significant ($t = -0.17$ $p = 0.56$) difference between pre treatment (0.26 ± 0.01) and post treatment. (0.27± 0.01).

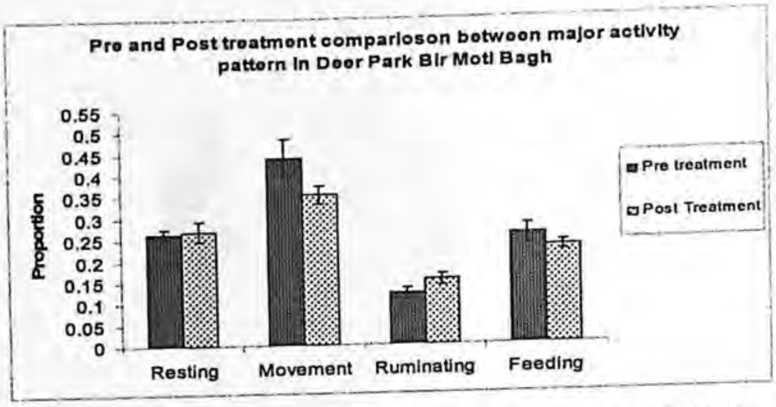


**Fig. 5.8 Comparison of major behaviroual activities at Bir Moti Bagh Deer Park**

In Deer Park Rampur Mandi movement was frequently observed activity followed by resting, feeding and rumination. The resting behaviour was significantly higher ($t=3.1$, $p=0.01$ ) during pre treatment ( $0.34 \pm 0.22$ ) and post treatment ( $0.26 \pm 0.02$) phase. Feeding activity was found significantly ($t = -4.533$, $p = 0.003$,) higher during post treatment ($0.22 \pm 0.01$) sampling. How ever there is no significant ($t =-1.0140$, $p =.16$) differences in movement between pre treatment ($0.37 \pm 0.03$) and post treatment ($0.41 \pm 0.03$) sampling. Post treatment sampling showed marginal increase in movement. The ruminating activity showed no differences between pre treatment ($0.11 \pm 0.01$) and post treatment ($0.11 \pm 0.01$).

