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Coprological Assessment of Gastrointestinal Parasites in Wild Animals of India: A Review

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Abstract: Parasites play an important role in the health of wild animals and can profoundly affect the conservation strategies. Although few studies are available on the prevalence of parasites in wild animals, most of these describe protozoans and helminthic infections in captive wild herbivores and carnivores which cause morbidities in the infected animals. Present study reviewed coprological prevalence of gastrointestinal parasites in wild animals of India which provides insight into the wildlife health and parasitic infection. Study reveals some interesting facts like infection of nematodes like *Strongyle*, *Strongyloides* and *Trichuris* in herbivores and *Toxocara* in felids and canids is most common while infection of trematodes, *Fasciola* and *Paramphistome* were only found in herbivores such as spotted deer, black buck and sambar. Wild carnivores were often infected with cestode species *Spirometra* and *Diphyllbothrium*. This review provides a comprehensive analysis of parasitic infection and its treatment based on existing reports from various parts of India including captive and natural habitat which recommend further detailed investigation for wildlife management.

Keywords: Gastrointestinal parasites, Coprological, Host, Helminth, Wild animals

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Introduction

India is incredibly diverse in terms of ecosystem and habitats, which provide suitable environment for a wide variety of flora and fauna. Wildlife holds significant importance in maintaining ecological balance, supporting biodiversity, and provide economic and cultural value (Niranjan *et al.*,

2020). However, threats like, habitat loss, poaching, climate change, human-wildlife conflict and diseases, especially arising from gastrointestinal parasites led into continuous declining of wildlife population (Jenkins *et al.*, 2015; Thawait and Miati, 2015). Parasites can affect host

survival and reproduction directly through pathological effects (blood loss, tissue damage, spontaneous abortion, congenital malformations and death) and indirectly by reducing the host's immunity and affecting the physical condition (Thawait *et al.*, 2014).

Parasitic diseases represent a major concern in wild animals, especially in captivity they are maintained in confined area and susceptible to almost all types of diseases particularly parasitic helminthic infection (Varadharajan and Kandasamy, 2000; Khutey *et al.*, 2020). While in natural habitat, animals range over large areas and they are frequently exposed to a variety of parasites (Gaur *et al.*, 1979, Barbosa, 2020); host are continuously re-infected (Hart, 1990), but the severity of these parasites depends on the health of host (Raja *et al.*, 2014). When diseases pass between different species; they can create significant problems for the entire ecosystem like, affecting biodiversity, changing behaviour or composition of animal populations and impact on interactions between species, including prey-predator relationships (Sengar *et al.*, 2017). Gastrointestinal parasites can be observed through the faeces, as they live in gastrointestinal tract. The presence or absence, abundance of certain parasites can serve as indicators of the overall health and condition of an ecosystem. This review discusses in brief on the occurrence of gastro-intestinal parasites in wild herbivores and carnivores as reported from India.

Gastrointestinal parasitic infections in wild animals of India:

The present study provides a comprehensive review of published documents and reports concerning gastrointestinal parasites found in wild animals across India (Fig 1). A majority of the infections found in captive or free ranging animals are helminthic infections. The literature included used the coproscopic methods for faecal samples analysis; direct smear, sedimentation and floatation techniques. Incidence of parasitic infection included in the analyses are organized as

per host and parasitic infection in Table 1.

Infection of GI parasites in wild herbivores:

Wild herbivore animals are susceptible to various kinds of gastrointestinal parasites. Helminth infections were most prevalent in herbivores like spotted deer, blue bull, black buck, sambar, chausinga, barking deer and hog deer (Table 2). Herbivores were infected frequently by nematodes like *Strongyloides* sp., *Strongyle* spp., *Trichuris* spp., *Ascaris* sp., *Trichostrongylus* sp. (Fig. 2). Nematodes have generally direct life cycle, eggs or larval stages directly infect the host via contaminated soil, water and food. *Strongyle*, *Strongyloides* and *Trichostrongylus* types of ova were found frequently in herbivores; third stage larvae are infective stage and inhabit in intestinal tract of the host, many infections are asymptomatic but in young ones it may cause diarrhea, anemia and reduce growth (Bowman, 2008; Zajac *et al.*, 2021). Trichuriasis is also a soil-transmitted helminth, most infections are light and asymptomatic but large number of worms (*Trichuris* spp.) cause inflammation of caecal mucosa associated with watery diarrhoea which usually contains blood (Urquhart *et al.*, 1996). Trematodes like *Paramphistome* sp. and *Fasciola* sp. were also recorded in herbivores. Metacercariae are infective stage of these parasites, when eggs come out through faeces which may enter to the suitable snail (intermediate host) and metacercariae develop and realise outside of the body; infection may occur when animals eat or drink water containing metacercariae (Rolfe *et al.*, 1991), leading weight loss and damages to rumen and reticulum of the host (Tanjung and Sibarani, 2018). While heavy infection of *Fasciola* sp. can develop anemia; juvenile enters in hepatic tissues, also migrates in parenchyma extensively and cause inflammation (Bowman *et al.*, 2008). *Moniezia* sp. was single infection of cestode with indirect life cycle; mites are intermediate host of this cestode, infective stage realised by intermediate host and ingested by definitive hosts and heavy infection reduce growth in young ones

Table 1: List of different parasitic species in various wild animals

Helminth Class	Parasitic Species	Host species
Protozoa	<i>Coccidian oocyst</i>	Barking deer, spotted deer, blue bull, black buck, sambar, chinkara, asiatic lion, tiger, snow leopard, jackal
Cestoda	<i>Spirometra</i> spp.	Tiger, leopard
	<i>Diphyllbothrium latum</i>	Tiger
	<i>Diphyllbothrium</i> sp.	Asiatic lion, leopard, jackal, wolf, hyena
	<i>Taenia</i> sp.	Tiger
	<i>Moniezia</i> spp.	Spotted deer, blue bull, black buck, sambar, hog deer
Trematoda	<i>Fasciola</i> sp.	Spotted deer, blue bull, black buck, sambar
	<i>Paragonimus</i> spp.	Tiger, wolf
	<i>Paragonimus westermani</i>	Tiger
	<i>Paramphistome</i> sp.	Chausinga, spotted deer, black buck, sambar
Nematoda	<i>Spirocera</i> sp.	Tiger, jackal
	<i>Strongyloides</i> sp.	Tiger, leopard, barking deer, blue bull, black buck, sambar
	<i>Strongyle</i> spp.	Asiatic lion, tiger, jackal, chausinga, barking deer, spotted deer, blue bull, black buck, sambar
	<i>Ascaris</i> sp.	Chausingha, sambar
	<i>Oesophagostomum</i> sp.	Sambar
	<i>Trichostrongylus</i> sp.	Spotted deer, blue bull, black buck
	<i>Toxocara</i> spp.	Asiatic lion, tiger, leopard, jackal
	<i>Toxascaris</i> sp.	Tiger
	<i>Toxoascaris leonine</i>	Asiatic lion, tiger, leopard
	<i>Toxocara cati</i>	Asiatic lion, tiger, leopard
	<i>Toxocara canis</i>	Hyena, wolf
	<i>Trichuris</i> sp.	Spotted deer, blue bull, black buck, sambar, chinkara
	<i>Ancylostoma</i> sp.	Asiatic lion, tiger, leopard, hyena, wolf

