STUDIES ON GASTROINTESTINAL PARASITES OF ASIAN ELEPHANTS

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CERTIFICATE

This is to certify that the thesis entitled **"*STUDIES ON GASTROINTESTINAL PARASITES OF ASIAN ELEPHANTS*"** submitted by **Mr. DARSHAN, S., I.D. No. MVHK 1453** in partial fulfillment of the requirements for the award of degree of **MASTER OF VETERINARY SCIENCE** in **WILDLIFE** of the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, is a record of bonafide research work carried out by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bengaluru
August, 2016

(Prof. MURALIDHARA, A.)
Major Advisor

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AFFECTIONATELY DEDICATED

TO

MY FAMILY

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LIST OF ABBREVIATIONS

%	Per cent
@	At
BBP	Bannerughatta Biological Park
BC	Before Christ
BW	Body weight
EPG	Egg per gram
g	Gram
kg	Kilo gram
Ltd.	Limited
mg	Milli gram
ml	Milli litre
No.	Number
Pvt.	Private
rpm	Revolutions per minute
SE	Standard error
Sp. gr.	Specific gravity
sp.	Species
yr	Year

Introduction

I. INTRODUCTION

The Asian elephant is one of the last few megaherbivores (i.e. those plant-eating mammals that reach an adult body weight in excess of 1,000kg) still extant on earth and are the largest mammalian herbivores.

The Asian elephant (*Elephas maximus*) enjoys a special status in India which harbours over 28,000 wild elephants. This is over 50 per cent of the total population of this species in the world. Elephant represents the Indian ethos. It has been very closely associated with the religion, myths, history and cultural heritage of India for centuries. It has been rightly said that one cannot imagine India without the elephant (Anon,1993).

India has a fascinating history of domesticating wild elephants. Various methods of capturing and training of elephants were evolved over a period of time in different geographical regions of the country. A lot of literature was produced in the ancient and the medieval period on the management and treatment of the domesticated elephant. Kings and noblemen used to patronize elephants in the past. Elephants were domesticated in the early days mostly for the military purposes. In the modern era, however, elephants have been used in state pomp, as status symbol by princes and the landed gentry, the great *shikar* meets, elephant-capturing, logging operations, tourism, temple processions, circus shows and to a limited extent in agricultural works.

The Asian elephant is also one of the world's most important charismatic 'flagship' species. Sukumar (1996) described Asian elephant as a keystone species across the biologically rich forests of tropical Asia, which has dominated the social, economic and

political life of people as has no other creature on this earth. Thus the conservation of the elephant will ensure the maintenance of biological diversity across a much larger area.

The Asian elephant now has a patchy distribution covering the Indian sub-continent, Indochina (with a small population in SW China) and parts of south-east Asia. In India and Sri Lanka, elephants are packed into relatively small forest areas. In Myanmar (Burma), Lao and Cambodia it is the opposite: elephants are thinly scattered across the largest remaining forest block in Asia.

There are several historical records, such as the Kautilya Arthasastra, that indicate legal protection for elephants by rulers of the sub-continent about 2,000 years back (Rangarajan, 1992). In more recent times, efforts for the conservation of the elephant in British India were initiated with the promulgation of the Madras Wild Elephant Preservation Act of 1873. Soon after, the Indian Government enacted the Elephant Preservation Act 1879, which applied to the entire country (Bist, 2006). This Act, along with the Indian Forest Act of 1927 (IFA-1927) and certain other State Acts, remained a major legal tool for protecting elephants in most parts of the country until 1972. But, all these Acts were quite liberal as regards capturing of elephants and permitted their killing under the pretext of protecting crops and public property. Ivory trade was kept outside the purview of law and there was no serious attempt to protect the habitat of elephants. As a result, the elephant population in the country continued to decline over the years.

Until recently, four subspecies of the Asian elephant were recognized by zoologist as valid: *Elephas maximus maximus* from Sri Lanka, *Elephas maximus indicus* from the

Asian mainland, *Elephas maximus sumatranus* from the island of Sumatra (Indonesia) and *Elephas maximus borneensis* from Borneo.

Elephants are the largest land-living animals with an evolutionary background of more than 60 years and face a variety of challenges in both wild and captivity, including the parasitic infestations. They are susceptible to a number of ailments which are analogous to those of horses and cattle. Among the different infectious diseases of elephants, internal parasitism is commonly encountered.

Elephants *(Elephas maximus)* are susceptible to gastrointestinal parasitic infection in the wild and in captivity, are often confined to small enclosures and/or maintained in isolation in damp unhygienic conditions that may result in enhanced susceptibility to parasitic disease.

Parasitic diseases often represent a major concern in zoo animals for the high environmental contamination due to the maintenance of animals in confined areas. Moreover, anthelmintics resistance limits the control of parasites of zoo animals. Unfortunately, inadequate information on diseases and parasites of zoo animals is a major limiting factor in zoological gardens. Investigations on endoparasitic fauna are important for the study of the prevalence and geographical distribution.

Like other species, elephants too are exposed to many parasitic diseases which causes weight loss, loss in productivity.

Hence the present study was undertaken with the following objectives:

a) To study the prevalence of gastrointestinal parasites in captive and semi-captive Asian elephants.

b) To record the prevalence of gastrointestinal parasitic infection at different age and gender of Asian elephants and at different seasons.

Review of Literature

II. REVIEW OF LITERATURE

2.1 History- Elephants

Epic texts of Aryans, the Ramayana and the Mahabaratha described the use of elephants in battles during the period of 1000-700 BC and the first record of an elephant killed in battle dated to 1100 BC. Being the powerful and largest terrestrial vertebrate, human uses were associated with this species several years ago.

Historical records have indicated that a Syrian king kept some of the earliest zoo elephants in the 9th century B.C. for building pyramids (Sillar and Meyler, 1968).

Elephants were grouped within the order of Proboscidae and family Elephantidae. Asian elephants comprised of Indian, Ceylon, Sumatran and Malaysian elephants (Fowler, 1986).

Joshi (1991) reported that elephants were known to have been trained since 3000 BC in the Indus valley.

The history of India is associated with the mega herbivore – elephant, and there is a deep interlacing between the Indian elephants and Indian culture for many centuries (Anon, 1993).

Jayakumar (2001) indicated historic distribution of elephants from the Tigris and Euphrates valleys of Syria and Iraq to the yellow river of China and south to Sumatra. A fragmented population of elephants currently existed in India eastwards and elephants have an evolutionary history of 60 million years.

Asian elephant, *Elephas maximus*, which is identified in the Indian subcontinent has encountered conservation challenge and is considered as a cultural icon (Christy *et al*., 2005).

2.2 Host –Parasite interaction

Most free-living organisms harbour parasites of several species which can adversely affect host health, fecundity and foraging, and may also modify host behaviour to facilitate parasite transmission (Wesenberg-Lund 1931; Holmes & Bethel 1972; Moore 1984).

Hamilton and Zuk (1982) reported that parasitism has been shown to directly affect both the evolution and ecology of hosts through processes such as sexual selection or parasite-mediated competition, which can lead to reduction in population size or the extinction of one host.

Puustinen and Mutikainen (2001) reported that in many host–parasite interactions the effects of parasitism extend beyond the direct negative effect of the parasites on host growth, reproduction, and survival. Parasites manipulate host behavior, affect host vulnerability to predation, apart from the structure and dynamics of host communities by changing the competitive interactions among host species.

Torr *et al.* (2004) have indicated in their study that nematodes were lethal parasites widespread in nature and has a broad range of infective larvae found in soil.

Pedersen *et al.* (2007) have found helminth parasites are ubiquitously across vertebrate taxa and pose substantial threats to the welfare, management and conservation of both natural and captive populations.

2.3 Predisposing Factors for Parasitic Infection

Rogers and Sommerville (1963) indicated that potential factors determining the transmission of parasites include- environmental conditions which affect the viability and behaviour of parasite propagules, feeding, movement, and defecation patterns of the host.

Dharmarajan *et al.* (2005) in their study have shown that external environmental factors have been known to affect the helminth loads in the host species. The main route through which the environment influences parasitism is through its effect on stages of the parasite's life cycle that are outside the host, like larvae.

Chapman *et al*. (2006) reported that nutritional stress viz limited food availability, deficiencies in dietary components- particularly protein and energy influence susceptibility of hosts to parasites as they affect immuno-competence.

Fowler (2006) has indicated that healthy wild animals may harbor large number of protozoal and helminth parasite without showing clinical signs of disease.

Asian Elephants (*Elephas maximus)* are susceptible to gastrointestinal parasitic infection in the wild and in captivity as they are confined to small enclosures or maintained in isolation in damp unhygienic conditions which may enhance susceptibility to parasitic disease (Vanita *et al*., 2011).

Internal parasites are of particular importance in the case of free ranging Asian elephants (*Elephas maximus*) as management actions that confine elephants to restricted areas such as parks may favor the buildup of internal parasite infections through contaminated feeding grounds and nutritional stresses (Abeysinghe *et al*., 2012).

Hing *et al*. (2013) stated that parasites can directly affect host fecundity, morbidity and mortality, or indirectly, for example, via host debility and influence on immunocompetence.

Mbaya *et al.* (2013) opined that intrinsic (host demography) and extrinsic factors (environment and population density) often affect prevalence and worm burden in elephants.

2.4 Effects of Parasitic Infection

Severe submandibular and ventral abdominal edema were noticed in Asian elephants (Elephas maximus) infected with *Fasciola jacksoni* at Central Malaysia (Caple *et al*., 1978).

Chandrasekharan (1989) reported clinical signs namely mud eating, reduction in feed and water intake, paleness of mucous membrane and foetid diarrohea leading to death of elephants due to gastrointestinal nematodes infection.

Suresh *et al.* (2001) reported that elephants affected with strongylosis infestation exhibited clinical symptoms namely varying degrees of inappetance, pallor of conjunctivae and passing of foul smelling and slightly diarrhoeic dung.

Arunachalam *et al.* (2007) reported that, like other domestic animals, elephants were also exposed to many of parasitic diseases which cause weight loss and loss in productivity.

Jani (2008) reported that elephants harbouring parasites were found clinically dull, depressed and lethargic, dehydrated and passed loose feces in addition to soil licking.

Parasitic diseases constitute one of the major problems causing mortality in wild animals, the effects range from sub-clinical symptoms to death. Parasites can affect host survival and reproduction directly through blood loss, tissue damage, spontaneous abortion, congenital malformations and death and reducing the host's immunity (Allwin *et al*., 2016).

Baines *et al.* (2015) reported that parasites can reduce body condition, reproductive success, and survival in their hosts.

Helminth parasites pose substantial threats to the welfare, management and conservation of both natural and captive populations, which is true for endangered or endemic species (Lynsdale *et al*., 2015).

2.5 Parasitism in Captive and Semi-captive Asian elephants

Zasityte and Grikienciene (2002) stated that investigations on endoparasitic fauna are important for the study of the prevalence and geographical distribution of parasites.

Saseendran *et al.* (2003) reported that large numbers of elephants in captivity at Kerala were susceptible to parasitic diseases. Gastrointestinal nematodes in elephants were very common and have been responsible for frequent illness.

Vanitha *et al.* (2011) reported that occurrence of intestinal parasites varied significantly among the three management systems (temple, private and forest department) with the prevalence of parasite infection being higher among captive elephants in the forest department (48%) system than in temple (32%) and private (31%) systems.

Occurrence of parasites in animals housed in zoo might vary according to the type of husbandry practices, disease prophylaxis and treatment administered. Parasitic diseases often represent a major concern in zoo animals for the high environmental contamination due to the maintenance of animals in confined areas (Rahman *et al*., 2014).

Miller *et al.* (2015) stated that wild elephant populations may be adversely or positively affected by captive populations, which have limited fecundity and undocumented levels of compromised health.

2.6 Occurrence of Gastrointestinal Parasites in Asian Elephants

The intestinal parasites of the Asian elephant that have been reported are nematodes *Murshidia*, *Quilonia*, *Amira*, *Decrusia*, *Equinurbia*, *Choniangium*, and *Bathmostomum*, all of the order Strongyloidea, and *Parabronema* of order Spiruroidea, and the platyhelminths *Brumptia*, *Pseudodiscus*, *Paramphistomum*, and *Fasciola* of order

Digenea, and *Anoplocephala* of order Taenioidea (Bhalerao 1933, 1935; Gupta 1974; Chandrashekaran *et al*., 1979).

Fernando and Fernando (1961) have found *Murshidia* sp., *Quilonia* sp., *Equinurbia* sp., *Choniangium epistonam* and Amphistome trematode– *Pfenderius papillatus* from the dung samples of elephants of Malaya.

Soulsby (1982) has indicated occurrence of *Anoplocephala manubriata* and various helminthic parasites in elephants.

Wallach and Boever (1983) reported the occurrence of lung worm and gastric nematodes namely *Murshidia* sp., *Quilonia* sp. and *Amira* sp. in elephants.