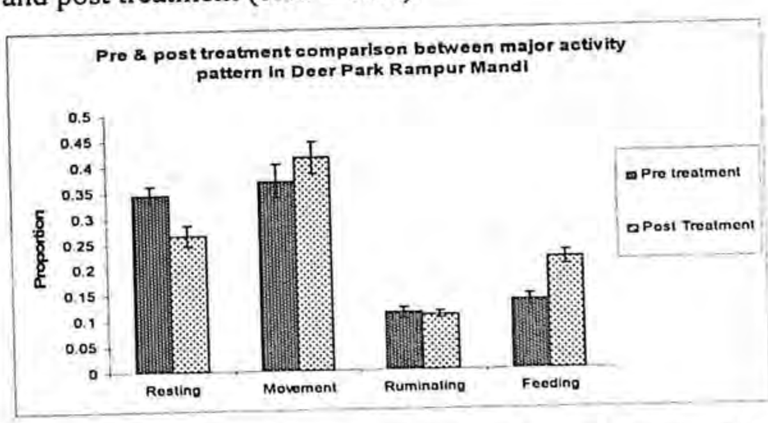


**Fig. 5.9 Comparison of major behaviroual activities at Rampur Mandi Deer Park**

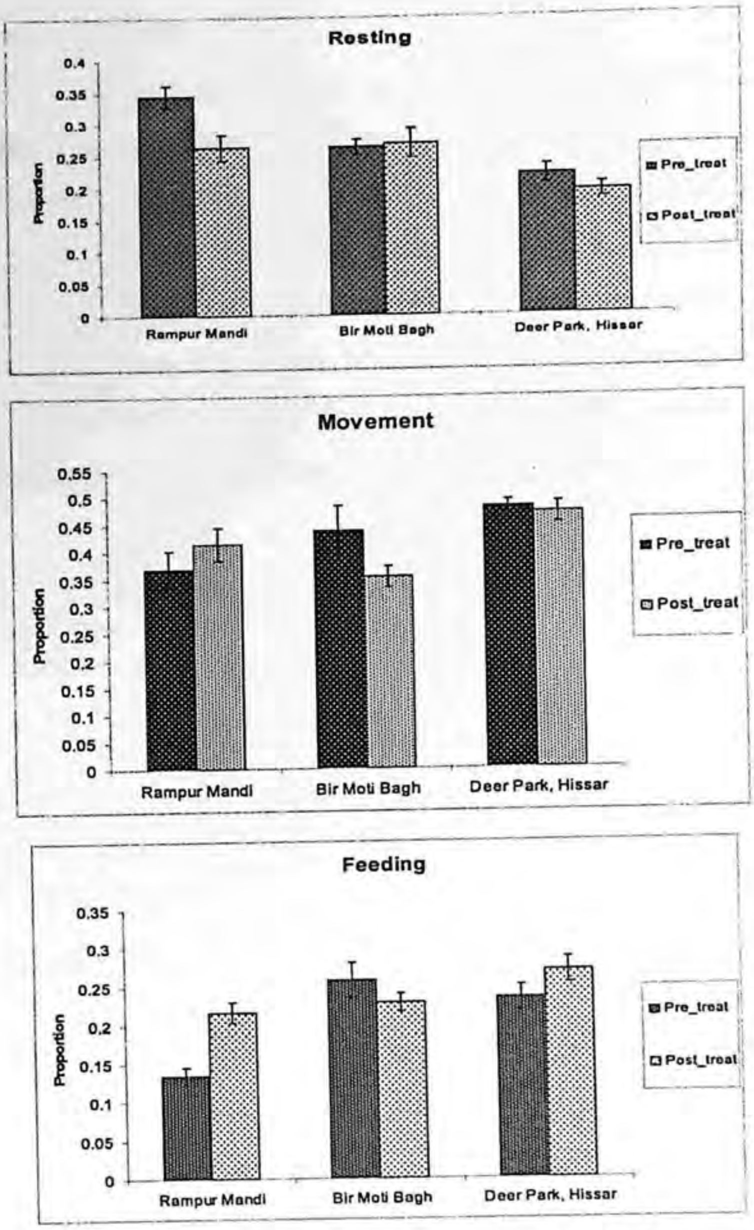


**Figure- 5.10: Comparison of pre and post treatment behavioural activities across the three deer parks**

The behavioral states during pre treatment and post treatment were compared across the three deer park. There were no appreciable changes seen in ruminating activity though other behavioral states showed some changes. These are presented as Figure 5.7, 5.8 and 5.9. Comparisons of pre and post treatment resting behavior across the three deer parks

### 5.8 Behaviour and EPG.

An assessment of changes in behavior as a result of altered parasitic load was analysed by rating the variation in the three major behavioral activities observed (Table 5.7) . This was compared with the daily rate of change of EPG. Changes were detected in the pre and post –treatment phases. Resting activity showed marginal decline at Bir Moti Bagh and Hissar Deer Parks while there was a remarkable declined at Rampur Mandi Deer Park. Movement was found to increase in Hissar while it decline at Bir Moti Bagh and Rampur Mandi. Feeding activity was increased at Rampur Mandi and HIssar Deer Parks while it declined at Bir Moti Bagh.

**Table 5.7 Table depicting variation in three behavioral activities observed at different deer parks**

| Parks Name | Anthelmintic | r | Resting | Movement | Feeding |
|---|---|---|---|---|---|
| Deer Park, Hissar | Fenbendazole | 0.19 | +0.08 | -0.046 | -0.081 |
| Deer Park, Bir Moti Bagh | Fenbendazole & Praziquantel | 0.27 | +0.005 | +0.086 | +0.030 |
| Deer park, Rampur Mandi | Ivermectin | +0.51 | +0.027 | +0.011 | -0.035 |

