



Parasites and parasitic diseases of wildlife in India. 2 . Carnivores and birds

M B CHHABRA¹ and K M L PATHAK²

Indian Council of Agricultural Research, New Delhi 110 001 India

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ABSTRACT

The impact of parasites on health and conservation of wildlife is increasingly recognized as an important area. There is a woeful paucity of Indian literature other than sporadic case reports, on captive as well as free-ranging animals/birds. The order Carnivora is a large group having 8 families of which felids and canids contain important members with a substantially shared spectrum of parasites and diseases caused by them. Bulk of the information relates to helminths, several of which are associated with important disease conditions and resultant morbidity and occasional mortality. These include the trematode *Paragonimus*, the cestode *Echinococcus* / hydatid and the nematodes, *Toxocara/Toxascaris*, *Baylisascaris*, *Ancylostoma*, *Uncinaria*, *Galonchus*, *Dirofilaria*, *Strongyloides*, *Spirocerca* and *Gnathostoma*. Almost all of them are transmissible to man and thus have zoonotic significance. Among protozoan maladies, trypanosomiasis, babesiosis and coccidian infections are prominent. Regarding wild birds, the data is derived almost entirely from those in captivity of cages in zoos across the country. Most studies relied on faecal examination but a few necropsy reports were also accessible, including fatal parasitisms. In general, the trematodes were almost entirely Echinostomatids, the cestodes were Davaineids, Dilepidids and Hymenolepidids, and the nematodes comprised Subuluroids, Trichuroids, Spiruroids and Filaroids. In recent years, some dedicated first records at necropsy, have contributed to the information pool. These include ascarid *Contracaecum spiculiugerum* in a wild pelican, highly pathogenic echinostomid *Balfouria monogama* in an endangered stork species, and another nodular fluke *Chaunocephalus ferox* in another species of stork. The most prevalent protozoans in birds are coccidia, some of which are pathogenic. The arthropods are made up of predominantly phthirapteran lice, and less often ticks, mites and fleas. For control, regular anthelmintics and other antiparasitic agents as employed in their domestic counterparts, are variously reported to be effective.

Key words: Birds, Carnivores, Parasites, Parasitic diseases, Wildlife

The Order Carnivora includes over 250 species of wild carnivores distributed worldwide, of which around 60 species belonging to 8 families are found in India (Acharjyo 2002). Majority of them are flesh-eaters but some like bears, civets, etc. are omnivorous. Now there is a palpable resurgence of interest in the conservation and rehabilitation of wildlife. As a consequence, projects such as 'Project Tiger' are in operation across the country. Many carnivore species are also exhibited as captive show animals in zoos or in free-ranging bio-parks. Regardless of habitat, the health care of these valuable animals remains a major concern of the managers and veterinarians tasked with their upkeep. Increased attention to healthcare has found manifestation in the organizations of seminars, symposia, workshops and training programmes at regional/national levels as well as publication of books/journals on the subject. As an off-shoot of these, a

mass of recent information has been generated (Chhabra and Pathak 2012). Parasitic infections of various aetiologies, constitute a perpetual challenge, and depending on their degree, may cause high morbidity and mortality. The young may become unthrifty with consequent lowered resistance and exhibition value. Additionally, some zoonotic parasites pose a risk factor for the handlers. Parasites and parasitic diseases of carnivores have been treated in inclusive reviews on wildlife in general (Arora 1994, Islam 2006). However, there was also a dedicated review (Nashiruddullah and Chakraborty 2001) on parasites of captive wild carnivores, but limited to Asom State Zoo (ASZ) only. Acharjyo (2004) addressed the subject on a national scale but dealt with helminthiasis only. For obvious reasons, the data in literature is almost entirely related to animals in captivity. In the present review, the data is proposed to be arranged according to the major carnivore host families. In each case, the helminths constitute the predominant group with regard to the number of known parasites, as well as the important disease conditions they may cause.

Present address: ¹(chhabra.manmohan@gmail.com), 2518, Sector D-2, Vasant Kunj, New Delhi 110 070. ² Deputy Director General (Animal Sciences), ICAR, Krishi Bhavan, New Delhi 110001(ddg.icar@nic.in).

Family Felidae (cats)

Due to vastness of data on helminth parasites, it has been detailed separately for important felid host species, while protozoa and arthropods are being dealt collectively on whole-family basis. In general, the intensity of infection in older felids was significantly lesser than their younger counterparts (Kumar and Rao 2003, Singh *et al.* 2006).

The wild cat (*Felis chaus*) was found parasitized with the trematode *Euparyphium malayanum* at necropsy in Baranga zoo, Odisha (Patnaik and Acharjyo 1970) while coprological evidence for *Euparyphium* sp. was found in Nandankanan zoo (Mahali *et al.* 2010). The cestode recorded in the first-named report (Patnaik and Acharjyo 1970) was *Spirometra erinaceae* while *Hymenolepis* sp. and *Diphyllbothrium* sp. were identified as faecal eggs at Thrissur Zoo, Kerala (Varadharajan *et al.* 2001).