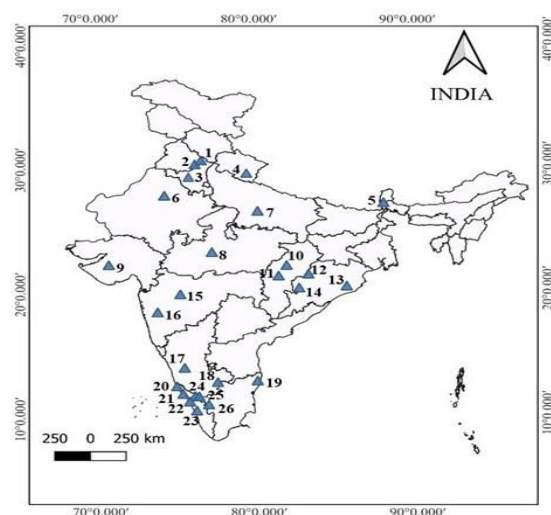


Fig. 1: Locations of reported GI parasites in wild animals of India; (1) Mahendra Chudhary Zoological Park, Punjab; (2) Bir Moti Bagh, Punjab; (3) Hinsar, Hariyana; (4) Tarai region South, Uttarakhand; (5) Tal Chhappar Sanctuary, Rajasthan; (6) Kanpur Zoo, Uttar Pradesh; (7) Padmaja Naidu Himalayan Zoo, West Bengal; (8) Van Vihar National Park, Madhya Pradesh; (9) Rajkot Municipal Corporation Zoo, Gujarat; (10) Kanan pendari Zoo, Chhattisagadh; (11) Nandanvan Zoo, Chhattisagadh; (12) Barnawapara Wildlife Sanctuary, Orissa; (13) Nandankanan Zoo, Orissa; (14) Bhubanesawar, Orissa; (15) Siddharth Muncipal Zoo, Maharashtra; (16) Rajiv Gandhi Park, Maharashtra; (17) Tyavarekoppa Tiger and Lion Safari unit, Karnataka; (18) Bannerghata Biological Park, Karnataka; (19) Arinagar Anna Zoo, Tamil Nadu; (20) Kasaragod, Northern Kerala; (21) Kannur, Northern Kerala; (22) Kozhi, Northern Kerala; (23) Thrissur District, Kerala; (24) Wayanand, Kerala; (25) Wayanand Wildlife Sanctuary, Kerala; (26) V.O.C. Park, Coimbatore Tamil Nadu.

Table 2: Reports of various GI parasites in wild herbivores

Host	Parasitic Species	Locality
Chausingha (<i>Tetracerus quadricornis</i>)	<i>Ascaris</i> spp.	Kanan Pendari Zoo, Chhatisagadh (Thawait and Maiti, 2015)
	<i>Paramphistome</i> sp.	Nandankanan Zoological Park, Orissa (Das <i>et al.</i> , 2018)
	<i>Strongyloides</i> sp.	Nandankanan Zoological Park, Orissa (Das <i>et al.</i> , 2018)
	<i>Strongyle</i> sp.	Nandankanan Zoological Park, Orissa (Das <i>et al.</i> , 2018)
Barking deer (<i>Muntiacus muntjak</i>)	<i>Strongyloides</i> sp.	Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Northern Kerala (Nimisha <i>et al.</i> , 2017); Bhubaneswar, Orissa (Nayak <i>et al.</i> , 2018)
	<i>Coccidian oocyst</i>	Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
Spotted Deer (<i>Axis axis</i>)	<i>Fasciola</i> sp.	Tarai region South, Uttarakhand (Banrejee <i>et al.</i> , 2005); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bhubaneswar, Orissa (Nayak <i>et al.</i> , 2018); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Paramphistome</i> sp.	Tarai region South, Uttarakhand (Banrejee <i>et al.</i> , 2005); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bhubaneswar, Orissa (Nayak <i>et al.</i> , 2018); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Moniezia</i> spp.	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000); Northern Kerala (Nimisha <i>et al.</i> , 2017); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
	<i>Ascaris</i> sp.	Kanan pendari Zoo, Chhatisagadh, (Thawait and Maiti, 2015); Nandanvan Zoo, Chhattisgadh (Thawait <i>et al.</i> , 2014)
	<i>Strongyloides</i> sp.	Bhubaneswar, Orissa (Nayak <i>et al.</i> , 2018); Nandankanan Zoological Park, Orissa (Das <i>et al.</i> , 2018); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009)
	<i>Strongyle</i> sp.	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000); Tarai region South, Uttarakhand (Banrejee <i>et al.</i> , 2005); Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Bhubaneswar, Orissa (Nayak <i>et al.</i> , 2018); Thrissur District, Kerala (Jaya and Aja, 2018); Nandankanan Zoological Park, Orissa (Das <i>et al.</i> , 2018); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020); Nandanvan Zoo, Chhattisgadh (Khutey <i>et al.</i> , 2020)
	<i>Trychostrongylus</i> sp.	Rajkot Municipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001)
	<i>Trichuris</i> sp.	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Hisar, Haryana (Swain <i>et al.</i> , 2017); Nandankanan Zoological Park, Orissa (Das <i>et al.</i> , 2018); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
Blue Bull (<i>Boselaphus tragocamelus</i>)	<i>Coccidia oocyst</i>	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000); Tarai region South Uttarakhand (Banrejee <i>et al.</i> , 2005); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020)
	<i>Fasciola</i> sp.	Tarai region South Uttarakhand (Banrejee <i>et al.</i> , 2005); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Moniezia</i> spp.	Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019); Hisar, Haryana (Sharma <i>et al.</i> , 2021)
	<i>Paramphistome</i> sp.	Tarai region South Uttarakhand (Banrejee <i>et al.</i> , 2005); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Strongyloides</i> sp.	Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016)
	<i>Strongyle</i> sp.	Tarai region South, Uttarakhand (Banrejee <i>et al.</i> , 2005); Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020); Hisar, Haryana (Sharma <i>et al.</i> , 2021)
	<i>Trychostrongylus</i> sp.	Rajkot Muncipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001)
	<i>Trichuris</i> sp.	Tarai region South Uttarakhand (Banrejee <i>et al.</i> , 2005); Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020);
	<i>Coccidian oocysts</i>	Tarai region South, Uttarakhand (Banrejee <i>et al.</i> , 2005); Van Vihar National Park,