**Plate 1:** **Chital pellets showing different consistency (sticking of pellets to cow dung like appearance)**

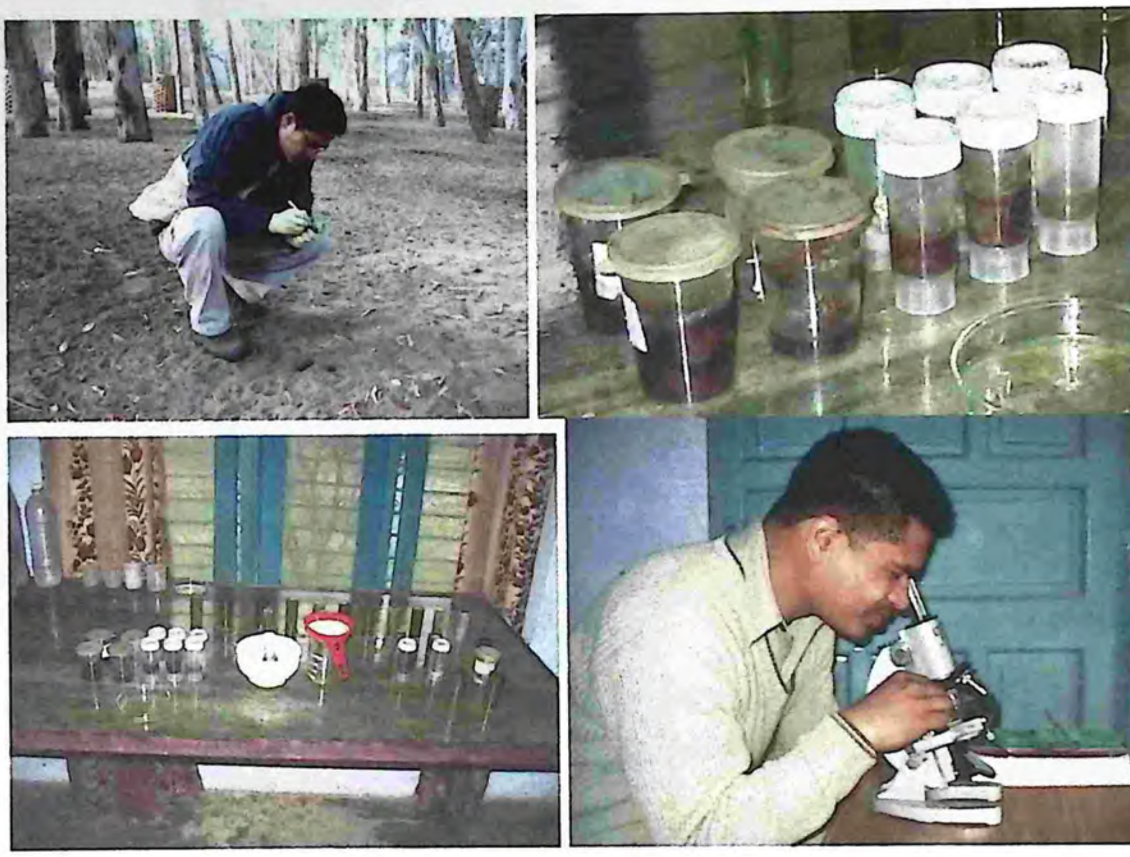

**Plate 2:** **Field laboratory established at Bir Moti Bagh Deer Park, Patiala (a) Faecal samples (b)Floatation technique (c) Microscopy**




**Plate 3: Animals feeding individually after habituation at (a) Hissar, (b) Bir Moti Bagh and (c) Rampur Mandi deer Parks**