More recently, another cestode *Joyeuxiella pascalei* was reported at necropsy in a wild cat at Puducherry (Das *et al.* 2011). It was incriminated for catarrhal enteritis in duodenum among other pathological changes. Among nematodes, specific identification of *Toxocara cati* at necropsy was credited to Patnaik and Acharjyo (1970) at Baranga zoo. Coprological finding of *Toxocara* sp. eggs was reported from Thiruvananthapuram zoo (Varadharajan and Pythal 1999), Thrissur zoo (Varadharajan *et al.* 2001), both in Kerala, and from Nandankanan in Odisha (Mahali *et al.* 2010). In between *Toxocara* at necropsy was found in ASZ, Asom (Nashiruddullah and Chakraborty 2001) and *Filaroides osleri* at postmortem (p.m.) at Maharajbagh, Nagpur (Dakshinkar *et al.* 2001). The other ascarid of cats, viz. *Toxascaris* was also recorded as faecal eggs in Nandankanan (Mahali *et al.* 2010). The latter was reported *Ancylostoma* eggs in faeces following another report of the same from Coimbatore in Tamil Nadu (Varadharajan and Kandasamy 2000). Evidence via faecal examination for eggs was also produced for spirurids by these workers at Coimbatore and at Thrissur (Varadharajan *et al.* 2001). The latter report had *Capillaria* sp. as the additional finding. The pathogenic filariid *Filaroides osleri* was reported from Maharajbagh zoo (Dhoot *et al.* 2002), while the only acanthocephalan from felids *Oncicola* sp. was recorded in Asom (Patnaik and Acharjyo 1970).

Leopard cat (*Prionailurus bengalensis*): Two cestodes and 5 nematode species have been recorded. *Echinococcus granulosus* at necropsy in Thekkady, Kerala (Easwaran *et al.* 2003) was found associated with enteritis and was regarded as the probable cause of death. *Diphyllbothrium latum* was found at necropsy in ASZ, Asom (Nashiruddullah and Chakraborty 2001). As regards nematodes, faecal ascarid eggs and *Toxocara caris* worms at necropsy were reported from Thekkady in Kerala (Easwaran *et al.* 2003). Earlier, *Ancylostoma braziliense* at necropsy in Baranga zoo, Odisha (Patnaik and Acharjyo 1970) and faecally from Lucknow

and Kanpur zoo (Gaur *et al.* 1979) were reported. In Nandankanan zoo, Rao and Acharjyo (1984) recovered *A. caninum* at necropsy while in the same zoo, *Filaroides osleri* was found in the bronchioles or in nodules in the lung (Rao *et al.* 1971, Rao and Acharjyo 1984).

Another felid, Golden cat (*Catopuma temminkei*) was found to harbour the trematode *Paragonimus westermanii* at necropsy in Nandankanan zoo (Rao and Acharjyo 1984, 1991). *Toxocara cati* was found by faecal examination at Baranga zoo (Patnaik and Acharjyo 1970) and *Dirofilaria immitis* at necropsy in Nandankanan (Rao and Acharjyo 1993), all in Odisha.

Bengal tiger (*Panthera tigris*): The only trematode *P. westermanii* was variously reported at necropsy from lung tissue, such as Nandankanan Bio-Park, Odisha (Rao and Acharjyo 1984, 1991), Corbett National Park, Uttar Pradesh (Arora and Das 1988), Kanha National Park, Madhya Pradesh (Parihar and Shrivastava 1988), Chennai, Tamil Nadu (Latha *et al.* 2000) and ASZ, Asom (Nashiruddullah and Chakraborty 2001). The cestodes recorded were *Taenia pisiformis* and *Spirometra erinaceae* in Baranga zoo, Odisha (Patnaik and Acharjyo 1970), *T. taeniaeformis* from Corbett National Park, Uttar Pradesh (Gaur *et al.* 1980) and *Spirometra* sp. from Chennai, Tamil Nadu (Latha *et al.* 2000). The reports on nematodes being numerous are given in Table 1.

Lion (*Panthera leo*): Recent records of trematodes include eggs of *Nanophyetes salmincola* in faeces at Maharajbagh zoo, Nagpur (Dhoot *et al.* 2002) and *Schistosoma* spp. In faecal samples at Nandankanan zoo, Odisha (Mahali *et al.* 2010). Clinical schistosomiasis had been reported from Maharashtra (Shrikhande *et al.* 2002). The only record of cestode was hydatid cyst in liver at Nagpur Zoo (Ganorkar *et al.* 1997). The reports on nematodes is given in Table 2.