Fowler (1986) reported *Fasciola jacksoni* and *Fasciola hepatica* in Asian elephants and nematodes causing parasitic infection in elephants which include Ascarids, Oxyurids, Strongylids, Paramphistomes, Ancylostomes (*Bathnostomum sangeri*) Syngamids (gape worms) and Filarids (*Indofilaria pattabiramani*).

Mikota *et al.* (1994) reported a massive infection of colon with the trematodes *Protofasciola robusta*, which led to death in case of a captured three month old African elephant.

Chandrasekharan *et al*. (1995) reported Strongyle infection prevalence as 91.27 per cent among the captive elephants in Kerala.

Matsuo and Suprahman (1997) recorded nematode *(Murshida falcifera),* trematodes *(Hawkesius hawkesi* , *Pfenderius papillatus*) and larval botfly *(Cobboldia*

elephantis) in the gastrointestinal tract of Sumatran elephant at Way Kambas National Park, Indonesia.

Jayathangaraj *et al.* (2001) quoted that *Decrusia* sp. and *Murshidia* sp. was predominant gastrointestinal parasites in elephants.

Raman *et al.* (2001) reported that Strongylid infections were widespread in elephants in India and the survivability of the third stage larvae was perhaps considered as one of the most important features in the life cycle of Strongylid nematodes as a source of infection in elephants.

Suresh *et al.* (2001) reported Strongylosis infestation in elephants at Nehru Zoological Park, Hyderabad and in captive elephants at Tirupathi.

Vidya and Sukumar (2002) recorded the prevalence of *Murshidia* sp., *Quilonia* sp., *Amira* sp., *Decrusia* sp., *Equinurbia* sp., *Choniangium* sp., *Bathnostomum* sp., *Parabronema* sp., *Brumptia* sp., *Pseudodiscus* sp., *Paramphistomum* sp., *Fasciola* sp., *Anoplocephala* sp. and *Srtongyles* in the dung samples obtained from the free-ranging elephants of Nilgiri Biosphere Reserve.

Kashid *et al.* (2002) reported the incidence of helminthic infection in elephants as 25 per cent at Kanha National Park, Madhya Pradesh.

Arora (2003) demonstrated eggs of *Fasciola gigantica* in fecal samples collected from elephants in Uttranchal and Orissa regions.

Saseendran *et al.* (2003) recorded 10.10 per cent prevalence for strongyle infestation and 7.07 per cent Amphistome infestation in captive Asian elephants maintained at Guruvayoor temple, Thrissur, Kerala.

McAloon (2004) found *Anoplocephala manubriata* tapeworm of Asian elephants in the substrate sample collected from Kodanadu Forest Range, Ernakulum District and Guruvayur Devaswom Temple grounds, Thrissur District, Kerala, India.

Dharmarajan *et al.* (2005) recorded infestation of *Bathmostomum* sp, *Decrusia* sp, *Quilonia* sp, *Murshidia* sp, *Anoplocephala* sp, flukes and spiruroid in Asian elephants at Mudumalai National Park, Tamil Nadu.

Singh *et al.* (2006) reported common parasitic infections of Strongyle (85.71%) followed by Amphistome (14.29%) and mixed infections of Strongyle and Amphistome (14.29%) in Asian elephants at Mahendra Choudhury Zoological Park, Chhatbir, Punjab.

Arunachalam *et al.* (2007) reported *Strongyle* sp. eggs were found to be predominant species followed by *Anoplocephala* sp. of tapeworm and *Bivitellobilharzia nairi* trematode in wild elephants at Theppakadu, Nilgiris, Tamil Nadu. The prevalence rate of nematode, cestode and trematode were 36.36 per cent, 9.09 per cent and 9.09 per cent respectively.

Nakande *et al.* (2007) reported that the elephants were generally infested with *Strongyles*- the dominant parasites irrespective of the period or zone. Other parasites such as *Strongyloides, Eimeria, Ciliates, Trematodes* were also reported *at* Pama reserve, Burkina Faso, Africa.

Anandakumar *et al.* (2008) reported helminthic infection with *Murshidia* sp., *Quilonia* sp. *and Amira* sp. of *Strongyles* in captive Asian elephants at Mudumalai elephant camp, Tamil Nadu.

Jani (2008) reported *Fasciola* sp., *Paramphistosomum* sp., *Strongyloides* sp., *Oesophagostomum* sp., *Murshidia* sp. and *Ascarids* occurrence in the dung samples obtained from the temple elephants of Gujarat.

Islam (2010) found *Fasciola jacksoni* in freshly voided dung samples from captive Asian elephants reared at Kaziranga National Park, Assam.

Vanitha *et al.* (2011) reported *Strongyle* infection in captive Asian elephants maintained by forest department in Tamil Nadu.

Nishanth *et al.* (2012) reported the infections of *Strongyles*, *Strongyloides* sp. *Anoplocephala* sp. *Bivitellobilharzia* sp. and mixed infection of *Strongyles* and *Strongyloides* sp. in the free-ranging elephants from Mudumalai sanctuary, Anamalai sanctuary and Sathymangalam forest, Tamil Nadu.

Vimalraj *et al.* (2012) reported the prevalence of *Strongyloides* sp. (58%), *strongyles* (24%), *Bivitellobilharzia* sp. (4%) and mixed infection of *strongyles* with *Strongyloides* sp. (14%) in free-ranging elephants of Sathyamangalam Forest Divisions of Tamil Nadu state.

Hing *et al.* (2013) reported that *Fasciola* (liver fluke) was found most with prevalence rate 70.2 per cent followed by *Strongyle* 66.3 per cent and *Anoplocephala*

50.0 per cent in Asian elephants at the Lower Kinabatangan Wildlife Sanctuary and the Tabin Wildlife Reserve, key range areas in Sabah, Malaysian Borneo.

Bhoyar *et al.* (2014) reported the occurrence of *Schistosoma nairi* from four female circus elephants at Bidar, Karnataka.

Lynsdale *et al.* (2015) reported *Strongyle* and *Strongyloides* in fecal samples, with suspected *Paramphistomum* eggs in Semi-captive Asian elephants at Myanmar.

Pandit *et al.* (2015) reported various parasitic infections with *Fasciola jacksoni, Paramphistome, Oesophagostome, Chabertia, Schistosomes, Dicrocelium* and *Moneizia*. Among the above prevalence of *Fascioloides magna* was found to be 9 per cent and that of *Strongyloides westeri* was found to be 23 per cent at Chitwan National Park, Nepal.

2.7 Gender differences on occurrence of gastrointestinal parasites in Asian elephants

Suresh *et al.* (2001) studied gender-wise incidence of gastrointestinal parasites in captive Asian elephants at Nehru Zoological Park, Hyderabad. Incidence of gastrointestinal parasite was predominant in female (24.6%) than male (18.75%).

Vanitha *et al.* (2011) reported that the prevalence of helminthic infection was significantly higher in females (40%) than male (29%), under captive conditions in Asian elephants at Tamil Nadu.

Mbaya *et al.* (2013) reported that the prevalence of gastrointestinal parasitic infection was high in male (34.38%) than female (27.0%) in African elephants at Chad Basin National Park, Nigeria.

Pechimuthu (2014) reported the parasitic prevalence as high in female Asian elephants than male in Tamil Nadu state.

Baines *et al.* (2015) reported that the prevalence of gastrointestinal parasite was significantly high in female (39%) than male (10%) in African elephants at Okavango delta, Botswana.

2.8 Seasonal influence on gastrointestinal parasites in Asian elephants

Suresh *et al.* (2001) indicated that parasitic infections in Asian elephants were predominant during summer (52.63%), followed by monsoon (42.10%) and winter season (5.26%) in their study at Nehru Zoological Park, Hyderabad.

Vidya and Sukumar (2002) reported higher parasite loads in the dry season compared to the wet season in Asian elephants at Nilgiri Biosphere Reserve in southern India.

Dharmarajan *et al.* (2005) reported there was significantly higher helminth loads in all wild herbivores sampled during the southwest monsoon as compared to the dry season at Mudumalai wildlife sanctuary, Southern India.

Vanitha *et al.* (2011) reported that the prevalence rate of gastrointestinal parasites in Asian elephants varied significantly across seasons, with the highest rate during

summer (49%) followed by monsoon (41%) and the lowest rate during winter (15%) in Tamil Nadu state.

Vimalraj *et al.* (2012) reported helminth parasites in Asian elephants were significantly high during the dry season, as compared to the wet season at Sathyamangalam forest division, Tamil Nadu.

Mbaya *et al.* (2013) studied the seasonal prevalence of gastrointestinal parasitic infections of African elephants (L. *Africana*) of the Chad Basin National park, Nigeria. The prevalence rate in rainy season and dry season was 50.29 per cent (May-September) and 13.86 per cent (October- April) respectively.

Pechimuthu (2014) reported that captive elephants showed high prevalence of gastrointestinal parasite during summer (55%), followed by monsoon (37.5%) and pre monsoon (25%). The post monsoon season (22.5%) recorded a lower helminthic infection in Tamil Nadu state.

Baines *et al.* (2015) studied that prevalence of gastrointestinal parasites varied seasonally, and was significantly high during dry season (January-February) in African elephants at Botswana.

2.9 Age -wise prevalence of gastrointestinal parasites in Asian elephants

Suresh *et al.* (2001) reported that parasitic infection in Asian elephants was high in 30 years and above (33.33%) than at age group of 0 to 15 years (9.04%).

Vanitha *et al.* (2011) reported the prevalence of intestinal parasites in Asian elephants was 41 per cent in adult group, 29 per cent in sub–adult group, and 25 per cent in juvenile calves in captive elephants of Tamil Nadu.

Mbaya *et al.* (2013) recorded that parasitic infection as 51.16 per cent in young calves and 34.48 per cent in adults in African elephants.

Pechimuthu (2014) reported that adult elephants were sensitive to helminthic infection, followed by juvenile and sub-adults were comparatively resistant to parasitic infection in Asian elephants.

Baines *et al.* (2015) reported that age was not associated with the prevalence of coccidia or nematode ova, or nematode egg density in African elephants. However, fluke prevalence increased with increasing elephant age.

2.10 Therapeutic drugs against gastrointestinal parasites of Asian elephants

Sundaram *et al.* (1971) reported that treatment with tetramisole (nilverm) @ 4.5 – 5mg/kg body weight was effective against *Murshidia* sp., *Quilonia* sp., *Amiroides* sp. and *Decrusia* sp., in Asian elephants.

Chandrasekharan *et al.* (1982) used hexachlorophene @ 10mg/kg BW for amphistome infestation in Indian elephants showed 100% efficacy against P. *collinsi* and P. *hawkesi*.

Lakhar and Das (1988) used fenbendazole @ 12g dissolved in 200ml of water in two divided doses at three days interval for treatment of trichostrongyle infection and was effective in Asian elephants.

Chandrasekharan (1989) suggested single oral administration of praziquintal @ 2.5-4mg/kg and niclozamide @ 75-100mg/kg was effective against cestode infection in elephants.

Rao *et al.* (1990) used fenbendazole for treatment @ 24-30g per animal orally against Strongyle infection and was effective in Asian elephants.

Islam (1995) used triclabendazole @ 9mg/kg body weight and oxyclozanide @ 7.5mg/kg body weight in single dose showed 100% and 72% efficacy against fluke infection in elephants.

Suresh *et al.* (2001) used albendazole @ 5mg/kg BW orally for treating strongylosis in elephants.

Saseendran *et al.* (2003) indicated regular deworming with Albendazole @ 2mg/kg body weight showed effectiveness against strongylosis in Asian elephants.

Materials and Methods

III. MATERIALS AND METHODS

3.1 Materials

3.1.1 Study animals

In the present study the captive and semi-captive Asian elephants located at following places served as source:

I. Bannerghatta Biological Park, Bengaluru, Karnataka (semi-captive).

II. Sri Chamarejendra Zoological Garden, Mysuru, Karnataka (captive).

III. Sakrebylu Elephant Camp, Shivamogga, Karnataka (semi-captive).

IV. Dubare Elephant Camp, Kodagu, Karnataka (semi-captive).

3.1.1.1 Captive and Semi- captive Asian elephants (Varma *et al*., 2010)

Captive elephants- Considered were elephants confined to a single place under human care such as zoos for conservation, education and science.

Semi-captive elephants- These elephants were exposed to a range of natural to semi-natural living conditions as in elephant camps maintained by forest department.

3.1.1.2 Study period

Study period considered was January to May, 2016 where January-February was considered as winter season and March-May was considered as summer season. Due to time constraints and restriction of forest department rainy season samples could not be collected.

3.1.2 Laboratory materials

The laboratory materials used in the present study were.

3.1.2.1 Equipments

a) Compound microscope (Olympus make, India)

b) Electronic weighing balance

c) Centrifuge

d) Refrigerator

e) McMaster's slide

f) Baermann's apparatus

g) Mortar and pestle

h) Tea strainers

3.1.2.2 Glass wares and plastic ware

The glassware used in the present study includes neutral glass of Corning and Borosil India Ltd., make. Plastic ware included centrifuge tubes, plastic petri plates were procured from M/s. Tarson Products Pvt. Ltd., Kolkata.