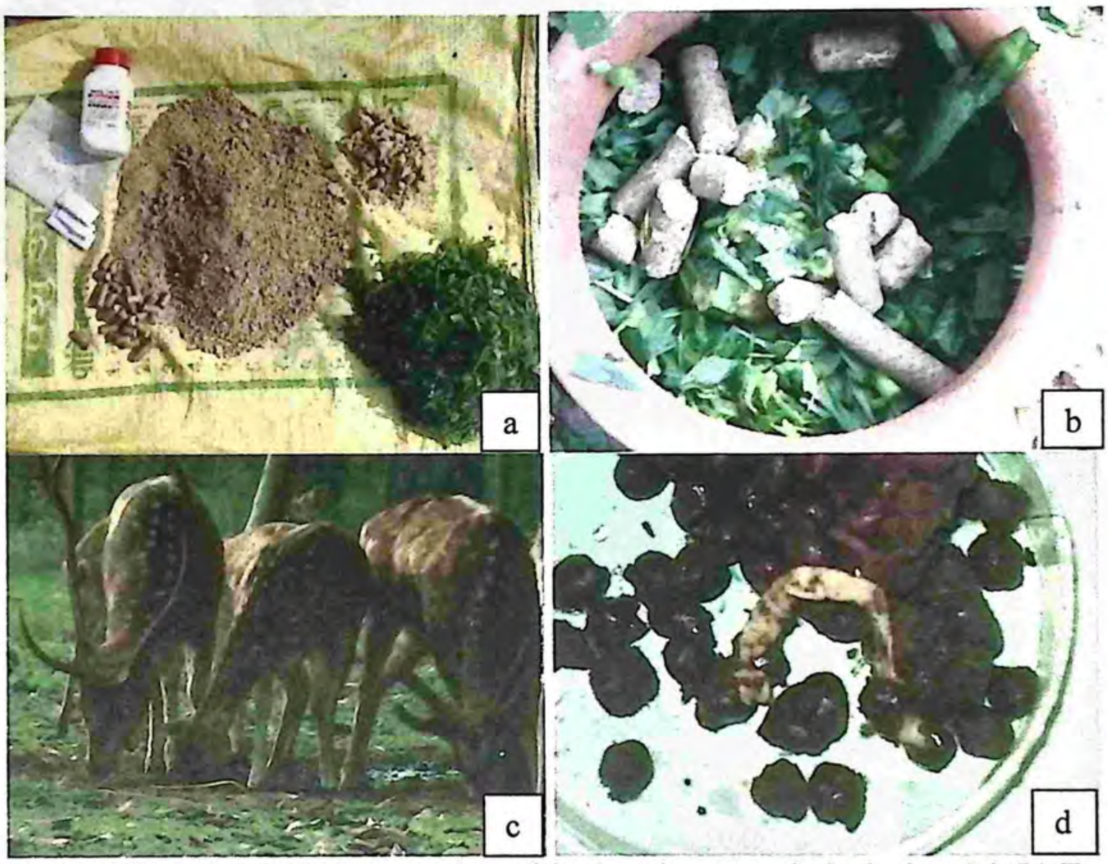


**Plate 4: Drug trial (a) Preparation of feed prior to anthelmintic trial (b) Feed placed in earthen pot (c) Animal feeding from the earthen pot (d)Tapeworm segment (*Moneizia* sp.) shed in feces following de-worming**

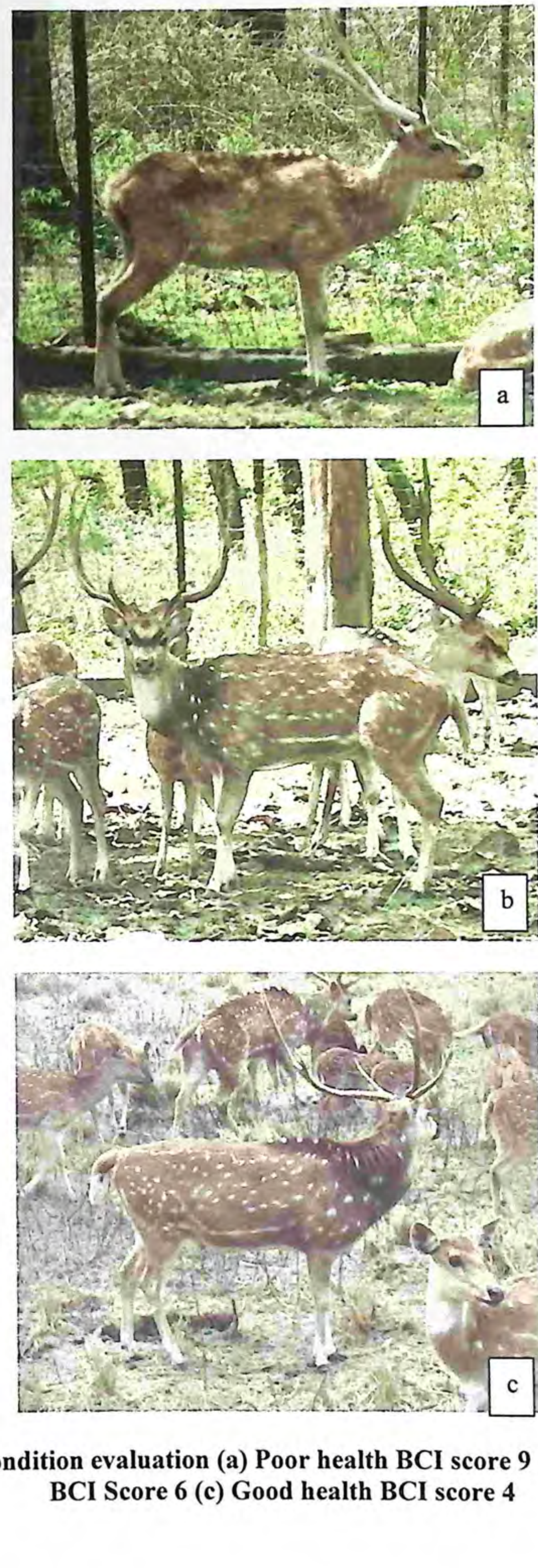


**Plate 5: Body condition evaluation (a) Poor health BCI score 9 (b) Fair health BCI Score 6 (c) Good health BCI score 4**