		Madhya Pradesh(Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Hisar, Haryana (Sharma <i>et al.</i> , 2021)
Black buck (<i>Antelope cervicapra</i>)	<i>Fasciola</i> sp.	Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Moniezia</i> spp.	Thrissur District, Kerala (Jaya and Aja, 2018); Nandanvan Zoo, Chhattisgarh (Khutey <i>et al.</i> , 2020)
	<i>Paraphitome</i> sp.	Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Ascaris</i> sp.	Kanan pendari Zoo, Chhatisagadh (Thawait and Maiti, 2015); Tal Chhapar Sanctuary of Rajasthan (Chouhan <i>et al.</i> , 2021)
	<i>Strongyloides</i> sp.	Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Kanpur Zoological Park, Uttar Pradesh(Niranjan <i>et al.</i> , 2020); Tal Chhapar Sanctuary, Rajasthan (Chouhan <i>et al.</i> , 2021)
	<i>Strongyle</i> sp.	Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016); Thrissur District, Kerala (Jaya and Aja, 2018); Nandanvan Zoo, Chhattisgarh (Khutey <i>et al.</i> , 2020); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020); Tal Chhapar Sanctuary, Rajasthan (Chouhan <i>et al.</i> , 2021)
	<i>Trichuris</i> sp.	Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020); Tal Chhapar Sanctuary, Rajasthan (Chouhan <i>et al.</i> , 2021)
	<i>Coccidian oocysts</i>	Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016)
	<i>Trychostrongylus</i> sp.	Rajkot Muncipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001)
Sambar (<i>Rusa unicolor</i>)	<i>Fasciola</i> sp.	Van Vihar National Park, Madhya Pradesh(Singh <i>et al.</i> , 2009); Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020); Barnawapara wildlife Sanctuary , Chhattisgarh (Verma <i>et al.</i> , 2020); Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Moniezia</i> sp.	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000)
	<i>Paramphistome</i> sp.	Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Van Vihar National Park, Madhya Pradesh(Singh <i>et al.</i> , 2009); Thrissur District, Kerala (Jaya and Aja, 2018); Nandanvan Zoo, Chhattisgarh (Khutey <i>et al.</i> , 2020); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Ascaris</i> sp.	Kanan pendari Zoo, Chhatisagadh (Thawait and Maiti, 2015)
	<i>Strongyloides</i> sp.	Van Vihar National Park, Madhya Pradesh(Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016)
	<i>Strongyle</i> spp.	Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Van Vihar National Park, Madhya Pradesh (Singh <i>et al.</i> , 2009); Thrissur District, Kerala (Jaya and Aja, 2018); Nandanvan Zoo, Chhattisgarh (Khutey <i>et al.</i> , 2020); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Oesophagostomum</i> sp.	Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020);
	<i>Tichuris</i> sp.	Van Vihar National Park, Madhya Pradesh(Singh <i>et al.</i> , 2009); Barnawapara wildlife Sanctuary, Chhattisgarh (Verma <i>et al.</i> , 2020)
	<i>Coccidian oocysts</i>	Van Vihar National Park, Madhya Pradesh(Singh <i>et al.</i> , 2009); Bir Moti Bagh mini zoo (Deer Park), Punjab (Mir <i>et al.</i> , 2016)
Chinkara (<i>Gazella bennettii</i>)	<i>Strongyle</i> sp.	Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
	<i>Trichuris</i> sp.	Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
	<i>Coccidian oocyst</i>	Mahendra Choudhury Zoological Park, Punjab (Singh <i>et al.</i> , 2006a)
Hog deer (<i>Axis porcinus</i>)	<i>Moniezia</i> sp.	Nandanvan Zoo, Chhattisgarh (Khutey <i>et al.</i> , 2020)