Leopard / panther (*Panthera pardus*): Among trematodes, *Paragonimus* had been reported at necropsy from Kerala (Pythal *et al.* 1993) in a leopard which had fatal concurrent parasitism with the hookworm *Galonchus pernicius*. Coprologically the lung fluke was reported from Thiruvananthapuram Zoo (Varadharajan and Pythal 1999) and from Maharajbagh Zoo, Nagpur (Dhoot *et al.* 2002). From the latter locality, Dhoot *et al.* (2002) also reported another fluke *Nanophyetes salmincola*. The predominant cestode reported was *Dlatum* from Thiruvananthapuram (Varadharajan and Pythal 1999), Thrissur (Varadharajan *et al.* 2001) and Maharajbagh, Nagpur (Dhoot *et al.* 2002) by faecal examination. The same was found at necropsy at Asom State Zoo (Nashiruddullah and Chakraborty 2001). *Dipylidium* sp. was reported from Nagpur (Dhoot *et al.* 2002) while faecal positivity for *Mesocostoides lineatus* in a leopard cub from Baranga Zoo, Odisha (Patnaik and Acharjyo 1970). *Spirometra* has been variously recorded from Rajkot zoo (Parsani *et al.* 2001) and from Nagpur (Gawande *et al.* 2007). Recently, Ananda *et al.* (2011) identified *Taenia taeniaeformis* and *spirometra mansonoides* in a dead leopard

Table 1. Nematode infection in Bengal tiger

Nematode name	Procedure	Locality	Reference
<i>Toxocara cati</i>	Faecal	Baranga Zoo, Odisha	Patnaik and Acharjyo (1970)
<i>Toxocara</i> sp.	Faecal	Thiruvananthapuram Zoo, Kerala	Varadharajan and Pythal (1999)
<i>Toxocara</i> sp.	Faecal	Rajkot Zoo, Gujarat	Parsani <i>et al.</i> (2001)
<i>T.canis</i> adult	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>T.canis</i> (Larva in pulmonary tissue)	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>T. cati</i>	Faecal	MC Zoological Park, Chhatbir, Punjab	Singh <i>et al.</i> (2006)
<i>Toxocara</i> sp.	Faecal	Nandankaran Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Toxoscaris leonine</i>	Faecal	Lucknow and Delhi Zoos	Chauhan <i>et al.</i> (1973)
<i>Toxoscaris leonine</i>	Faecal	Uttar Pradesh	Gaur <i>et al.</i> (1979)
<i>Toxoscaris leonina</i>	Faecal	Uttar Pradesh	Arora and Das (1988)
<i>Toxoscaris leonine vomitus</i>	Necropsy and	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Toxoscaris leonine</i>	Faecal	Maharajbagh Zoo, Nagpur	Dhoot <i>et al.</i> (2002)
<i>Toxoscaris leonina</i>	Faecal	MC Zoological Park, Chhatbir, Punjab	Singh <i>et al.</i> (2006)
<i>Toxoscaris</i> sp.	Faecal	Nandankaran	Mahali <i>et al.</i> (2010)
<i>Ancylostoma</i> sp.	Faecal	Lucknow and Delhi Zoos	Chauhan <i>et al.</i> (1973)
<i>Ancylostoma</i> sp.	Faecal	Uttar Pradesh	Gaur <i>et al.</i> (1979)
<i>Ancylostoma</i> sp.	Faecal	Thiruvananthapuram Zoo	Varadharajn and Pythal (1999)
<i>Ancylostoma</i> sp.	Faecal	Rajkot Zoo, Gujarat	Parsani <i>et al.</i> (2001)
<i>Ancylostoma</i> sp.	Faecal	Maharajbagh Zoo, Nagpur	Dhoot <i>et al.</i> (2002)
<i>Ancylostoma</i> sp.	Faecal	MC Zoological Park, Chhatbir	Singh <i>et al.</i> (2006)
<i>A. braziliense</i>	Necropsy	Chennai (TN)	Jeya Thilakan <i>et al.</i> (2007)
<i>Ancylostoma</i> sp.	Faecal	Nandankaran Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Dirofilaria immitis</i>	Necropsy	Nandankaran Zoo, Odisha	Rao and Acharjyo, (1993)
<i>Dirofilaria immitis</i>	Necropsy	Birsa Biological Park, Ranchi	Gupta <i>et al.</i> (1999)
<i>Dirofilaria immitis</i>	Necropsy	Birsa Biological Park, Ranchi	Haque and Ahmed (2002)
<i>Capillaria aerophila</i>	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Trichuris</i> sp.	Necropsy	Corbett National Park, U.P.	Arora and Das (1988)
<i>Ollulanus tricuspis</i>	Necropsy	Sundarbans, West Bengal	Mandal and Chaudhury (1988)
<i>Bronchostrongylus subcrenatus</i>	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Gnathostoma spinigerum</i> adult	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Gnathostoma spinigerum</i> adult (Larva in liver)	Necropsy	Vandaloor Zoo, Chennai	Thilakan <i>et al.</i> (2007)
<i>Gnathostoma spinigerum</i> adult	Necropsy	Vandaloor Zoo, Chennai	Thilakan <i>et al.</i> (2007)
<i>Gnathostoma spinigerum</i> adult	Necropsy	Pench Tiger Reserve, Madhya Pradesh	Shrivastava <i>et al.</i> (2011)
<i>Galonchus perniciosus</i>	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Strongyloides</i> sp.	Faecal	Thiruvananthapuram Zoo	Varadharajan and Pythal (1999)
<i>Spirocerca lupi</i>	Faecal	Maharajbagh Zoo, Nagpur	Dhoot <i>et al.</i> (2002)
<i>Physaloptera</i> sp.	Faecal	Nandankaran Zoo, Odisha	Mahali <i>et al.</i> (2010)