3.1.2.3 Chemicals

a) Sodium chloride (Sp. gr. 1.18) used as floatation fluid.

b) Sucrose (Sp. gr. 1.25) used as floatation fluid in McMaster egg counting technique.

c) Zinc sulphate, $ZnSO_4$ (32.5%, Sp. gr. 1.18) used as floatation fluid in McMaster egg counting technique.

3.1.2.4 Disposables

a) Disposable Plastic Gloves

b) Zip-lock packaging material

c) Polythene covers

3.2 Methods

3.2.1 Collection of fecal sample

In the present study, fecal samples were collected as early as possible following defecation. From each dung pile, a representative sample was collected from the outer and inner parts of different boli. Parts of fecal material in contact with soil were avoided. Fecal samples approximately 20-25 grams were collected into a clean polythene cover and transported to laboratory for further examination.

3.2.2 Macroscopic examination of the fecal sample

The macroscopic examination of the fecal sample was made to note the characteristic features like consistency, colour, and presence of mucus, blood, helminthes parasites, segments and their stages.

3.2.3 Microscopic examination of the fecal sample

Qualitative methods viz direct method, centrifugal sedimentation technique and floatation technique was carried out for identification of parasitic egg/ova. Positive samples were subjected to McMaster's egg counting technique.

3.2.3.1 Direct method (Soulsby, 1982)

1) A small quantity of feces was placed on a neat slide. Few drops of water were added, mixed thoroughly with the help of a glass rod. Cover slip was placed on the slide.
2) The slide was examined under microscope for the presence of parasitic egg/ova (objective 10x and 40x).

3.2.3.2 Centrifugal sedimentation technique (Soulsby, 1982)

3.2.3.2.1 Principle

Based on specific gravity of worm eggs which is considerably greater than that of water and fecal debris, if the feces are suspended in water, eggs will sediment faster than most fecal particles.

3.2.3.2.2 Methodology

1) 1-2 g of fecal sample was placed in a mortar.
2) 10-15 ml of water was added, mixed thoroughly using pestle.
3) The fecal suspension was filtered through a tea strainer into another beaker.
4) The fecal suspension was transferred to centrifuge tube and centrifuged at 3000 rpm for 3 minute.
5) Supernatant was discarded.
6) Sediment was mixed well and a small quantity of sediment was taken on a neat slide, mixed with drop of water.
7) Cover slip was applied and was examined under low and high power objectives of microscope.

3.2.3.3 Floatation technique (Soulsby, 1982)

3.2.3.3.1 Principle

The principle is to use an emulsifying fluid of a greater specific gravity than that of the parasite eggs, which result in flotation of eggs in the solution. Thereby mere examination of the solution in the top most layers will clearly indicate the presence of egg. The fecal material and fiber settle at the bottom.

3.2.3.3.2 Methodology

1) Approximately 1-2 g of feces was taken in a beaker.
2) 15 ml of sodium chloride solution was poured into the beaker.
3) Feces and flotation fluid were mixed (stirred) thoroughly.
4) The resulting fecal suspension was poured through a tea strainer into another beaker.
5) The fecal suspension was poured into a test tube.
6) The test tube was placed in a test tube rack and allowed to stand.
7) The test tube was gently topped off with the suspension leaving a convex meniscus at the top of the tube.
8) A cover slip was carefully placed on top of the test tube and allowed to stand for 20 minutes.
9) Cover slip was carefully lifted off from the tube, together with the drop of fluid adhering to it.
10) Cover slip was placed on a clean microscope slide labeled with the sample number.
11) Slide was examined using the 10x and 40x objective lens of a compound microscope for identification of parasite eggs, larvae and cysts based on morphology.

3.2.4 McMaster's egg counting technique (Soulsby, 1982)

1) Three gram of feces was placed in a beaker.
2) 42 ml of sodium chloride solution was added into the beaker.
3) The contents were mixed (stirred) thoroughly using glass rod.
4) The fecal suspension was filtered through a tea strainer into another beaker.
5) While stirring the filtrate in a beaker, a sub-sample was taken with a Pasteur pipette.
6) Both sides of the McMaster counting chamber were filled with the sub-sample and allowed to stand for 5 minutes.
7) The chambers were examined under low power objective of the microscope and all the eggs and coccidian oocyst within the engraved area of both chambers were counted.
8) The number of eggs per gram (EPG) of feces was calculated by adding the egg counts of the two chambers together and multiplied by multiplication factor of 100.

3.2.5 Coproculture and Identification of third stage larvae (Bhatia *et al*., 2007)

Positive samples for strongyle eggs from the Asian elephants collected at Bannerghatta Biological Park, Bengaluru, Sri Chamarajendra Zoological Garden, Mysuru, Sakrebylu elephant camp, Shivamogga and Dubare elephant camp, Kodagu were cultured by petri dish method (Anon, 1971) to obtain third stage infective larvae.

3.2.5.1 Procedure

The fecal sample was broken up finely using pestle and mortar. Based on consistency of feces few drops of water or charcoal were added in case of dry and wet feces, respectively. Culture dishes were then filled with mixture closed and was placed in a dark area at room temperature for 7 days. The culture were stirred each day to inhabit the fungal growth and also to aerate the lower layers of the culture to get uniform growth.

3.2.5.2 Recovery of larvae from cultures

After 7 days of incubation the cultured material was transferred to the Baermann apparatus, which were allowed to stand overnight. The entire supernatant fluid was collected in a plastic jar and was centrifuged at 1500 rpm for 5 minutes to concentrate larvae.

3.2.5.3 Identification of larvae

A small drop of the suspension of larvae was placed on a microscopic slide with the help of Pasteur pipette and a drop of Lugol's Iodine solution was added to kill the larvae. The mixture was mixed carefully and cover slip placed gently and then examined under the microscope and identification was done based on morphology of larvae.

3.2.6 Statistical Analysis

The data generated were subjected to chi square test for statistical analysis to arrive at conclusion.

Results

IV. RESULTS

The present study was under taken to study the prevalence of gastrointestinal parasites in Asian elephants in parts of Karnataka. A total of 60 fecal samples were collected from the captive Asian elephants at Sri Chamarejendra Zoological Garden, Mysuru (8 samples) and semi-captive Asian elephants belonging to Bannerghatta Biological Park, Bengaluru (12 samples), Sakrebylu elephant camp, Shivamogga (20 samples) and Dubare elephant camp, Kodagu (20 samples) in Karnataka state during the period January to May, 2016. Among which 30 (50%) samples were positive for gastrointestinal parasites which included 3 from Sri Chamarajendra Zoological Garden, 7 elephants from Bannerughatta Biological Park, 10 from Sakrebylu elephant camp and 10 from Dubare elephant camp and identified parasitic eggs were 12 (40%) *Strongyle* sp., 3 (10%) *Strongyloides* sp., 9 (30%) Amphistome sp., 2 (6.66%) had mixed infection with *Strongyle* sp. and *strongyloides* sp. and 4 (13.33%) had mixed infection with *Strongyle* sp. and *Amphistome* sp (Table-3) (Figure-3).

4.1 Managemental practices observed in captive and semi-captive Asian elephants

In captive Asian elephants practices followed were, shelter with concrete flooring, source of water for drinking and bathing from water tanks and bore wells maintained in the zoos, bathing once in a day, elephants rest under semi-natural condition, interaction with human being was 8 hours per day, feeding pattern includes stall feeding with variety of tree leaves, green grasses and grains, restraining with chains, veterinary care available for 24 hours, vaccination for Haemmorhagic septicemia, Anthrax and Foot and mouth diseases and elephants dewormed once in 3 months.

In semi-captive Asian elephants practices followed were, shelter with earthen flooring, source of water for bathing and drinking from river and ponds, bathing once in a day, elephants rest under natural condition, interaction with human being was 4 hours per day and rest of the day elephants were in the forest, feeding pattern include stall feeding and allowed to graze in the forest, restraining by drag chains. Elephants trained for activities such as safari, logging and for Dasara festival, doctors visit once in a week or month for treatment of elephants and elephants dewormed once in 6 months.

4.2 Macroscopic examination of fecal sample

In captive and semi-captive Asian elephants, the color of fecal samples ranged from brown to green. The fecal material was in the form of large bolus with fibrous material and had semisolid consistency and no blood and parasitic worms were observed in fecal samples.

4.3 Prevalence of gastrointestinal parasites in Captive Asian elephants

Among 8 elephant fecal samples collected from Sri Chamarajendra Zoological Garden, Mysuru, 3 (37.5%) were positive for *Strongyle* sp. (Table-2) (Figure-2).

4.4 Prevalence of gastrointestinal parasites in Semi-captive Asian elephants

A total of 52 fecal samples were collected from semi-captive Asian elephants in which 27 (51.92%) were positive for gastrointestinal parasites (Table-2) (Figure-2).

Out of 12 fecal samples collected from Bannerughatta Biological Park, Bengaluru, 7 (58.33%) were positive for gastrointestinal parasitic infestation which

included 4 (33.33%) *Strongyle* sp., 2 (16.66%) *Strongyloid sp*. and 1 (8.33%) had mixed infection of *Strongyle* sp. and *Amphistome* sp. eggs.

A total of 20 fecal samples were collected from Sakrebylu elephant camp, Shivamogga in which 10 (50%) samples were positive for gastrointestinal parasitic infestation and identified parasitic infestation were 2 (10%) *Strongyle* sp., 7 (35%) *Amphistome* sp. and 1 (5%) mixed infection of *Strongyle* sp. and *Amphistome* sp.

Out of 20 samples collected from Dubare elephant camp, Kodagu, 10 (50%) were positive for gastrointestinal parasitic infestation and identified parasitic infestation were 4 (20%) *Strongyle* sp., 2 (10%) *Amphistome* sp., 1 (5%) *Strongyloid* sp., 2 (10%) mixed infection of *Strongyle* sp. and *Amphistome* sp. and 1 (5%) had mixed infection of *Strongyle* sp. and *Strongyloid* sp.

4.5 Gender-wise prevalence of gastrointestinal parasites in Asian elephants.

A total of 60 fecal samples collected during the present study; in which 33 were belonging to male elephants and 27 were female. Out of 33 male elephants, 13 (39.39%) were positive for gastrointestinal parasites which included one elephant from Bannerughatta Biological Park, 5 from Sakrebylu elephant camp, 7 from Dubare elephant camp and prevalence of gastrointestinal parasites was found to be nil in Sri Chamarajendra Zoological Garden, Mysuru. Out of 27 females, 17 (62.96%) were positive for gastrointestinal parasites which included 3 elephants from Sri Chamarajendra Zoological Garden, Mysuru, 6 from Bannerughtta Biological Park, 5 from Sakrebylu elephant camp and 3 from Dubare elephant camp (Table-4) (Figure-4).

4.6 Age-wise prevalence of gastrointestinal parasites in Asian elephants

A total of 60 fecal samples were screened during the present study. The prevalence of gastrointestinal parasites was high in adults (52.77%) which included 1 elephant from Sri Chamarajendra Zoological Garden, Mysuru, 3 from BBP, 6 from Sakrebylu elephant camp and 9 from Dubare elephant camp. In Sub-adults (5-15 year) prevalence rate was 47.36 per cent, which included 2 elephants from Sri Chamarajendra Zoological Garden, Mysuru, 3 from BBP, 4 from Sakrebylu elephant camp and in juveniles (0-5 year) prevalence rate was 40 per cent, which included 1 elephant from Bannerughatta Biological Park and 1 elephant from Dubare elephant camp (Table-5) (Figure-5).

4.7 Seasonal prevalence of gastrointestinal parasites in Asian elephants

Study period of this study was January to May, 2016 so, where January-February considered as winter and March-May considered as summer (Indian Meteorological Department).

Out of 20 fecal samples collected during winter season (January to February) from Bannerughatta Biological Park and Sri Chamarajendra Zoological Garden, 10 (50%) were positive for gastrointestinal parasites in Asian elephants.

A total of 40 fecal samples were collected from Sakrebylu elephant camp and Dubare elephant camp during summer season (March to May), in which 20 (50%) were positive for gastrointestinal parasites in Asian elephants (Table-6) (Figure-6).

4.8 Coproculture

A total of 12 fecal samples positive for *Strongyle* ova were kept for culture to obtain third stage infective larvae. The larvae identified were belonging to genus-*Murshidia* was identified.

Murshidia sp. larvae were medium in size with curved to wrinkled sheath; long tail and lumen of intestine was wavy with 29-32 triangular intestinal cells (Bhatia *et al.,* 2007) (Plate-7 and 8)

4.9 Egg per gram (EPG) of different helminths

The EPG of 21 fecal samples were done and parasitic infestation was evaluated. The mean±SE EPG in case of *Strongyle* sp. was 333.33±48.25 ranging from 0 to 600, mean±SE EPG in case of *Strongyloides* sp. was 300±57.80 ranging from 0 to 500, mean±SE EPG in case of Strongyle and *Strongyloides* sp. was 400±00 ranging from 0 to 400, mean±SE EPG in case of Strongyle and *Amphistome* sp. was 225±25 ranging from 0 to 300 (Table-7).