(Zajac *et al.*, 2021). Coccidian oocyst were also frequently reported in different herbivores and cause diarrhoea.

Infection of GI parasites in wild carnivores:

Wild felids like asiatic lion, tiger, leopard, white tiger, snow leopard and canids like hyena, jackal,

wolf, and fox were found infected by helminthic and protozoan parasites (Table 3). Gastrointestinal parasites have different life cycle stages and animals may be infected by either an intermediate host of parasites or a faecal-oral route. Infections of *Toxocara*, *Strongyle*, *Ancylostoma*, *Spirometra*, and *Diphyllbothrium*

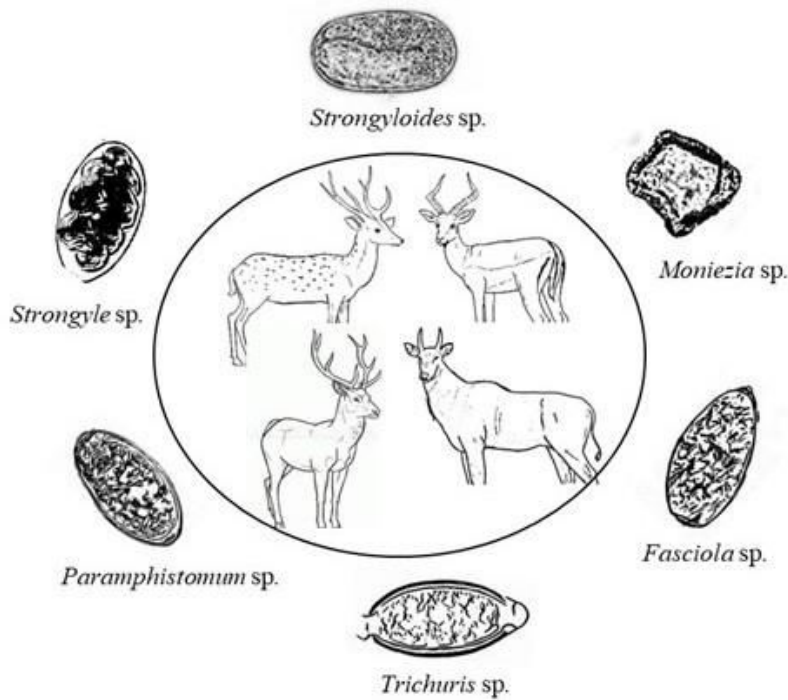


Fig 2. Common GI parasites in wild herbivores

Table 3: Reports of various GI parasites in wild carnivores

Host	Parasitic Species	Locality
Asiatic Lion (<i>Panthera leo</i>)	<i>Diphylobothrium</i> sp.	Sidhharth Muncpal Zoo, Maharashtra (Ghoke <i>et al.</i> , 2012); Nandanvan Zoo, Chhattisgad (Thawait <i>et al.</i> , 2014)
	<i>Strongyle</i> spp.	Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Toxocara</i> spp.	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000); Rajkot Muncpal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001); Nandanvan Zoo Chhattisagadh (Thawait <i>et al.</i> , 2014); Kanan pendari Zoo, Chhatisagadh (Thawait and Maiti, 2015); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Toxascaris leonina</i>	Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Nandankanan Zoo, Orissa (Dehuri <i>et al.</i> , 2013); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Toxocara cati</i>	Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a)
	<i>Ancylostoma</i> sp.	Rajkot Muncpal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001); Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Nandankanan Zoo, Orissa (Dehuri <i>et al.</i> , 2013); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Coccidian oocyst</i>	Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016)
Tiger (<i>Panthera tigris</i>)	<i>Spirometra</i> sp.	Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Northern Kerala (Nimisha <i>et al.</i> , 2017); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Diphylobothrium latum</i>	Wayanad Wildlife Sanctuary, Kerala (Arjun <i>et al.</i> , 2017)
	<i>Taenia</i> sp.	Wayanad Wildlife Sanctuary, Kerala (Arjun <i>et al.</i> , 2017); Northern Kerala (Nimisha <i>et al.</i> , 2017)
	<i>Paragonimus</i> sp.	Sidhharth Muncpal Zoo, Maharashtra (Ghoke <i>et al.</i> , 2012); Northern Kerala (Nimisha <i>et al.</i> , 2017)
	<i>Paragonimus</i>	Wayanad Wildlife Sanctuary, Kerala (Arjun <i>et al.</i> , 2017)

	<i>westermanni</i>	
	<i>Spirocera</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
	<i>Strongyloides</i> sp.	Northern Kerala (Nimisha <i>et al.</i> , 2017); Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020)
	<i>Strongyle</i> sp.	Arignar Anna Zoological Park, Tamil Nadu (Balaji <i>et al.</i> , 2016); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Wayanad Wildlife Sanctuary, Kerala (Arjun <i>et al.</i> , 2017); Northern Kerala (Nimisha <i>et al.</i> , 2017)
	<i>Toxocara</i> spp.	Rajkot Municipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001); Kanan pendari Zoo, Chhatisagadh, (Thawait and Maiti, 2015); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Wayanad Wildlife Sanctuary, Kerala (Arjun <i>et al.</i> , 2017); Northern Kerala (Nimisha <i>et al.</i> , 2017); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019); Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