in forest near Shimoga, Karnataka.

The reports on nematodes were numerous and given in Table 3.

The list was extended by *Spirocerca lupi* in Oesophagus and *Gnathostoma spinigerum* from the gastric wall of leopard (Arora and Chakraborty 2009).

Other felids: In clouded leopard (*Neofelis nebulosa*), faecal eggs of cestodes, viz. *Spirometra erinaceae* and *Taenia taeniaformis* at Baranga zoo, Odisha (Patnaik and Acharjyo 1970) and *Diphyllbothrium latum* at ASZ, Asom (Nashiruddullah and Chakraborty, 2001) were found. Toxocariasis in snow leopard (*Panthera uncia*) from Darjeeling Zoo (Maity *et al.* 1994) and hydatidosis in jaguar (*Panthera onca*) from Zoological Park at Chennai

(Sathasivam *et al.* 2009) were also recorded.

Disease conditions due to helminthic infections

Paragonimiasis is widely distributed in both free-living and captive wild carnivores. The flukes remain inside the cysts chiefly in lung parenchyma and are rarely the cause of death. Grossly small greyish white nodules up to 1 cm in diameter and microscopically bronchial hyperplasia due to infiltration with mononuclear cells under the epithelial lining (Parihar and Shrivastava 1988) were observed. Cysts containing one or more reddish brown oval-shaped flukes could be seen in one or both lungs, which may also show patches of atelectasis and emphysema (Rao and Acharjyo 1991). Echinococcosis / hydatidosis in which both adult

Table 2. Nematode infection in captive lion

<i>Toxocara</i> sp.	Faecal	Zoological Park, Coimbatore (T.N.)	Varadharajan and Kandasamy (2000)
<i>Toxocara</i> sp.	Faecal	Thrissur Zoo, Kerala	Varadharajan <i>et al.</i> (2001)
<i>Toxocara</i> sp.	Faecal	Rajkot Zoo, Gujarat	Parsani <i>et al.</i> (2001)
<i>Toxocara</i> sp.	Faecal	Waynad, Kerala	Ravindran <i>et al.</i> (2006)
<i>T. cati</i>	Faecal	MC Zoological Park, Chhatbir (Punjab)	Singh <i>et al.</i> (2006)
<i>Toxocara</i> sp.	Faecal	Nandankanan Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Toxascaris</i>	Faecal	Lucknow Zoo	Chauhan <i>et al.</i> (1973)
<i>Toxascaris</i>	Faecal	Lucknow and Kanpur Zoo	Gaur <i>et al.</i> (1979)
<i>Toxascaris</i> sp.	Faecal	Bikaner Zoo	Tanwar <i>et al.</i> (1984)
<i>Toxascaris</i> sp.	Faecal	Thiruvananthapuram Zoo	Varadharajan and Pythal (1999)
<i>Toxascaris</i> sp.	Faecal	Thrissur Zoo	Varadharajan <i>et al.</i> (2001)
<i>T. leonoina</i>	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>T. leonoina</i>	Faecal	Maharajbagh Zoo, Nagpur	Dhoot <i>et al.</i> (2002)
<i>T. leonoina</i>	Faecal	MC Zoological Park, Chhatbir (Punjab)	Singh <i>et al.</i> (2006)
<i>Toxascaris</i>	Faecal	Waynad, Kerala	Ravindran <i>et al.</i> (2006)
<i>Toxascaris</i>	Faecal	Nandankanan Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Ancylostoma</i>	Faecal	Rajkot Zoo, Gujarat	Parsani <i>et al.</i> (2001)
<i>A. duodenale</i> and <i>A. paraduodenale</i>	Necropsy	Zoolgoical Park, Gwalior	Agrawal and Chauhan (2001)
<i>Ancylostoma</i> sp.	Faecal	Thrissur Zoo, Kerala	Varadharajan <i>et al.</i> (2001)
<i>Ancylostoma</i> sp.	Faecal	Maharajbagh Zoo, Nagpur	Dhoot <i>et al.</i> (2002)
<i>Ancylostoma</i> sp.	Faecal	MC Zoological Park, Chhatbir (Punjab)	Singh <i>et al.</i> (2006)
<i>Ancylostoma</i> sp.	Faecal	Nandankanan Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Galonchus pernicius</i>	Faecal	Baranga Zoo, Asom	Patnaik and Acharjyo (1970)
<i>Dirofilaria immitis</i>	Necropsy	Nandankanan Zoo, Odisha	Rao and Acharjyo (1993)
<i>Dirofilaria immitis</i>	Necropsy	Birsa Biological Park, Ranchi	Gupta <i>et al.</i> 1999Haque and Ahmed, (2002)
<i>Dirofilaria immitis</i>	Necropsy	Asom State Zoo	Narshiruddullah and Chakraborty (2001)