Table 1: Prevalence of gastrointestinal parasites in Asian elephants at different study places

Study place	Total No. of fecal samples examined	No. of animal positive (%)
BBP, Bengaluru	12	7 (58.33%)
Sri Chamarajendra Zoological Garden, Mysuru	8	3 (37.5%)
Sakrebylu Elephant Camp, Shivamogga	20	10 (50%)
Dubare Elephant Camp, Kodagu	20	10 (50%)
Total	60	30 (50%)

Table 2: Prevalence of gastrointestinal parasites in Captive and Semi-captive Asian elephants

Type of rearing	Total No. of samples examined	No. of animal positive (%)
Captive	8	3 (37.5%)
Semi-captive	52	27 (51.92%)
Total	60	30 (50%)

Figure 1: Prevalence of gastrointestinal parasites in different study places

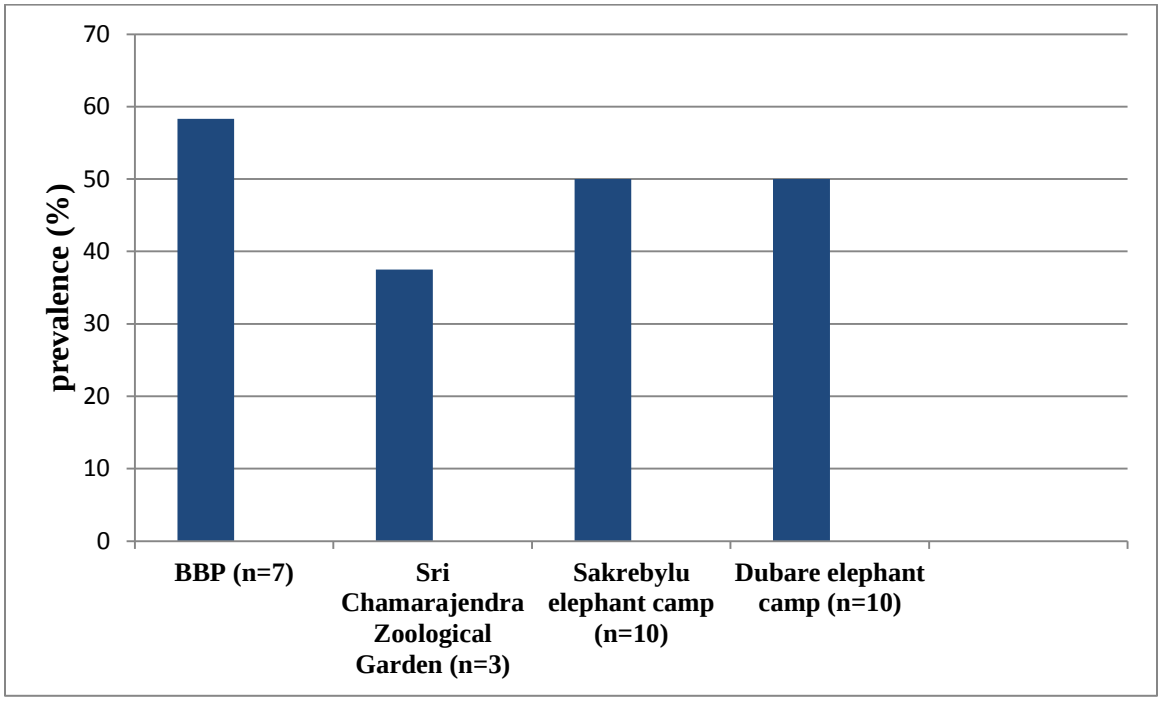

Figure 2: Prevalence of gastrointestinal parasites in Captive and Semi-captive Asian elephants

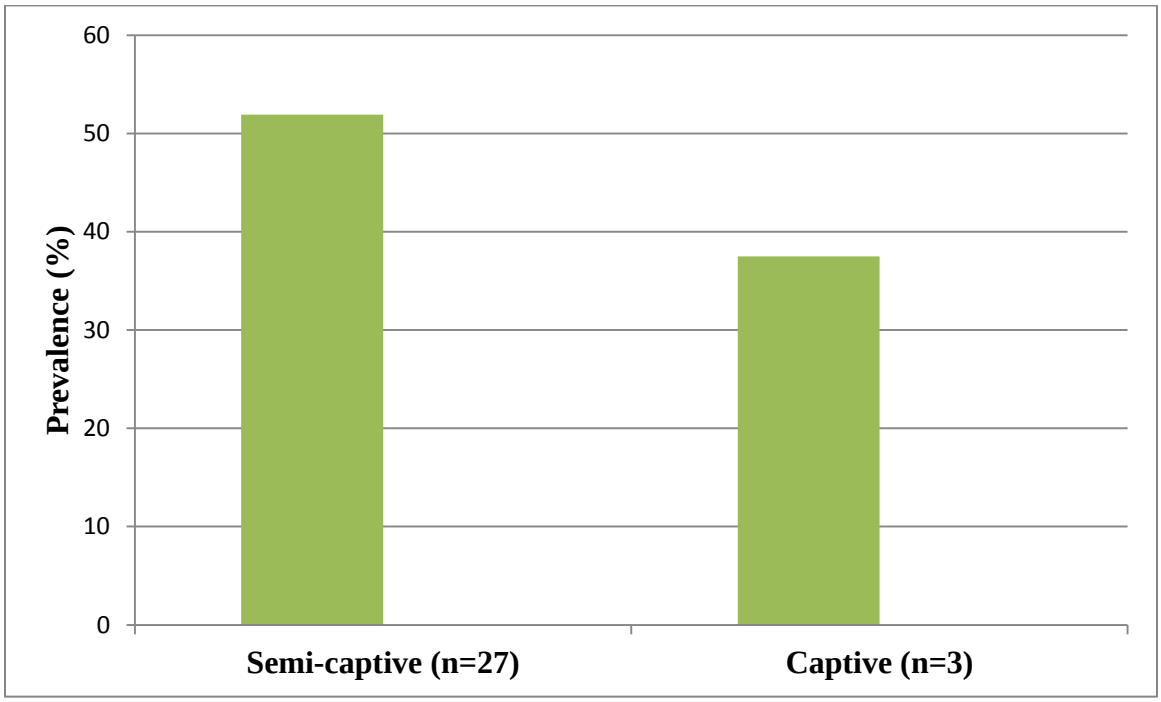

Table 3: Prevalence of different species of gastrointestinal parasites in Asian elephants (n=30)

Type of parasitic ova		No. of animal positive
Strongyle sp.		12 (40%)
Strongyloides sp.		3 (10%)
Amphistome sp.		9 (30%)
Mixed infection	*Strongyle and Strongyloides* sp.	2 (6.66%)
	Strongyle and Amphistome sp.	4 (13.33%)
Total		30 (50%)

Figure 3: Prevalence of different species of gastrointestinal parasites in Asian elephants

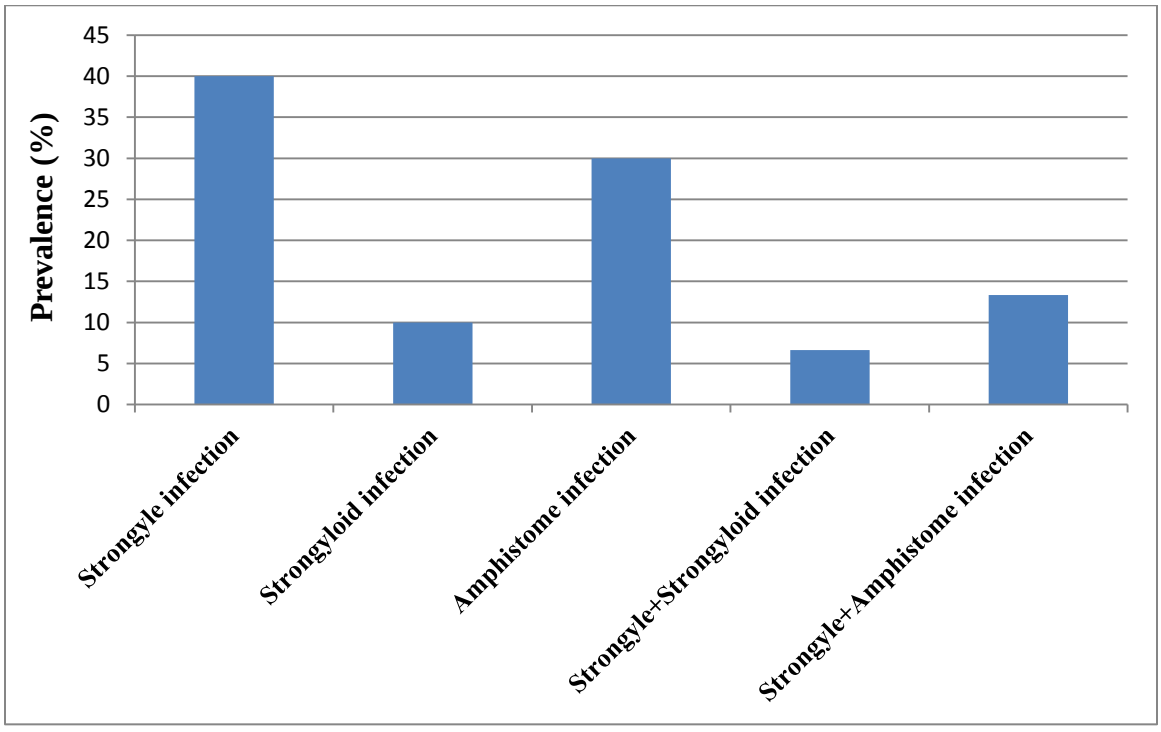

Table 4: Gender-wise prevalence of gastrointestinal parasites in Asian elephants

Gender	No. of animal examined	No. of animal positive (%)
Male	33	13 (39.39%)
Female	27	17 (62.96%)

Table 5: Age-wise prevalence of gastrointestinal parasites in Asian elephants

Age group	No. of animals	No. of animal positive (%)
0-5 yr (juvenile)	5	2 (40%)
5-15 yr (sub-adult)	19	9 (47.36%)
15 yr & above (adult)	36	19 (52.77%)

Figure 4: Gender-wise prevalence of gastrointestinal parasites in Asian elephants