	<i>Toxoascaris</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008); Arignar Anna Zoological Park, Tamil Nadu (Balaji <i>et al.</i> , 2016)
	<i>Toxascaris leonina</i>	Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019); Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020)
	<i>Trichuris</i> sp.	Wayanad Wildlife Sanctuary, Kerala (Arjun <i>et al.</i> , 2017)
	<i>Ancylostoma</i> sp.	Rajkot Municipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	Nematode larva	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Coccidian oocyst</i>	Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
White tiger	<i>Spirocera</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008)
Snow leopard (<i>Panthera uncia</i>)	<i>Spirometra</i> spp.	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Toxocara</i> spp.	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Toxascaris leonina</i>	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Toxocara cati</i>	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Coccidian oocyst</i>	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
Leopard (<i>Panthera pardus</i>)	<i>Spirometra</i> spp.	Rajkot Municipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001); Sidhharth Municipal Zoo, Maharashtra (Ghoke <i>et al.</i> , 2012); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016)
	<i>Diphyllobothrium</i> spp.	Sidhharth Municipal Zoo, Maharashtra (Ghoke <i>et al.</i> , 2012); Nandanvan Zoo, Chhattisgad (Thawait <i>et al.</i> , 2014)
	<i>Strongyloides</i> sp.	Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020)
	<i>Strongyle</i> sp.	Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Toxocara</i> spp.	Rajkot Municipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001); Kanan pendari Zoo, Chhatisagadh, (Thawait and Maiti, 2015); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016); Nandanvan Zoo, Chhattisgad (Thawait <i>et al.</i> , 2014); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019); Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Toxoascaris leonina</i>	Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a)
	<i>Toxocara cati</i>	Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020); Padmaja Naidu Himalayan Zoological Park, West Bengal (Pariyar <i>et al.</i> , 2021)
	<i>Ancylostoma</i> sp.	Mahendra Chaudhary Zoological Park, Punjab (Singh <i>et al.</i> , 2006a); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
Hyena (<i>Hyaena hyaena</i>)	<i>Diphyllobothrium</i> spp.	Nandanvan Zoo, Chhattisgad (Thawait <i>et al.</i> , 2014)
	<i>Toxocara canis</i>	Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020)
	<i>Ancylostoma</i> sp.	Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
Jackal (<i>Canis aureus</i>)	<i>Diphyllobothrium</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008)
	<i>Diphylidium</i> spp.	Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)
	<i>Strongyle</i> spp.	Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016)
	<i>Toxocara</i> spp.	Kanan pendari Zoo, Chhatisagadh, (Thawait and Maiti, 2015); Tyavarekoppa Tiger and Lion Safari unit, Karnataka (Javaregowda, 2016)