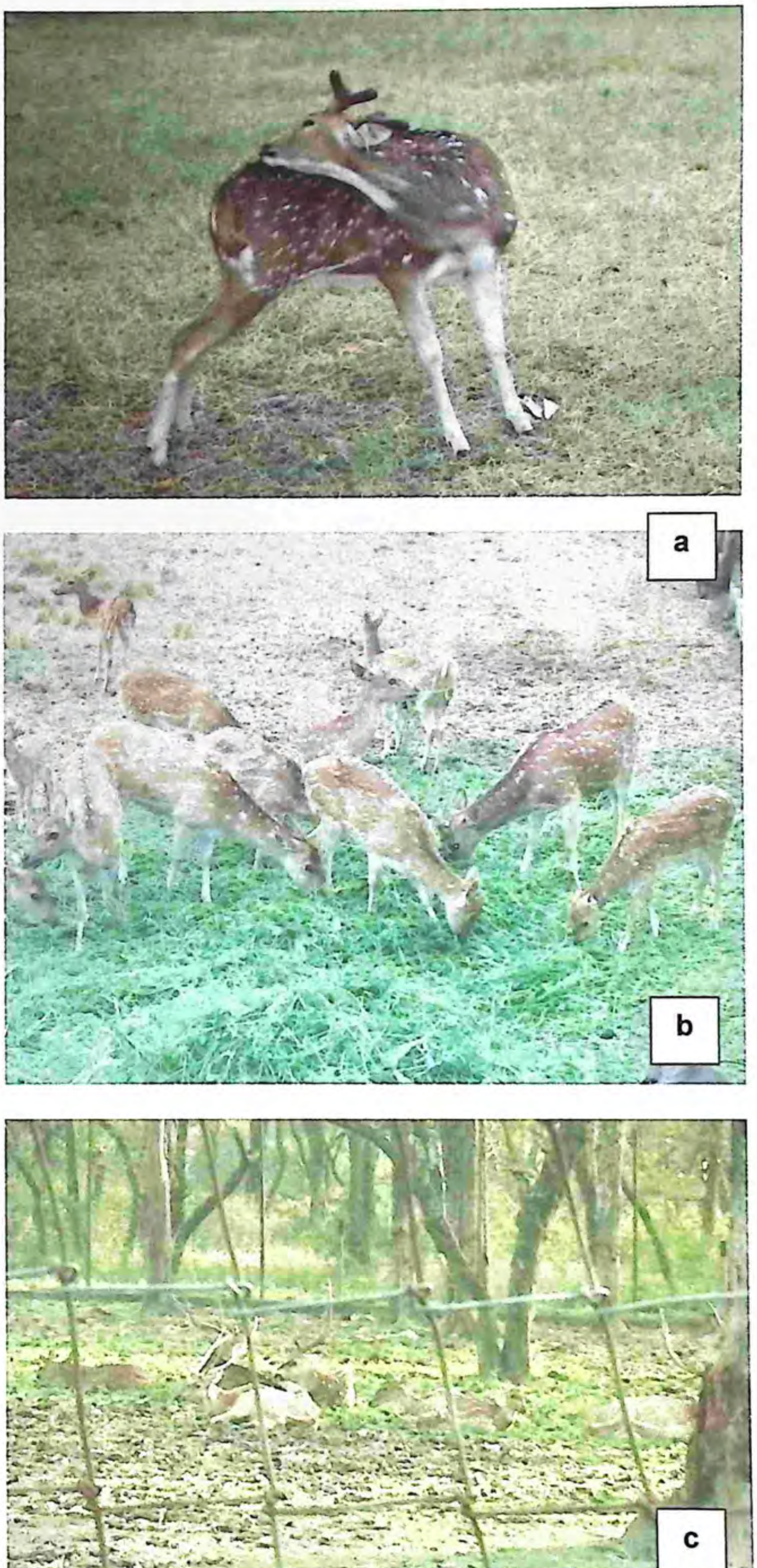


**Plate 6: Grooming, feeding and resting behavioral state**

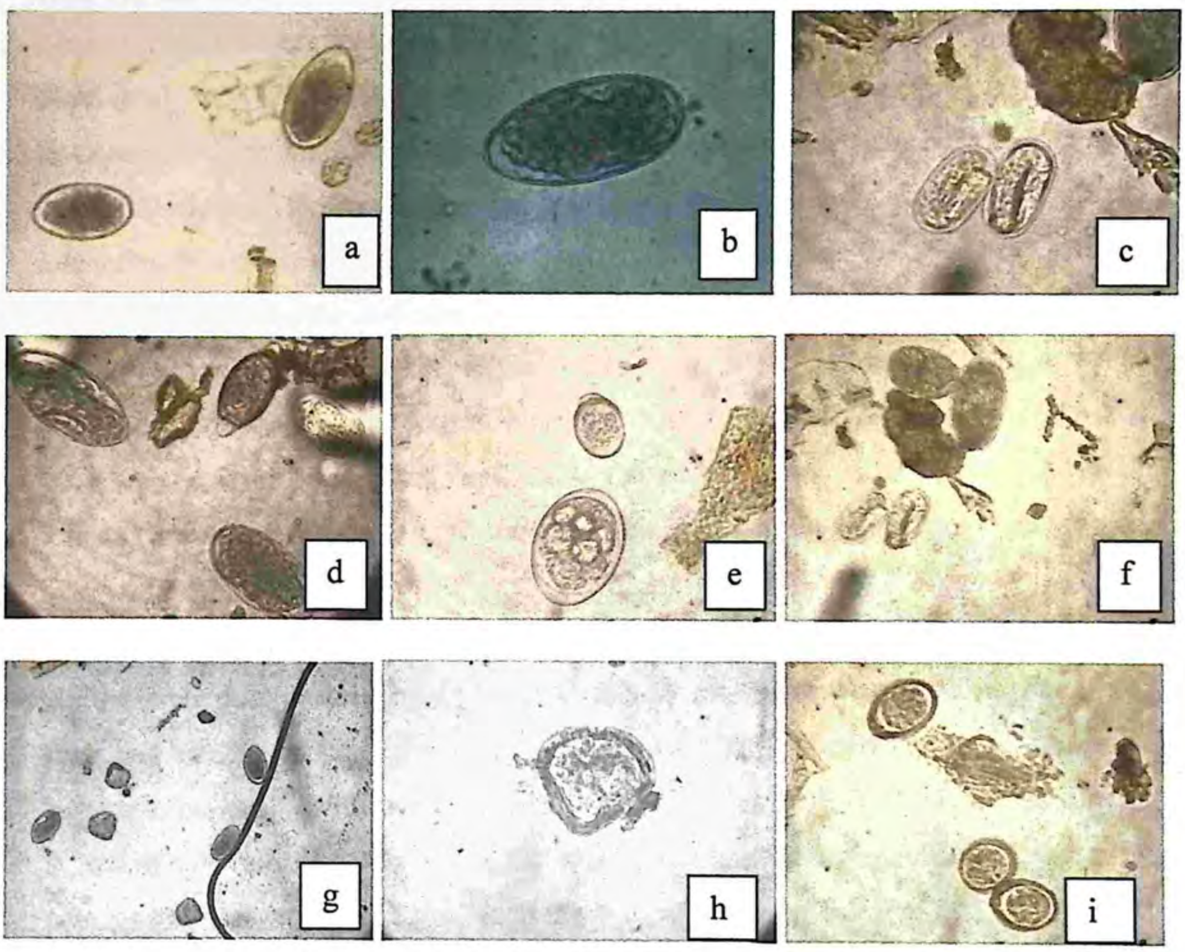


Plate 7. Parasitic ova encountered during the study (a) Strongyle ova 10X (b) Strongyle ova 40X (c) Strongyloides ova 20 X (d) Mixed infection of Strongyle, Strongyloides and Trichuris ova 20 X (e) Ascaris ova and coccidial oocyst 40 X (f) Strongyle, Strongyloides ova 20 X (g) Moneizia and Strongyle ova 10 X (h) Monezia ova 40 X (i) Coccidial oocyst 40 X

# DISCUSSION

During the study, the overall parasitic prevalence in Chital (*Axis axis*) in all the three deer park was high ranging from 87.59% in Deer Park, Hissar to 100% in Rampur Mandi and Bir Moti Bagh, Deer park. Similar high parasitic prevalence of 96.31% and 76% has been reported by Kashid et al. 2003 and Varadharajan and Pythol, 1999, however few workers reported low prevalence of 33% ( Bordoloi,1991), 46.67 % ( Modi et al., 1997), 68.05% (Varadharajan and Subramanium 2003) among ungulates in captivity. The high prevalence in the present study can be due to high animal densities, inadequate disinfection and sanitation practices and irregular deworming schedules. Moreover green fodder provided to the animals from the neighboring fields forms an important source of continuous infection and exposes the animal to infective parasitic larvae or the eggs. These factors thus contribute significantly to the parasitic burden. The findings in the present study are in tandem with the studies of Goossens 2005 who reported that cervids kept in zoo and animal parks are likely to be at risk of infections with nematodes due to the dense housing condition and consequently the heavy contaminations of enclosures.

All the three deer parks showed single or mixed/ multi species infection. Hisar Deer Park had 22.23% single species infection and 62.27% of mixed species infection whereas Rampur Mandi had 11.11 % single species and 88.88% mixed species infection. 100% of the animals in Bir Moti Bagh had mixed species infection. The present findings are almost similar to the findings of Varadharajan and Kandasamy, 2002, who reported, 66% animals to have single species infection and 34% had mixed species parasitic infection. The high percent of mixed infection in the present study might be as a result of regular repeated exposure to different parasites coupled with irregular deworming practices and therby buildup of parasitic load. Chakraborty and Islam 1996 however reported that 40% of the herbivores in Kaziranga National Park had one or more (mixed) parasitic infections. The difference in the present study may be due to the fact that present study was carried out in captivity and management interventions were not applied *in toto*.