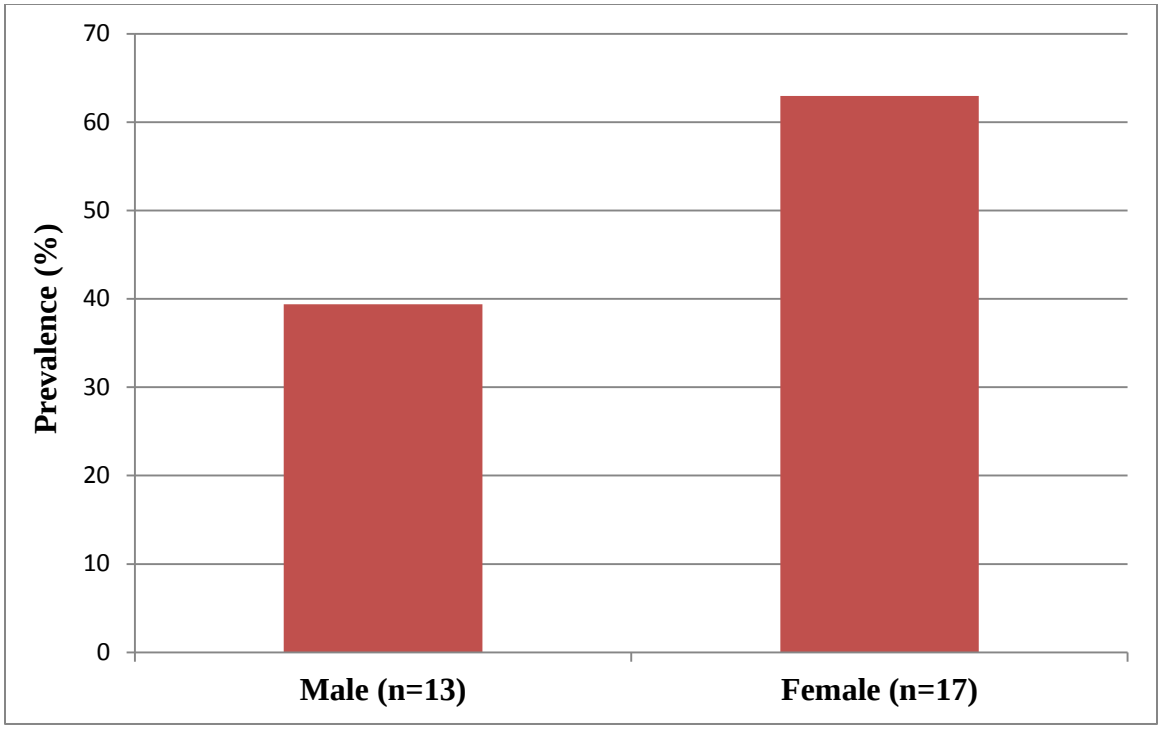

Figure 5: Age-wise prevalence of gastrointestinal parasites in Asian elephants

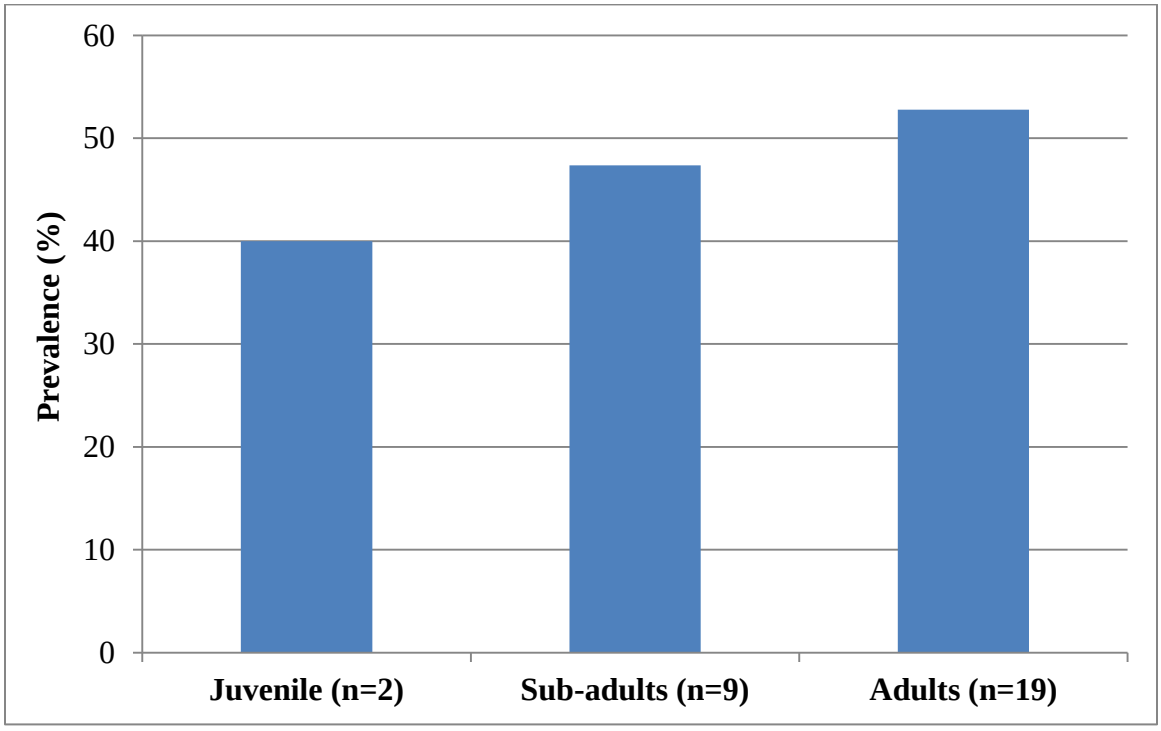

Table 6: Seasonal prevalence of gastrointestinal parasites in Asian elephants

Season	No. of animals examined	No. of animals positive (%)
Winter (January-February)	20	10 (50%)
Summer (March-May)	40	20 (50%)
Overall	60	30 (50%)

Figure 6: Seasonal prevalence of gastrointestinal parasites in Asian elephants

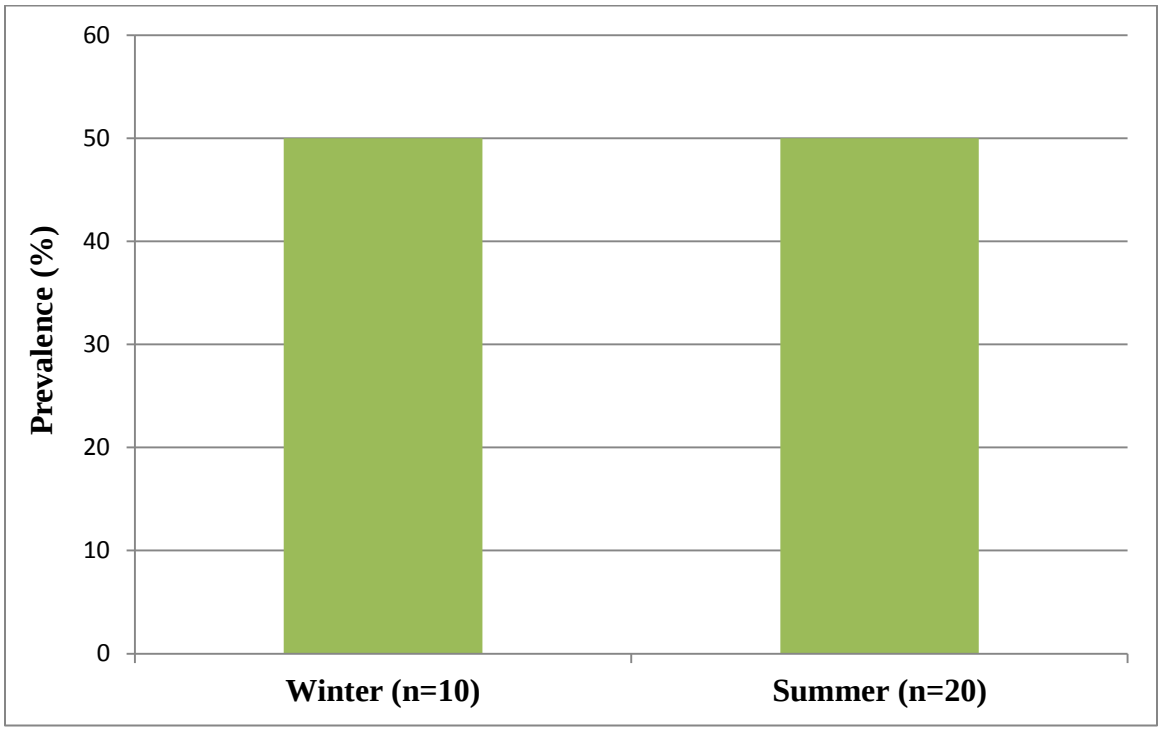

Table 7: Mean fecal egg count in Asian elephants

Parasitic egg/ova	EPG	Mean fecal egg count
Strongyle	0-600	333.33 ±48.25
Strongyloides sp.	0-500	300.00 ±57.80
Strongyle and *Strongyloides* sp.	0-400	400.00 ±00
Strongyle and *Amphistome* sp.	0-300	225.00 ±25

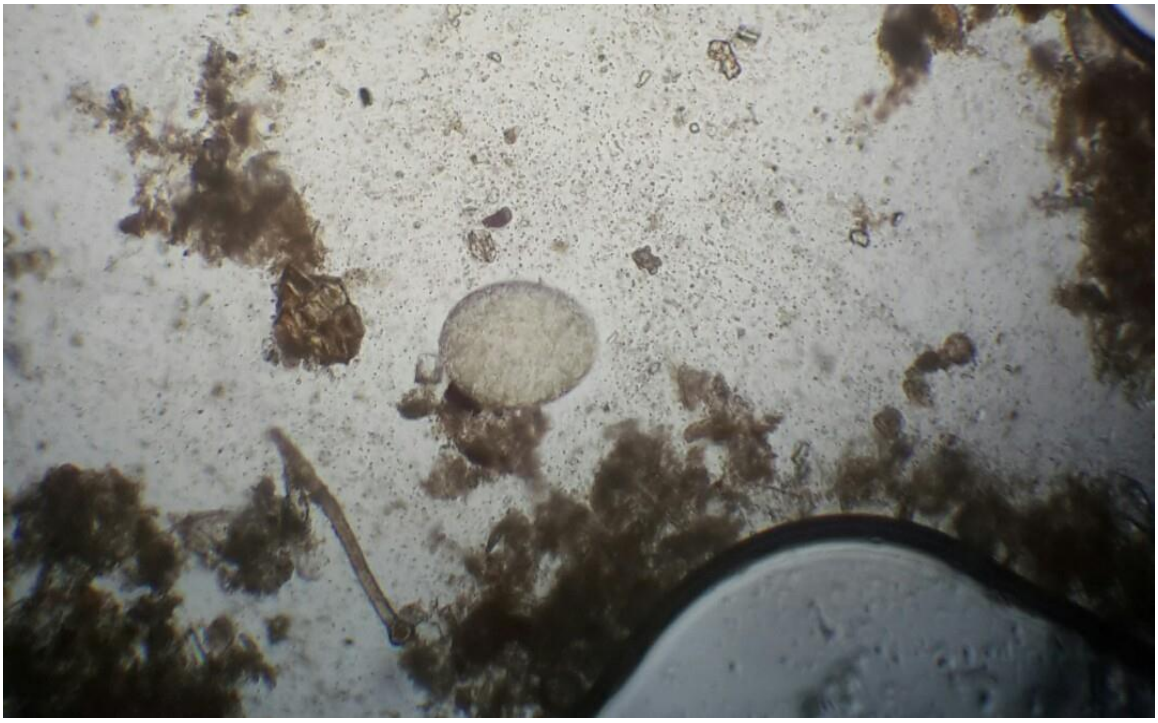

Plate 1: Egg of *Amphistome* sp. identified in fecal sample of Asian elephants (10X)

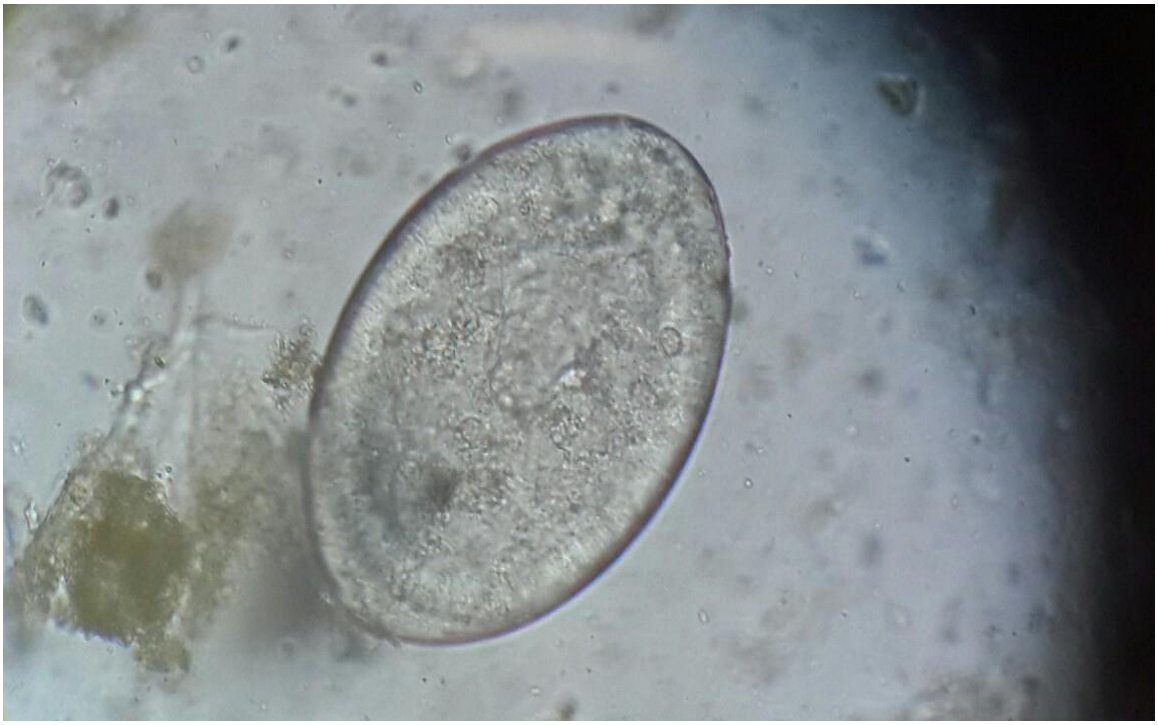

Plate 2: Egg of *Amphistome* sp. identified in fecal sample of Asian elephants (40X)