	<i>Spirocera</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008; Pawar <i>et al.</i> , 2019)
	<i>Ancylostomum</i> spp.	V.O.C. park and Mini Zoo, Tamil Nadu (Varadharajan and Kandasamy, 2000); Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Coccidian oocyst</i>	Kanpur Zoological Park, Uttar Pradesh (Niranjan <i>et al.</i> , 2020);
Fox (<i>Vulpes bengalensis</i>)	<i>Coccidian oocyst</i>	Rajkot Municipal Corporation Zoo, Gujarat (Parasani <i>et al.</i> , 2001)
Wolf (<i>Canis lupus pallipes</i>)	<i>Toxocara canis</i>	Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Paragonimus</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008)
	<i>Ancylostoma</i> sp.	Bannerghatta Biological Park, Karnataka (Manjunatha <i>et al.</i> , 2019)
	<i>Diphyllbothrium</i> sp.	Rajiv Gandhi Zoological Park, Maharashtra (Shrikhande <i>et al.</i> , 2008)
	<i>Diphylidium</i> spp.	Rajiv Gandhi Zoological Park, Maharashtra (Pawar <i>et al.</i> , 2019)

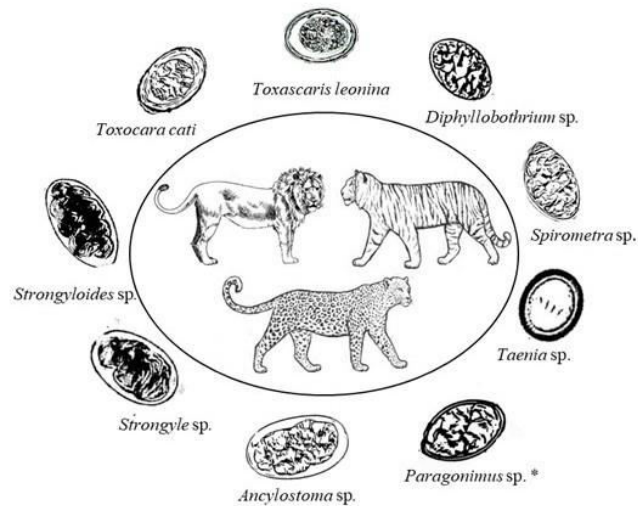


Fig 3. Common GI parasites in wild felids. *only found in Tiger.

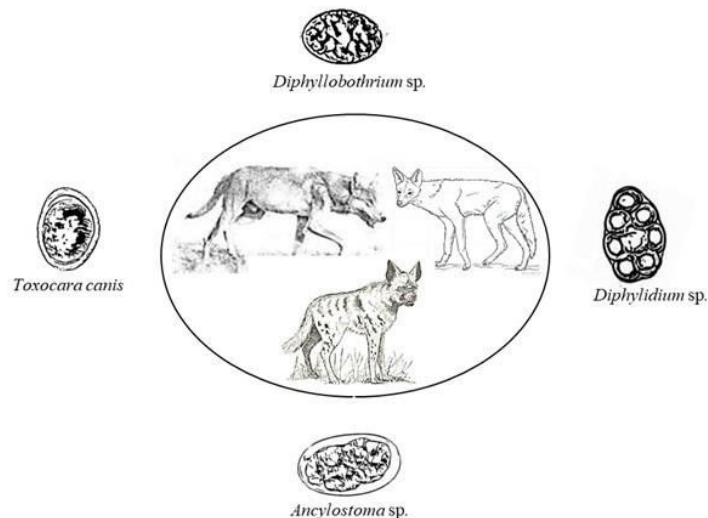


Fig 4. Common GI parasites in wild canids.

were frequently found in felids (Fig. 3) and canids (Fig. 4).