Table 3. Nematode infection in captive leopard/panther

<i>Toxocara</i> sp.	Faecal	Rajkot Zoo, Gujarat	Parsani <i>et al.</i> (2001)
<i>T. cati</i>	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Toxocara</i> sp.	Faecal	M.C. Zoological Park, Chhatbir (Pb)	Singh <i>et al.</i> (2006)
<i>Toxocara</i> sp.	Faecal	Nandankanan Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Toxascaris leonina</i>	Faecal	Lucknow and Delhi Zoo	Chauhan <i>et al.</i> (1973)
<i>Toxascaris</i> sp.	Faecal	Thiruvananthapuram Zoo	Varadharajan and Pythal (1999)
<i>T. leonina</i>	Faecal	Maharajbagh Zoo, Nagpur	Dhoot <i>et al.</i> (2002)
<i>T. leonina</i>	Faecal	Bannerghata Biological Park, Bangalore	Chandranark <i>et al.</i> (2005)
<i>Ancylostoma</i> sp.	Faecal	Nehru Zoo, Hyderabad	Suresh <i>et al.</i> (2000)
<i>Ancylostoma</i> sp.	Faecal	Thrissur Zoo	Varadharajan <i>et al.</i> (2001)
<i>Ancylostoma</i> sp.	Faecal	MC Zoological Park, Chhatbir (Pb)	Singh <i>et al.</i> 2006
<i>Ancylostoma</i> sp.	Faecal	Nandankaran Zoo, Odisha	Mahali <i>et al.</i> (2010)
<i>Ancylostoma</i> sp.	Faecal	Wayanad distt. Kerala	Ravindran <i>et al.</i> (2011)
<i>Uncinca</i> sp.	Necropsy	Asom State Zoo	Nashiruddullah and Chakraborty (2001)
<i>Galonchus pernicius</i>	Necropsy	Barang Zoo, Odisha	Patnaik and Acharjyo (1970)
<i>G. pernicius</i>	Necropsy	Thiruvananthapuram	Pythal <i>et al.</i> (1993)
<i>Dirofilaria immitis</i>	Necropsy	Nandankanan	Rao and Acharjyo (1993)
<i>Dirofilaria immitis</i>	Necropsy	Birsa Biological Park, Ranchi	Haque and Ahmed, (2002)
<i>Filaroides osleri</i>	Necropsy	Bannerghatta Biological Park, Bangalore	Chandranark <i>et al.</i> (2005)
<i>Strongyloides</i> sp.	Faecal	Thrissur Zoo, Kerala	Varadharajan <i>et al.</i> (2001)

worms in small intestine as well as metacystode stage were reported in wild carnivores. The adult tapeworms are known to cause catarrhal enteritis. Because of potential human infection, all of these parasitic conditions are considered zoonotic (Acharjyo 2004). *Dirofilaria immitis* or heartworm disease caused principally by *D.immitis* is a vector-borne

disease of zoonotic importance. The disease has been reported in a wide range of felids and canids. Clinically, dyspnoea, anorexia, posterior weakness and at necropsy, hypertrophy of right ventricle and obstruction of pulmonary artery with a bunch of worms at site of its origin from right ventricle (Gupta *et al.* 1999). Treatment with diethyl carbamezate (DEC)