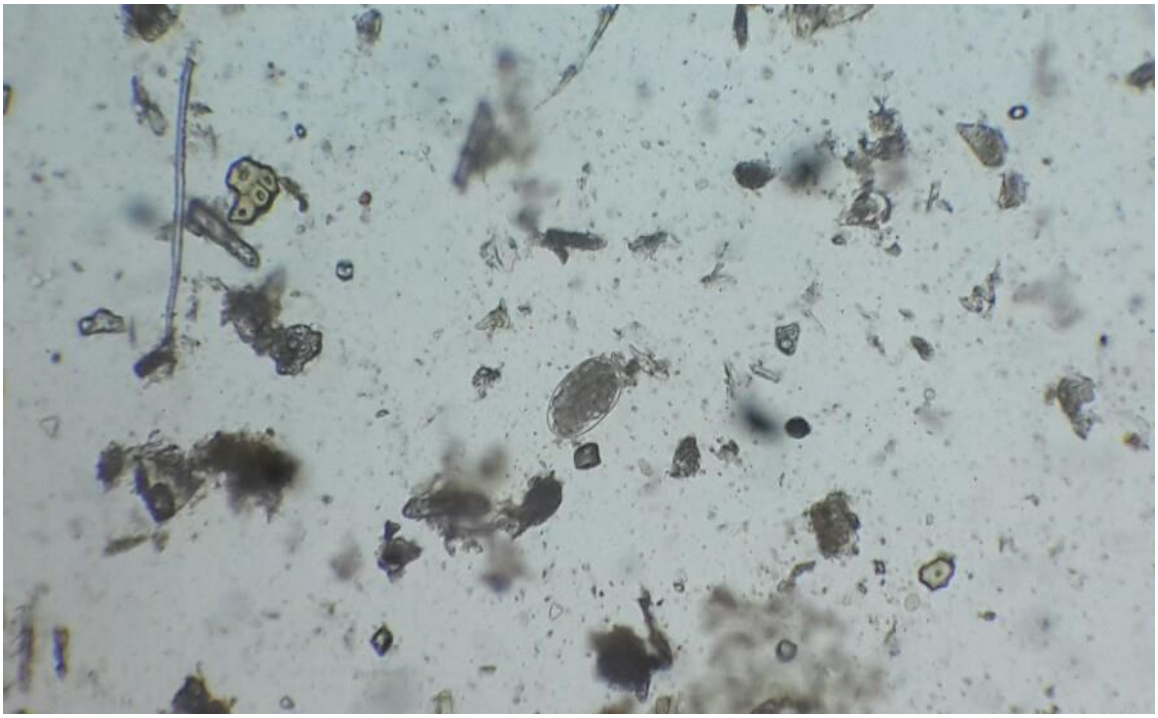

Plate 3: Egg of *Strongyle* sp. identified in fecal sample of Asian elephants (10X)

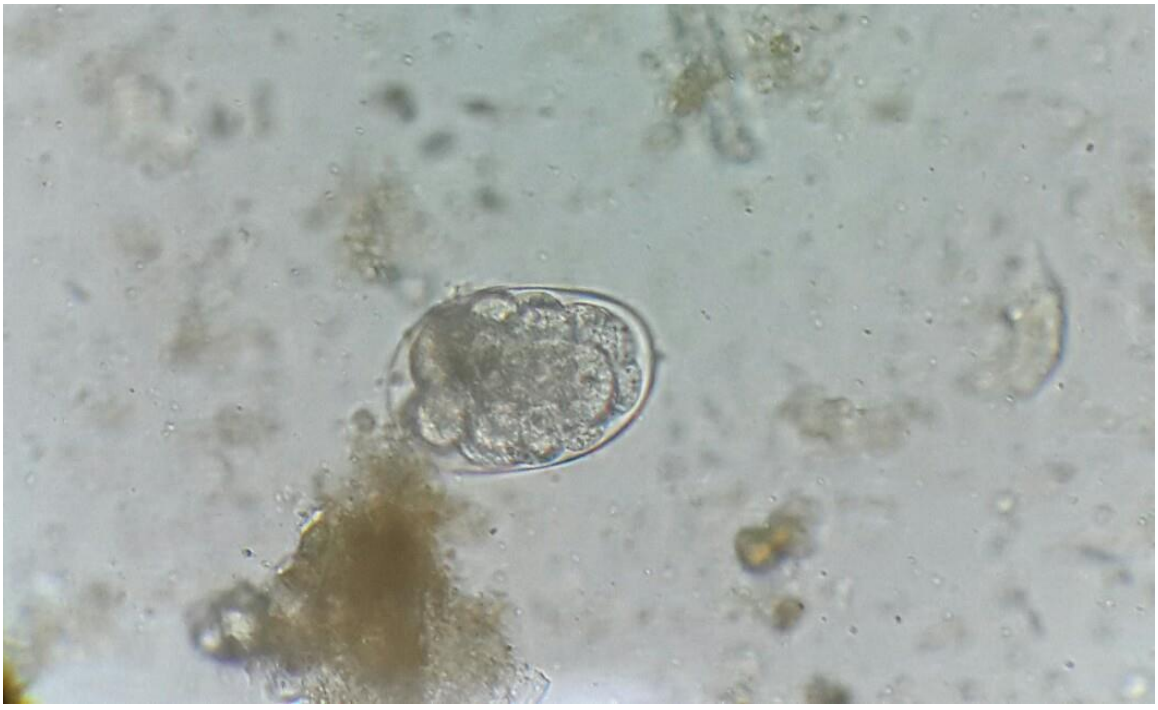

Plate 4: Egg of *Strongyle* sp. identified in fecal sample of Asian elephants (40X)

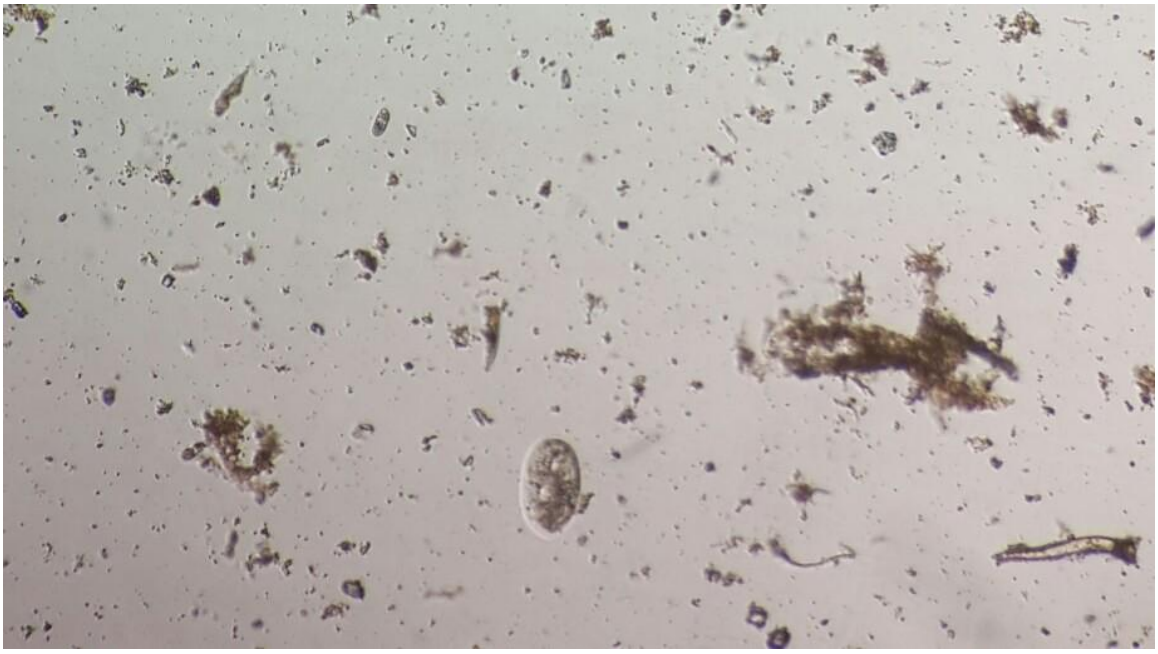

Plate 5: Egg of *Strongyloides* sp. identified in fecal sample of Asian elephants (10X)

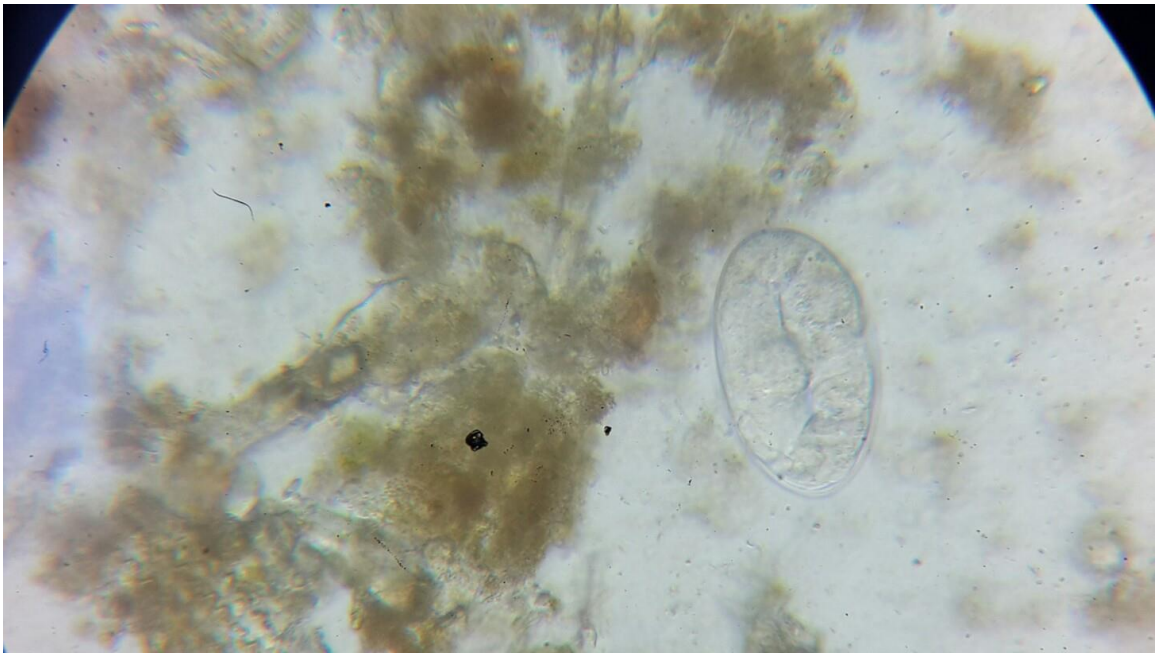

Plate 6: Egg of *Strongyloides* sp. identified in fecal sample of Asian elephants (40X)

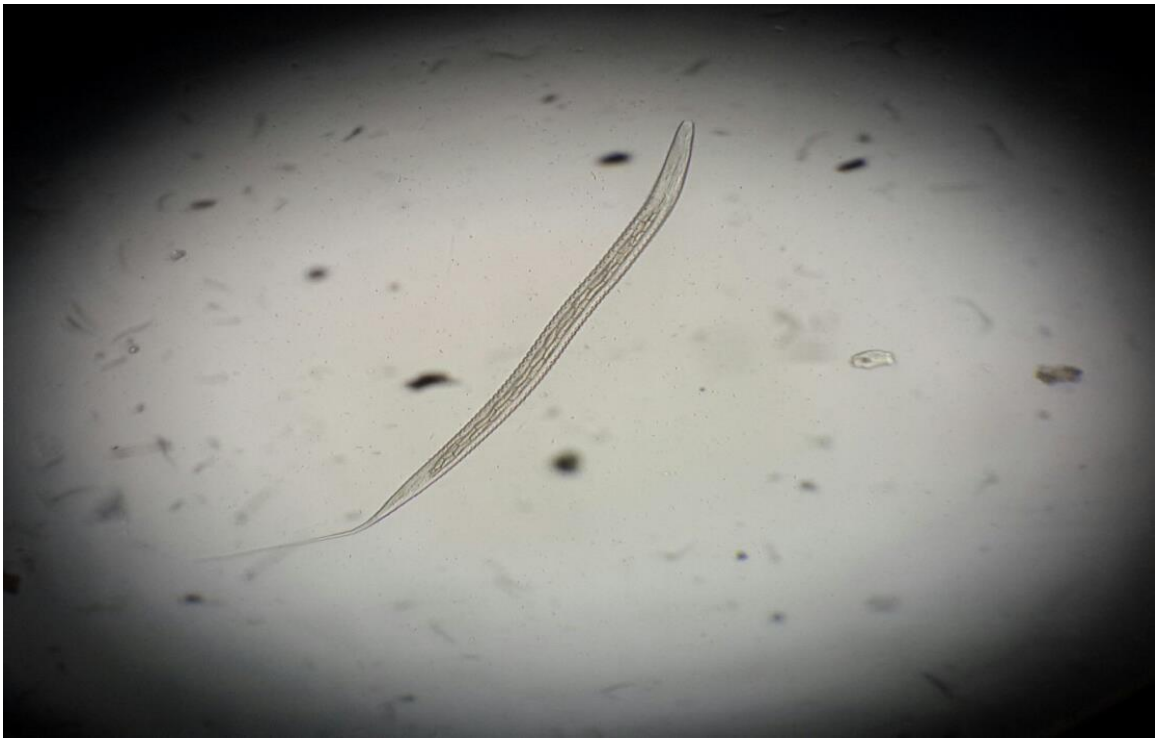

Plate 7: Infective larval stage of *Murshidia* sp. identified in fecal sample of Asian elephants (10X)