Common nematode infections viz., *Spirocera* sp., *Strongyloides* sp., *Strongyle* spp., *Toxocara* spp.,

Toxoascaris leonina, *Toxocara cati*, *Toxocara canis* and *Ancylostoma* sp. were reported in wild carnivores. All these nematodes have a direct life cycle, eggs are shed through faeces and the

infective stage develops in a suitable environment which may be ingested by the definitive host. Several species of *Toxocara* were prevalent in carnivores; it causes Toxocariasis, especially in felids causing illness in all age groups and mortality in young ones (Acharjyo, 2004). *T. canis* and *T. cati* can cause chronic ill-thrift in young ones, while *Toxoascaris* is much less common with minor clinical significance (Bowman, 2008; Zajac *et al.*, 2021). Several other helminthic infections of cestodes were recorded in carnivores viz., *Spirometra* spp., *Tania* sp., *Diphyllobothrium* sp., *Diphyllobothrium latum*. The presence of *Spirometra* and *Diphyllobothrium* might be due to ingestion of contaminated food with infective second stage (spargana) as their life included two intermediate host - cyclopes are first intermediate host while snakes, birds and mammals are second intermediate host; adult worm lives in small intestine mainly to subcutaneous tissues which cause pain and inflammation (Soulsby, 1982; Zajac *et al.*, 2021). Few cases were reported of *Paragonimus* sp. and *Paragonimus westermani* a trematode infection in tigers. Crabs and crayfish are intermediate hosts and transmission may occur through the consumption of infected lower carnivores as they often include fish and crabs in their diets (Arjun *et al.*, 2017). The flukes remain inside the lung parenchyma and rarely in the brain, spinal cord and other organs without causing serious damage (Acharjyo, 2004).

Treatment of GI parasites:

For the control of GI parasites in captive wild animals, drug applications are mainly consisting as therapeutic management of parasitic infections. However, few studies reported for the treatment of GI parasites of wild herbivores as compared to carnivores. Albendazole was used to treat *Trichuris* spp., *Strongyle* spp., *Monezia* spp. in herbivores and *Toxocara* spp., *Diphylidium* spp. in carnivores at Rajiv Gandhi Zoological Park and Wildlife Animal Research Center at Pune, Maharashtra (Pawar *et al.*, 2019). Combination of fenbendazole along with praziquantel was used

against the infection of *Ancylostoma* spp. and *Spirometra* spp. in captive Royal Bengal Tiger at Kanan Pendari Zoo, Bilaspur, Chhatisagadh (Chandrakar *et al.*, 2023). Kumar *et al.* (2005) reported the use of ivermectin against Toxocariasis in Lion, which were previously treated with piperazine at Mahendra Chaudhari Park, Patiala, Punjab. Dose of ivermectin (0.3 mg/kg body weight) reduced 100% eggs count of *Toxoascaris leonina* and *Ancylostoma* spp. in lion, while pyrantel pamoate and levamisole were used at Nandankanan Zoo, Orrisa (Dehuri *et al.*, 2013). Combination of oxclozanide and levamisole were also used to treat infection of *Ancylostoma* spp., *T. leonina* and *Spirometra* spp. in captive lion at Bannerghatta Biological Park, Bengaluru, Karnataka (Ganger *et al.*, 2019). Albendazole, piperazine adipate, pyrantel pamoate, sulphadimidine, fenbendazole were given to different age group of lion in captivity at Mahendra Choudhary Zoological Park, Punjab to treat infection of *Toxascaris leonina*, *Toxocara cati* and *Ancylostoma* spp.; however, re-occurrence of *T. leonina* infection was observed by day 30 post-treatment (Singh *et al.*, 2006b).

Conclusion

Studies on gastrointestinal parasitic diseases of wild herbivores and carnivores are most important for the conservation of animals. Helminthic and protozoan infection were most prevalent in wild animals. Nematodes were commonly spread followed by trematodes and cestodes. Present study provides information gap for detailed epidemiological study of GI parasites in wild animals. Appropriate identification and diagnosis of parasite through molecular techniques will help to prevent parasitic infection. Also regular monitoring of the parasites, transmission to other host and understanding behavioural strategies to avoid parasites by host will prevent and control parasitic infection in captive and wild dwelling animals.

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