citrate @ 3mg/kg b.w. for 35 days was suggested. Hookworm infections caused by *Ancylostoma* spp., *Uncinaria* spp. and *Galonchus perniciosus*, are associated with haemorrhagic and necrotic enteritis with resultant blood loss and anaemia. Further, *G. perniciosus* is known to cause formation of intestinal nodules containing encysted parasites surrounded by a zone of inflammatory cells (Chanda *et al.* 1995, Nashiruddullah and Chakraborty 2001). Toxocariasis, particularly *Toxascaris leonina* is most common in carnivores, specially felids (Nashiruddullah and Chakraborty 2001), causing morbidity in all age groups and mortality in young ones. Successful treatment of clinical toxocariasis (*T.cati*) in snow leopards was reported from Darjeeling zoo (Maiti *et al.* 1994) Mixed infection of *Toxocara*, *Ancylostoma* and tapeworm was treated by ivermectin injection (Sur *et al.* 2001). Piperazine resistant toxocariosis in lions was managed by ivermectin (Kumar *et al.* 2005). Gastro intestinal helminths *T.leonina* and *Ancylostoma* spp. infections in panthers were treated with ivermectin @200 ig kg⁻¹ b.w. intramuscular, pyrantel pamoate @ 10 mg kg⁻¹ b.w., albendazole @ 3 g/animal as single dose, piperazine adipate @ 100 mg kg⁻¹ b.w. and Prazital (combination of praziquantel with pyrantel pamoate and fenbendazole) in different groups (Singh *et al.* 2006). Treatment with appropriate drug was effective in controlling the different parasites but ivermectin and piperazine were considered drugs of choice in their respective categories. Therapeutic efficacy of 3 antinematodal drugs, albendazole, pyrantel pamoate and ivermectin, was tried in tigers (Sahoo *et al.* 2010). Clinical gnathostomiasis with nodular growths in the stomach was found in an adult tigress that died at Dudhwa National Park, Uttar Pradesh (Arora and Prasad 1989). There were ulcerative and necrotic changes along with peritonitis. Observations of Thilakan *et al.* (2007) at Vandaloor Zoo, Chennai were also similar. The p.m. examination also revealed large numbers of *A.braziliense* worms. Zoonotic gnathostomiasis of human eye has been reported from north-east India recently (Barua *et al.* 2007, Islam *et al.* 2011).

Protozoa and protozoan diseases of wild felids: The wild felids are frequent subject to clinical trypanosomiasis. It was reported in the jungle cat (*Felis chaus*) in Maharajbagh Zoo, Nagpur, characterized by bilateral corneal opacity (Dakshinkar *et al.* 2002) and in Nandankanan (Sahoo *et al.* 2009). According to Acharjyo (2000), large cats especially tigers are more susceptible. Accordingly, sporadic cases with pyrexia, anorexia, panting, occasional convulsions and sudden death as major signs, were reported (Chaudhary *et al.* 1986, Upadhye and Dhoot 2000a, Devasena and Shobhamani 2006). Outbreaks such as that among circus tigers in Andhra Pradesh involving 5 adults and 4 cubs (Bhaskara Rao *et al.* 1995) and in Nandankanan (Parija and Bhattacharya 2001) resulting in death of 12 members of this valuable animal. Cure of trypanosomiasis in tiger cubs with triquin (quinapyramin) in Madhav National Park, Madhya

Pradesh was reported (Saxena 1993) and in a tiger with diminazine aceturate (Upadhye and Dhoot 2000a, Devasena and Shobhamani 2006). Another haemoprotozoan *Babesia* sp. is also quite prevalent among wild felids. Case reports from Ranchi Zoo in a tigress with characteristic haemoglobinuria (Sinha *et al.* 2000), low-grade parasitaemia in a lion in Lucknow zoo (Haque 2007), fatal cases among tigers at Zoological Park, Chhatbir in Punjab (Misra *et al.* 2008) and among leopards including fatal cases at Nagpur Zoo (Upadhye and Dhoot 2000b, Baviskar *et al.* 2007). Initial records of feline coccidia include *Eimeria hammondi* and *E.mathari* from Mathura (Dubey and Pande, 1965), *Isospora/I. felis* oocysts were found in faeces of tigers and lions at Lucknow (Chauhan *et al.* 1973), Mysore (Muraleedharan and Iswariah 1984), Chhatbir, Punjab (Singh *et al.* 2006) and Nandankanan (Mahali *et al.* 2010). *Isospora* oocysts in faeces of a leopard were recorded at Lucknow (Agrawal *et al.* 1981), Nandankanan (Mahali *et al.* 2010) and in Kerala (Ravindran *et al.* 2011), while *I.viverrina* from fishing cat (*Prionailurus viverrina*) was described (Agrawal and Chauhan 1993) as a new species from Mathura.