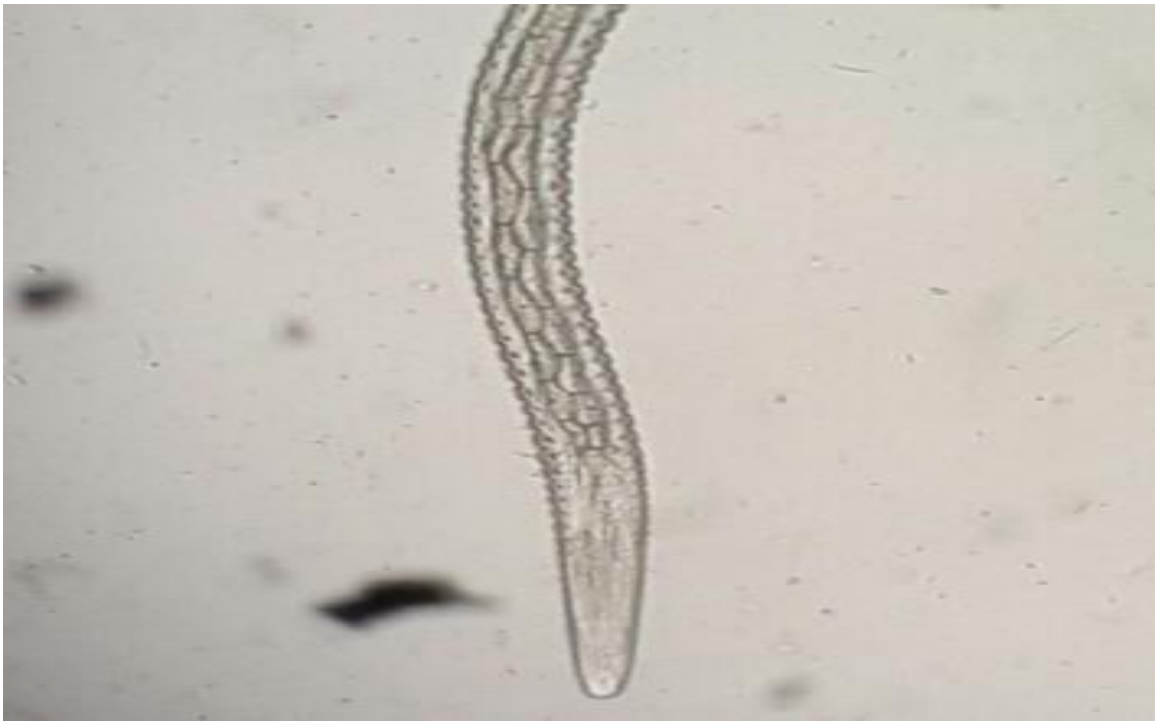

Plate 8: Infective larval stage of *Murshidia* sp. with triangular intestinal cell (40X)

Discussion

V. DISCUSSION

The present study was undertaken to know the prevalence of gastrointestinal parasites in Asian elephants in different parts of Karnataka. A total of 60 fecal samples were collected from Asian elephants maintained under captive and semi-captive condition in which 30 (50%) were positive for gastrointestinal parasitic infestation during the study period January to May 2016.

5.1 Managemental practices observed in captive and semi-captive Asian elephants

In captive Asian elephants practices followed were, shelter with concrete flooring, source of water for drinking and bathing from water tanks and bore wells maintained in the zoos, bathing once in a day, elephants rest under semi-natural condition, interaction with human being was 8 hours per day, feeding pattern includes stall feeding with variety of tree leaves, green grasses and grains, restraining with chains, veterinary care available for 24 hours, vaccination for Haemmorhagic septicemia, Anthrax and Foot and mouth diseases and elephants dewormed once in 3 months.

In semi-captive Asian elephants practices flowed were, shelter with earthen flooring, source of water for bathing and drinking from river and ponds, bathing once in a day, elephants rest under natural condition, interaction with human being was 4 hours per day and rest of the day elephants were in the forest, feeding pattern include stall feeding and allowed to graze in the forest, restraining by drag chains. Elephants trained for activities such as safari, logging and for Dasara festival, doctors visit once in a month for treatment of elephants and elephants dewormed once in 6 months.

The findings of the current study are in agreement with Varma *et al.* (2010) and Joseph *et al.* (2013). In semi-captive Asian elephants due to irregular veterinary care such as elephants were dewormed once in 6 months and no vaccination which also contribute for increased prevalence of parasitic infestation.

5.2 Macroscopic examination of fecal samples

In captive and semi-captive Asian elephants, the color of fecal samples ranged from brown to green. The fecal material was in the form of large bolus with fibrous material and had semisolid consistency and no blood and parasitic worms were observed in fecal samples. Color and consistency of fecal sample might be based on different feeding habits as elephants feed on variety of tree leaves, tree barks, grains and lush green fodder.

5.3 Prevalence of gastrointestinal parasites in captive Asian elephants

A total 8 fecal samples were collected from captive elephants at Sri Chamarajendra Zoological Garden, Mysuru. 3 (37.5%) were positive for parasitic infection in captive elephants.

The findings of the current study are in agreement with Vanitha *et al.* (2011) who have reported 37 per cent prevalence of gastrointestinal parasites in captive elephants in Tamil Nadu state. Similarly Suresh *et al.* (2001) found in their study that 29.23 per cent captive elephants were infected with gastrointestinal parasites at Nehru Zoological Park, Hyderabad which was comparable with the present study. The present results can be

related to good managemental practices, veterinary care and regular deworming followed at zoo.

However, lower and higher prevalence has also been reported by Saseendran *et al.* (2003) as 12.73 per cent and Singh *et al.* (2006) as 85.71 per cent parasitic infection in captive elephants at Kerala and Mahendra Choudhary Zoological Park, Punjab. This could be related to bad managemental practices, irregular deworming schedules, and rejection of deworming medicine by elephants and mixed group of animals.

5.4 Prevalence of gastrointestinal parasites in semi-captive Asian elephants

Out of 52 fecal samples collected from semi-captive Asian elephants, 27 (51.92%) were positive for parasitic infection which included 7 (58.33%) samples from Bannerughatta Biological Park, 10 (50%) samples from Sakrebylu elephant camp and 10 (50%) samples from Dubare elephant camp were positive for parasitic infection.

Pechimuthu (2014) in their study recorded mean parasitic infection rate as 55 per cent in elephants maintained by forest department in Tamil Nadu, which was comparable with the present study. However, Dharmarajan *et al.* (2005) have reported 85.29 per cent parasitic infection in elephants at Mudumalai Wildlife Sanctuary, Tamil Nadu which is high as compared to the present study.

Lower prevalence of gastrointestinal parasitic infestation has also been recorded by Arunachalam *et al.* (2007) who have recorded 44 per cent parasitic infection in elephants at Theppakadu, Nilgiris, Tamil Nadu.

As the semi-captive elephants are allowed to range in forest along with other wild animals with different age groups, animals are exposed to contaminated environment containing infective stage of parasite and irregular deworming pattern increases susceptibility to parasitic infection (Varma *et al*., 2010 and Vanitha *et al*., 2011). Strongylid infections were widespread in elephants in India and the survivability of the third stage larvae was perhaps considered as one of the most important features in the life cycle of Strongylid nematodes as a source of infection in elephants (Rahman *et al*., 2014).

5.5 Gender-wise prevalence of gastrointestinal parasites in Asian elephants

The prevalence of gastrointestinal parasites in Asian elephants was high in females (62.96%) as compared to males (39.39%).

The finding of the present study is in agreement with Suresh *et al.* (2001), Vanitha *et al.* (2011), Pechimuthu (2014) and Baines *et al.* (2015) who have indicated in their study that more social nature of females with frequent physical contacts to various age-sex classes compared to males increases susceptibility to parasitic infection.

5.6 Age-wise prevalence of gastrointestinal parasites in Asian elephants

Prevalence of gastrointestinal parasites in Asian elephants was high in adults (52.77%) followed by sub-adults (47.36%) and juveniles (40%).

The findings of the study are in agreement with Suresh *et al.* (2001), Vanitha *et al*. (2011) and Pechimuthu (2014) who have reported that adult animals were more infected by parasitic infection. As the age increases parasitic infection also increases as

elephants tend to feed on various type of tree leaves, tree barks and lush green grasses and that may carrying infective stage of parasites in exposed environment. Prevalence in juveniles could be related to their feeding habits as they feed on mother's milk which has been indicated in the literature.

5.7 Seasonal prevalence of gastrointestinal parasites in Asian elephants

A total of 60 fecal samples were collected during the period of study which included 20 samples collected during winter (Jan-Feb) in which 10 (50%) were positive for gastrointestinal parasites and 40 samples collected during summer (Mar-May) in which 20 (50%) were positive for gastrointestinal parasites. Based on sample size prevalence of gastrointestinal parasite was high in summer season.

Seasonal prevalence of parasitic study by Suresh *et al.* (2001), Vidya and Sukumar (2002), Vanitha *et al.* (2011), Vimalraj *et al.* (2012), and Pechimuthu (2014) who have indicated higher prevalence of parasitic infection during summer was due to the prevalence of ideal climatic condition (temperature and humidity) for faster rates of egg hatching and rapid development to the infective stage and due to poor hygienic conditions to the resources such as shelter, food and water and in winter survival of infective stage was difficult due to moisture content in environment.

5.8 Prevalence of different species of gastrointestinal parasites in Asian elephants

Out of 60 fecal samples collected from captive and semi-captive Asian elephants 30 (50%) were positive gastrointestinal parasites which included 12 (40%) *Strongyle* sp. 3 (10%) *Strongyloides* sp. 9 (30%) *Amphistome* sp. 2 (6.66%) had mixed infection with

Strongyle sp. and *Strongyloides* sp. and 4 (13.33%) had mixed infection with *Strongyle* sp. and *Amphistome* sp.

The findings of the study are in agreement with Nishanth *et al*. (2012) who have reported 40 per cent prevalence of *Strongyle* sp. and 8 per cent prevalence of mixed infection with *Strongyle* sp. and *Strongyloides* sp. in elephants at Mudumalai sanctuary, Tamil Nadu. Similarly, *Arunachalam et al*. (2007) found in their study the prevalence of *Strongyle* sp. to be 36.36 per cent in Asian elephants at Theppakadu, Nilgiris, Tamil Nadu which is comparable with the present study. However, higher prevalence have been reported by Chandrasekharan *et al*. (1995), who have reported prevalence of *Strongyle* sp. to be 91.27 per cent among captive elephants in Kerala. Singh *et al.* (2006) reported prevalence of *Strongyle* sp. and *Amphistome* sp. to be 85.71 per cent and 14.29 per cent respectively and 14.29 per cent prevalence of mixed infection of *Strongyle* sp. and *Amphistome* sp. in Asian elephants at Mahendra Choudhury Zoological Park, Punjab. Hing *et al*. (2015) reported the prevalence of *Fasciola* (liver fluke) to be 70.2 per cent, *Strongyle* sp. to be 66.3 per cent and *Anoplocephala* sp. to be 50 per cent in the study of Bornean elephants of Kinabatangan wildlife sanctuary and Tabin wildlife reserve, Malaysian Borneo respectively. This could be related to availability of high number of infective larvae or intermediate host and contamination of soil.

Lower prevalence of gastrointestinal parasitic infestation have also been reported by Saseendran *et al*. (2003) who have reported prevalence of *Strongyle* sp. to be 10.10 per cent and *Amphistome* sp. to be 7.07 per cent in captive elephants at Thrissur, kerala.

This could be related to less number of animals, stall feeding and good managemental practices followed in captive elephants.

The differences observed as compared to earlier results, the prevalence of gastrointestinal parasites in Asian elephants is probably due to differences in hygienic measures, poor drainage, food was given directly on the floor and drinking water from lake have high chance of fecal contamination, changed environment conditions and the movement of keepers from one enclosure to other in captive condition (Singh *et al.,* 2006 and Pandit *et al.,* 2015) and in semi-captive elephants due to social life and environment shared with wild elephants was likely to enhance susceptibility to parasitic infection (Vanitha *et al.,* 2011).

5.9 Coproculture

Samples positive for *Strongyle* ova were cultured to obtain third stage infective larvae. The larvae identified were belonging to Genus- *Murshidia*.

The finding of the present study is in agreement with the Matsuo and Suprahman (1997) who have recovered *Murshidia* sp. from positive fecal samples collected from Asian elephants at Way Kambas National Park, Indonesia. Similarly, Mbaya *et al*. (2013) have recovered *Murshidia* sp. from fecal samples infected with Strongyle from African elephants at Chad Basin National Park, Nigeria.

5.10 Egg per gram (EPG) of different helminthes

In the present study EPG of *Strongyle* sp. ranged between 0 to 600 and mean fecal egg count was 333.33±48.25, EPG of *Strongyloides* sp. ranged between 0 to 500 and

mean fecal egg count was 300±57.80, EPG of Strongyle and *Strongyloides* sp. ranged between 0 to 400 and mean fecal egg count was 400±00, EPG of Strongyle and *Amphistome* sp. ranged between 0 to 300 and mean fecal egg count was 225±25.