Species wise parasitic prevalence in chital sampled showed high incidence of *Strongylus* sp. in Hissar while *Trichuris* sp. was a dominant parasite in Bir Moti Bagh and Rampur Mandi Deer Park. The findings are in tandem with the findings of Mandal 2002 and Gaur 1979 who reported *Strongylus* sp. to be the dominant parasitic species in captivity. Vardarjan and Kandasamy 2002 also reported *Strongyles* and *Trichuris* to be the most common parasites encountered in ungulates in captivity. Other parasitic ova encountered during the study included *Strongyloides* sp. and *Ascaris* sp. Additionally, *Moneizia* sp. and *Coccidia* sp. were encountered at Hissar Deer Park. The parasitic species detections are similar to the findings of Mandal et al.. (2002) who reported *Strongyles* sp., *Strongyloides* sp., *Ascaris* sp., *Amphistome* sp. and *Fasciola* sp. in free ranging Chital in Mudumalai WLS. Modi et al. 1997 reported *Trichuris* sp, *Strongyloides* sp, *Stronglyes* sp, *Ascaris* sp, *Fasciola* sp, *Coccidia* sp and *Taenia* sp in herbivores in Patna Zoo.

Different anthelmintics either singly or in combinations was used in the trial. An innovative method of habituating the animals to feed from within the earthen pots was devised and found successful. The total parasitic prevalence as well as the EPG of feces decreased in all three deer parks following anthelmintic treatment. Similarly finding have been reported by other workers chiefly Goossens *et al.* 2005, Shahardar *et al.* 1995, Stephen *et al.* 1993, Todd *et al.* 1985.

Fenbendazole was administered at Hissar Deer Park orally at a dose rate of 7.5 mg per animal. There was a significant reduction in parasitic as well as EPG of feces after treatment. The findings are in tandem with the findings of Goossens et al 2006 and Shahardar et al.. (1995), Kennedy & Todd (1975) assessed the efficacy Fenbendazole at same dose against helminth infection and found it to be highly effective.

Praziquantel and fenbendazole were administered orally at a dose rate of 10mg/kg and 7.5 mg/kg at Bir Moti Bagh Deer park. This drug combination is a broad spectrum anthelmintic and has been effectively used in controlling both nematodes and cestodes. Praziquantel primarily acts against cestodes though has no effect on nematodes. In the present situation, no cestodes or trematodes were encountered and it's role in deworming in Bir Moti Bagh is uncertain. However, there was a significant decrease in the parasitic load post treatment but the parasites were not completely eliminated. This may be as a result of repeated reinfection of the animals together with build up of parasitic load within the enclosure. Goosen et al 2006 referred high contamination for grassy pastures with infective larvae/eggs in the previous year or before the first treatment as reason for failure of the treatment regimes in some herds

At deer park, Rampur Mandi , Ivermectin was administered orally at a dose rate of 200 μg/kg body weight and was found highly effective in significantly reducing parasitic load. However the parasites were present at a low grade even after 26 days post treatment. Foreyt *et al.* (2004), Goossens *et al..* (2006), Teresa et al.. (1995) reported marked decrease in helmith infection following ivermectin administration however Mukherjee *et. al.* 1994 reported complete elimination of parasites. In the present study Ivermectin was given orally whereas most of the workers used parenteral preparations. Yazwinski et al.. (1995) however used an oral presentation (Ivermectin sustained-release bolus having 135-day delivery period) that was highly effective, with > 98% efficacy for all nematode species present.

In the present study all the three drugs were found effective against parasitic infection and fenbendazole was most effective in controlling parasitic load.

Body condition evaluation was carried out prior to and following anthelmintic trial and significant changes were observed. The findings are in consonance with the finding of Irvine et al. 2006.

The role of external and internal parasites in shaping behavior is relatively unappreciated. The present study has attempted to observe behavioral consequences of helminthic infection in chital (*Axis axis*).

Significant change in feeding activity was observed after treatment in all three study sites. The change in feeding activity pattern could be seen as an adaptive foraging strategy to reduce the exposure to parasites (Gunn & Irvine, 2003; Hutchings *et al.*, 1999, 2002; Van der Wall *et al.* 2000). The avoidance of contaminated sites by various domestic and wild animals has been observed in some previous studies (Taylor, 1954; Odberg & Francis-smith 1977). However, in captive conditions, due to restricted foraging space, animals might reduce the food intake to minimize their infection risk. Bailey *et al.* (1996) reviewed the behavioral mechanisms, however, they did not mention the influence of parasites on forage intake, bite and patch selection.