Arthropod parasites: Myiasis in footpad wound due to *Sarcophaga* sp. in lion at ASZ, Asom (Nashiruddullah and Chakraborty 2001). Severe infestation with flea *Ctenocephalides felis felis* in leopard cat (*F. bengalensis*) from Asom (Islam 2010) and *Sarcoptes scabiei* mange infestation in lions at Bikaner Zoo (Gaurava and Singh 1999) were reported. In the last named, ivermectin was found effective for controlling mange. Ticks of genus *Haemaphysalis* are frequently found as listed by Geevarghese *et al.* (1997) such as *H.silvafelis* on jungle cat, *H.kinneari* on tiger, and *H.cuspidata* on leopard. Two species of *Amblyomma*, viz. *A.hebraeum* on tiger in Asom (Geevarghese *et al.* 1997) and an unidentified *Amblyomma* sp. on tiger at ASZ, Asom (Nashiruddullah and Chakraborty 2001) were also reported.

Fam. Viverridae (civets)

Trematodes reported include *Echinoparyphium* sp. from a palm civet (*Paradoxus hermaphroditus*) at Nandankanan (Rao and Acharjyo 1984), *Echinoparyphium* sp. and *Artyfechinostomum* sp. in large Indian civet (*Viverra zibetha*) from Nandankanan (Rao and Acharjyo 1995). *Artyfechinostomum malayanum* was reported from a small Indian civet (*Viverricula indica*) by Amrithraj *et al.* (1999). *Artyfechinostomum* sp. was also reported from civet cat at Coimbatore (Varadharajan and Kandasamy 2000) and from palm civet (*Paradoxurus grayi*) and small Indian civet in Thrissur Zoo (Varadharajan *et al.* 2001). A case report of paragonimiasis in a civet cat came from Manipur (Singh *et al.* 1998). The cestode *Joyeuxiella* sp. was recorded from palm civet in Thrissur Zoo (Varadharajan *et al.* 2001) while *Sparganum* was found postmortem in the subcutaneous tissue of the small Indian civet in ASZ, Asom (Nashiruddullah and

Chakraborty 2001). Faecal presence of nematode eggs included ascarid, spirurid and *Strongyloides* in palm civet in Thiruvananthapuram (Varadharajan and Pythal 1999) and in Thrissur zoo (Varadharajan *et al.* 2001). In the latter report, *Ancylostoma* and *Trichuris* were additional findings in the small Indian civet. Coumarane and Mohan (2008) reported *Ancylostoma* sp. and *Strongyloides* sp. from palm civet at Puducherry. The stomach worm *Rictularia cahirensis* was recovered at necropsy in the large Indian civet (Rao and Acharjyo, 1995), small Indian civet at ASZ, Asom (Nashiruddullah and Chakraborty 2001) and in a civet cat (*Viverricula malaccensis*) from Pantnagar, Uttaranchal (Kumar *et al.* 2005).

Fam. Hyaenidae

In striped hyaena (*Hyaena striata* or *Crocuta crocuta*), the lung fluke *P.westermani* was recorded in Nandankanan Zoo (Rao and Acharjyo 1995), while the cestodes *Dipylidium caninum* and *Diphylobothrium latum* from Mathura, Uttar Pradesh (Dubey 1963). Faecal examination revealed presence of nematode eggs of *Toxascaris* at Lucknow zoo (Chauhan *et al.* 1973), *Toxocara* at Thiruvananthapuram (Varadharajan and Pythal 1999) ascarid and *Ancylostoma* sp. at ASZ, Asom (Nashiruddullah and Chakraborty 2001), *Ancylostoma* sp. and *Trichuris* sp. at Nandankanan (Mahali *et al.* 2010). *Dirofilaria immitis* was recorded at Nandankanan (Rao and Acharjyo, 1995) and microfilariae in blood in Birsa Biological Park, Ranchi (Haque and Ahmad 200). Of protozoa, only coccidian oocysts identified as *Isospora levinei* were recorded at Nandankanan zoo (Rao and Acharjyo 1995). The latter also recorded the tick *Amblyomma javanensis* while *A. testudinarium* is also known to parasitize this host (Geevarghese *et al.* 1997).

Fam. Herpestidae

In the mongoose (*Herpestes edwardsi*), the only helminth found was the lung fluke *P.westermani* at necropsy at Nandankanan zoo and Biol. Park, Odisha (Rao and Acharjyo 1984, 1991, 1995). The protozoa recorded include *Babesia bengalensis* n. sp. described by Bandyopadhyay and Ray (1985) and coccidian oocysts in faeces identified as *Eimeria pandei*, *E.neulei* and *Isospora horaki* (Rao and Acharjyo 1995).