Nishant *et al.* (2012) have recorded mean fecal egg count of Strongyle as 340±32.07, *Strongyloides* sp. 300.00±31.62 and Strongyle and *Strongyloides* sp. 320±37.4 indicating mild to moderate parasitic infection in elephants at Mudumalai Sanctuary in Tamil Nadu, which was comparable with the present study. On the contrary, high mean fecal egg count was recorded by Suresh *et al.* (2001) as 671.4±130.20 in elephants at Nehru Zoological Park, Hyderabad.

Conclusion:

The present study indicated that prevalence of gastrointestinal parasites was 37.5 per cent in captive and 51.92 per cent in semi-captive Asian elephnats. Adult females had higher prevalence compared to male elephants. *Strongyle* infection was high among captive and semi-captive Asian elephants followed by Amphistome (30%) and mixed parasitic infestation (20%). Prevalence of gastrointestinal parasites was high in adult elephants. Seasonal prevalence indicated that in summer prevalence of gastrointestinal parasite was high.

Regular management, hygiene and preventive control measures may be adopted to minimize parasitic infection in semi-captive Asian elephants.

Summary

VI. SUMMARY

The present study was undertaken to understand the prevalence of gastrointestinal parasitic infection in captive and semi-captive Asian elephants. Gender-wise, age-wise and seasonal distribution of parasitic infestation was also recorded in the present study during the period January to May, 2016.

A total of 60 fecal samples were collected from captive Asian elephants at Sri Chamarajendra Zoological Garden, Mysuru and semi-captive Asian elephants belonging to Bannerughatta Biological Park, Bengaluru, Sakrebylu elephant camp, Shivamogga and Dubare elephant camp, Kodagu in Karnataka and gastrointestinal infection recorded were *Strongyle* sp. (40%), *Strongyloides* sp. (10%), *Amphistome* sp. (30%), mixed infection with *Strongyle* sp. and *Strongyloides* sp. (6.66%) and *Strongyle* sp. and *Amphistome* sp. (13.33%).

The prevalence of gastrointestinal parasitic infestation was found to be 37.5 and 51.92 per cent in captive and semi-captive Asian elephants.

Gastrointestinal parasitic infestation was found to be high in female (62.96%) when compared with male elephants (39.39%).

Gastrointestinal parasitic infestation was found to be high in adults (52.77%) followed by sub-adults (47.36%) and juveniles (40%).

Season-wise incidence indicated 50 per cent gastrointestinal parasitic infection in both winter (Jan-Feb) and summer (Mar-May).

Coproculture examination of positive fecal samples revealed infective larval stage of *Murshidia* sp. in Asian elephants.

The egg counts indicated only a light infection in captive Asian elephants at Sri Chamarajendra Zoological Garden, Mysuru, which may be due to good managemental practices and regular deworming. The egg counts were high in semi-captive Asian elephants of BBP, Sakrebylu elephant camp and Dubare elephant camp, as the elephants were not confined to a single place and the availability of forage and lush green grass was more in the forest and semi-captive elephants are allowed to range in forest and may combine with other wild animals which enhances susceptibility to parasitic infection.

The present study indicated that prevalence of gastrointestinal parasites has no relationship with the captive or semi-captive area. Adult females had higher prevalence due to social nature and a frequent physical contact to various age-sex classes compared to male's increases susceptibility to parasitic infection. *Strongyle* infection was high among captive and semi-captive Asian elephants. Prevalence of gastrointestinal parasites was high in adult elephants. Seasonal prevalence indicated in summer it was high.

Regular management, hygiene and preventive control measures may be adopted to minimize parasitic infection.

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Abstract

VIII. ABSTRACT

This study was undertaken to assess the prevalence of gastrointestinal parasites in captive and semi-captive Asian elephants in parts of Karnataka. Fecal samples were collected from captive elephants at Sri Chamarajendra Zoological Garden, Mysuru and semi-captive elephants belonging to Bannerughatta Biological Park, Bengaluru, Sakrebylu elephant camp, Shivamogga and Dubare elephant camp, Kodagu were analyzed from January to May 2016. The parasitic prevalence was evaluated by qualitative and quantitative examination of fecal samples (n=60) collected from different age/gender groups of elephants. Of the 60 elephants examined, 40% infected with *Strongyle* sp. 10 per cent with *Strongyloides* sp. 30 per cent with *Amphistome* sp. 6.66 per cent with mixed infection of *Strongyle* sp. and *Strongyloides* sp. and 13.33 per cent with mixed infection of *Strongyle* sp. and *Amphistome* sp. The prevalence of gastrointestinal parasites was high in semi-captive elephants (51.92%) when compared with captive elephants (37.5%). Prevalence of gastrointestinal parasites was high in females (62.96%) compared with males (39.39%). There was no significant difference between male and female. Prevalence of gastrointestinal parasites was high in adults (52.77%) followed by sub-adults (47.36%) and juveniles (40%) and there was no significant difference between three age groups. The seasonal prevalence of gastrointestinal parasites was 50 per cent in both winter and summer. Coproculture examination of positive fecal sample revealed infective larval stage of *Murshidia* sp. and egg per gram (EPG) indicated mild to moderate parasitic infection in Asian elephants.

Keywords: Captive and semi-captive Asian elephants, gastrointestinal parasite, prevalence.

Appendices

APPENDIX-I

General managemental practices in captive and semi-captive Asian elephants

[The Kerala captive elephants (2003), Varma *et al.*, 2010 and Joseph *et al.*, 2013]

Parameter	**Captive elephants (zoos)**	**Semi-captive elephants (maintained by forest department)**
Shelter type	Stable (tethering place) with partially concrete flooring	Forest with earthen flooring
Source of water for bathing and drinking	From water tanks and bore well	From river/stream
Bathing period	For not less than 3 hours per day	Average 2 hours per day
Resting place	Under semi-natural condition (sheds/tethering place)	Under natural condition (in forest with access to tree shade)
Interaction with human being	8-10 hours per day	4-5 hours per day
Work type	Not used for any work	Trained for activities such as safari, logging, patrolling as kunki
Feeding pattern	Stall feeding (tree leaves and barks, green grasses)	Stall feeding (ragi and paddy straw with jaggery) and allowed to range free in the forest
Restraining	By chains and hobbles	By drag chains
Free ranging	Not allowed	Allowed for 14-18 hours per day
Veterinary care	Available for 24 hours	Doctors visit once in a week or month
Vaccination	For Anthrax, Haemorrhagic septicemia and Foot and mouth disease	For Anthrax
Deworming	Once in 3 months	Once in 3 months

APPENDIX-II

DESCRIPTION OF ANIMAL STUDIED

BANNERUGHATTA BIOLOGICAL PARK, BENGALURU.

Sl. No.	Name of the Elephant	Gender (M/F)	Age	Parasite detected
1	Lilly	F	73 yrs	*Strongyle* sp. and *Amphistome* sp.
2	Veda	F	17 yrs	*Strongyle* sp.
3	Nisarga	F	13 yrs	*Strongyloides* sp.
4	Lakshmi	F	7 yrs	*Strongyle* sp.
5	Ashwatthama	M	6 yrs	-
6	Suvarna	F	41 yrs	-
7	Menaka	F	49 yrs	*Strongyloides* sp.
8	Roopa	F	8 yrs	*Strongyle* sp. *and Strongyloides* sp.
9	Ranga	M	1.5 yrs	*Strongyle* sp.
10	Gajendra	M	7 yrs	-
11	Sundar	M	16 yrs	-
12	Vanaraja	M	39 yrs	-

SRI CHAMARAJENDRA ZOOLOGICAL GARDEN, MYSURU

Sl. No.	Name of the Elephant	Gender (M/F)	Age	Parasite detected
1	Airavati	F	12 yrs	*Strongyle* sp.
2	Madesha	M	8 yrs	-
3	Aishwarya	F	13 yrs	*Strongyle* sp.
4	Abhimanyu	M	11 yrs	-
5	Kollegala	F	12 yrs	-
6	Padmavati	F	61 yrs	-
7	Gajalakshmi	F	36 yrs	*Strongyle* sp.
8	Rama	M	21 yrs	-

SAKREBYLU ELEPHANT CAMP, SHIVAMOGGA

Sl. No.	Name of the elephant	Gender (M/F)	Age	Parasite detected
1	Amrutha	F	31 yrs	*Strongyle* sp.
2	Ganesha	M	25 yrs	*Amphistome* sp.
3	Subhadra	F	10 yrs	-
4	Hemavati	F	13 yrs	*Amphistome* sp.
5	Kunti	F	26 yrs	-
6	New tusker	M	45 yrs	*Amphistome* sp.
7	Ajay	M	21 yrs	-
8	Kapila	F	14 yrs	*Strongyle* sp.
9	Manikanta	M	20 yrs	*Amphistome* sp. and *Strongyle* sp.
10	Gange	F	29 yrs	*Amphistome* sp.
11	Bhaskar	M	32 yrs	-
12	Surya	M	2 yrs	-
13	Geeta	F	12 yrs	*Amphistome* sp.
14	Sagar	M	9 yrs	*Amphistome* sp.
15	Netra	F	35 yr	-
16	Raghavendra	M	10 yrs	-
17	Hathi	M	20 yrs	*Amphistome* sp.
18	Bhanumati	F	23 yrs	-
19	Ranga	M	8 yrs	-
20	Rama	M	18 yrs	-

DUBARE ELEPHANT CAMP, KODAGU

Sl. No.	Name of the elephant	Gender (M/F)	Age	Parasite detected
1	Harsha	M	39 yrs	-
2	Prashantha	M	44 yrs	*Amphistome* sp.
3	Thirtharama	M	21 yrs	*Strongyloides* sp.
4	Vikram	M	50 yrs	*Strongyle* sp.
5	Ranjan	M	16 yrs	-
6	Ekadanta	M	45 yrs	-
7	Mayura	M	26 yrs	*Strongyle* sp. and *Amphistome* sp.
8	Ajay	M	25 yrs	-
9	Dhananjaya	M	35 yrs	*Strongyle* sp. and *Amphistome* sp.
10	Kaveri	F	36 yrs	*Strongyle* sp.
11	Subramanya	M	20 yrs	-
12	Eshwara	M	45 yrs	-
13	Vijaya	F	54 yrs	-
14	Myhtili	F	49 yrs	*Strongyle* sp. and *Strongyloides* sp.
15	Shivagange	F	13 yrs	-
16	Lopamudra	F	2 yrs	-
17	Prithvi	M	2yrs	-
18	Kapila calf	F	1 yr	*Strongyle* sp.
19	Wild elephant-1	M	17 yrs	*Amphistome* sp.
20	Wild elephant-2	M	20 yrs	*Strongyle* sp.

APPENDIX-III

EGG PER GRAM OF DIFFERENT PARASITES

Study place	Name of the elephant	Parasite detected	EPG
Bannerughatta Biological Park	Lilly	*Strongyle* sp. and *Amphistome* sp.	200
	Veda	*Strongyle* sp.	500
	Nisarga	*Strongyloides* sp.	300
	Lakshmi	*Strongyle* sp.	300
	Menaka	*Strongyloides* sp.	100
	Roopa	*Strongyle* sp. *and Strongyloides* sp.	400
	Ranga	*Strongyle* sp.	600
Sri Chamarajendra Zoological Garden	Airavati	*Strongyle* sp.	100
	Aishwarya	*Strongyle* sp.	200
	Gajalakshmi	*Strongyle* sp.	100
Sakrebylu elephant camp	Amrutha	*Strongyle* sp.	300
	Ganesh	*Amphistome* sp.	$+^{ve}$
	Hemavati	*Amphistome* sp.	$+^{ve}$
	New tusker	*Amphistome* sp.	$+^{ve}$
	Kapila	*Strongyle* sp.	500
	Manikanta	*Amphistome* sp. and *Strongyle* sp.	200
	Gange	*Amphistome* sp.	$+^{ve}$
	Geeta	*Amphistome* sp.	$+^{ve}$
	Sagar	*Amphistome* sp.	$+^{ve}$
	Hathi	*Amphistome* sp.	$+^{ve}$
Dubare elephant camp	Prashantha	*Amphistome* sp.	$+^{ve}$
	Thirtharama	*Strongyloides* sp.	500
	Vikram	*Strongyle* sp.	400
	Mayura	*Strongyle* sp. and *Amphistome* sp.	300
	Dhananjaya	*Strongyle* sp. and *Amphistome* sp.	200
	Kaveri	*Strongyle* sp.	500
	Mythili	*Strongyle* sp. and *Strongyloides* sp.	400
	Kapila calf	*Strongyle* sp.	300
	Wild elephant-1	*Amphistome* sp.	$+^{ve}$
	Wild elephant-2	*Strongyle* sp.	200