Sub clinical manifestations and their behavioral consequences, like suppressed feeding activity and lethargy were observed in chital at all study sites prior to treatment. A marked increase in feeding activity and decrease in resting activity was observed after anthelminthic treatment in two Deer Parks, mainly Deer Park Rampur Mandi, Dehradun and Deer Park Hissar. However, in case of Deer Park Bir Moti Bagh, results are not comparable with other two sites as no significant change was observed in activity patterns. The result indicates that animals are getting re-infected frequently. The consequence of re-infection in this site is also supported by some results discussed in previous section.

Chital is a group living animal and hence it has been observed in previous study that increase in group size increases the prevalence of contact transmitted parasites (Hoagland, 1979; Moore *et al.,* 1988). In case of bovids it was found that, gregarious animals are more likely to be infected with *Strongyles* then solitary genera. However, in captivity, stocking density is more relevant than group size. In a previous study by Goosen *et al* (2005) the stocking density is correlated with parasitic prevalence. Our results substantiate this study as Deer Park Birmoti Bagh has the highest stalking density (30) among all three sites showed higher disease prevalence compared to Deer Park Hissar (1.4) and Deer Park Rampur Mandi (12).

**Management implications of the study**

Our study revealed a very high incidence of parasite prevalence in all the deer parks sampled. Based on the study it is suggested that the deer parks adopt the following recommendations for better management of their facilities.

- Routine veterinary examination of animals and periodic fecal examination to assess the parasitic load should be carried out.
- De-worming of animals should be carried out at all deer parks based on this laboratory examination.
- The drugs used for de-worming should be frequently changed to avoid drug resistance being developed by the parasites.
- Green fodder being provided to the herbivores should be from areas where no livestock grazing is permitted to prevent transmission of infection from livestock to captive wild ungulates.
- Leguminous green fodder should be preferred over graminoids as a high protein diet increases the disease resistance of animals.
- Enclosure sanitation and hygiene is a very important aspect of disease control. Daily removal of dung should be carried out to prevent recurrence of infections from within the enclosure.
- Regular application of lime should be carried out for disinfecting the entire paddock area.
- Periodic soil or pasture rotation may reduce parasitic exposure.

**Summary**

The present study was carried out to assess the prevalence of helminth parasites and test efficacy of three anthelmintic namely fenbendazole, (Praziquantel & Fenbendazole) and Ivermectin. The study also aimed at assessing the effect of parasitism on condition and behaviour of animals.

Three deer parks *viz.* Deer Park, Hissar, Bir Moti Bagh, Patiala, and Deer Park Rampur Mandi were selected for the present study based on similarity in topography close proximity of laboratory facilities and similar management practices for assessment of parasitic load.

During the reconnaissance survey it was noted that veterinary cover was poor in all the deer parks. Veterinary care was provided only in emergency situations. This coupled with poor sanitation is responsible for the high parasitic load in all the deer parks.

The present study suggests a very high rate of prevalence of helminth infections across the three deer parks ranging from 87.5% to 100%. It was also observed that mixed species infections are the norm. Species wise parasitic prevalence across the three deer parks showed that S*trongyles* sp. and *Trichuris sp.* were the dominant parasitic genera found. Strongyles prevalence ranged from a low of 2.8.21% at Bir Moti Bagh to a high of 43.80% at Hissar.

Antihelmintic drug trials conducted at the three deer parks showed a decrease in prevalence till the 21$^{st}$ day and reached '0' at Deer Park, Hissar. Pre and post treatment (21$^{st}$ day) Eggs per Gram showed remarkable declines with a high of $177.11 \pm 20.597$ and a low of $0.1 \pm 0.41$. However parasitic prevalence estimated on the 26$^{th}$ day showed a recurrence of infection albeit at low levels. This is probably due to poor sanitation or recurrent infections occurring due to contaminated fodder.

Body condition evaluation of chital carried out at the deer parks, pre & post treatment suggests significant improvement in body condition post treatment.

The results of the behavior study suggest that parasitic load alters the behavior of animals. Our study showed marked changes in the three major behavior states for which the results were analyzed viz. feeding, resting and ruminating.

Based on the above it is recommended that deer parks have regular estimation of parasitic load and a deworming schedule should be developed based on the laboratory examinations. The deer parks should also follow proper sanitation measures viz. daily dung removal, periodic liming to control infections.

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