Fam. Canidae (Dogs and allies)

Ancylostomiasis in the Indian wild dog (*Cuon alpinus*) or Dhole was recorded from Arignar Anna Zoological Park, Chennai (Devaki *et al.* 2006) while *Dirofilaria immitis* had been reported earlier from Nandankanan (Rao and Acharjyo, 1993, 1995). The protozoan known in this host is a *Sarcocystis* sp. which was found to shed faecal sporocysts in Mudumalai and Tadoba National Parks and follow a chital-dhole life cycle (Jog *et al.* 2003). Upon confirmation of the obligatory 2 host cycle, the species was named as *S.axicuonis*

(Jog *et al.* 2005). The tick *Rhipicephalus sanguineus* (Geevarghese *et al.* 1997) of canids is cosmopolitan. In jackal (*Canis aureus*), concurrent infection of the trematode *Nanophyetus salmincola* with *Ancylostoma* sp. and *Isospora* sp., has recently been reported from a zoological part in Vellore (Latchumikanthan *et al.* 2012). The cestode *Echinococcus granulosus* was reported from Nandankanan (Rao and Acharjyo 1984). The occurrence of *Toxocara canis* had been recorded from ASZ, Asom (Nashiruddullah and Chakraborty 2001). The hookworm *Ancylostoma caninum* was more widely reported, viz. Nandankanan (Rao and Acharjyo 1984, 1995), Thiruvananthapuram (Varadharajan and Pythal 1999), Coimbatore (Varadharajan and Kandasamy 2000), Thrissur (Varadharajan *et al.* 2001), ASZ, Asom (Nashiruddullah and Chakraborty 2001), Maharajbagh, Nagpur (Dhoot *et al.* 2002) and MC Zool. Park, Chhatbir (Singh *et al.* 2006). Instance of aortic spirocercosis characterized by intimal surface riddled with haemorrhagic spots and nodulation was recorded from Mathura (Agrawal *et al.* 1986) while multiple nodular growths on oesophageal wall and constriction of its lumen were associated with a case report from Asom (Islam and Nashiruddullah 2000a). The parasites were enclosed in pus-filled nodular cavities. Other nematodes reported were *Dirofilaria immitis* from Nandankanan (Rao and Acharjyo 1993, 1995) and Birsa Biol. Park, Ranchi (Haque and Ahmad 2002), *Strongyloides* sp. and *Capillaria* sp. from Thrissur zoo (Varadharajan *et al.* 2001). Geevarghese *et al.* (1997) had listed the ticks *Haemaphysalis indoflava* and *R. sanguineus* from this host. Another important member of canidae family, viz. the Indian fox (*Vulpes vulpes* or *Vulpes begalensis*) plays host to an assortment of parasites. Among cestodes, *Dipylidium caninum* and *Mesocestoides lineatus* were recovered p.m. from Baranga zoo (Patnaik and Acharjyo 1970) and in Nandankanan (Rao and Acharjyo 1995). Large numbers of *Mesocestoides* were found in a wild fox near Srinagar (Pandit *et al.* 2007). Clinical ancylostomiasis (*A.caninum*) in captive fox cubs from Puducherry (Coumarane *et al.* 2009) was documented while the faecal prevalence of this parasite was earlier reported from Coimbatore Zoo (Varadharajan and Kandasamy 2000). Another hookworm *Uncinaria stenocephala* was recorded at p.m. from Baranga zoo (Patnaik and Acharjyo 1970). The heartworms *Dirofilaria immitis* and *D.repens* had also been recorded in Nandankanan (Rao and Acharjyo 1984, 1993, 1995) at necropsy. Pandit *et al.* (2007) recovered *Physaloptera* sp. from a dead wild fox near Srinagar. Other than helminths, coccidian species, viz. *Eimeria vulpes*, *E. hissani* and *I. vulpes* from Nandankanan (Rao and Acharjyo 1995) and arthropods like *Sarcoptes* (Pandit *et al.* 2007) and tick species *Haemaphysalis indoflava* and *R.sanguineus* (Geevarghese *et al.* 1997) are also on record. In the wolf (*Canis lupus*), the cestode *Echinococcus granulosus* was reported from Nandankanan Zoo (Rao and Acharjyo 1995). *Toxocara canis* was found in 5 wolf pups which died in

Darjeeling zoo (Chakraborty and Maiti 1995). *Ancylostoma braziliense* was found p.m. in two young wolves in Lucknow zoo (Chauhan *et al.* 1973). Large number of the hookworms were found attached to the mucosa and prominent lesions of enteritis were observed. The heartworm *D. immitis* had been recorded in wolf in Nandankanan (Rao and Acharjyo 1993, 1995) and Birsā Biol. Park, Ranchi (Haque and Ahmad 2002). Apart from these, the acarine *Haemaphysalis anomala* is listed from this host (Geevarghese *et al.* 1997).

Fam. Mustelidea

From the hog badger (*Arctomys collaris*), *Uncinaria (Anthrocephalus) longispiculum* had been recovered from pancreatic nodules in Nandankanan (Rao and Acharjyo 1984, 1995).

Fam. Ursidae (Bears and allies)

A free-ranging Himalayan black bear (*Selenarctos thibetinus*) in Asom was found infected with *Baylisascaris transfuga* (Islam and Nashiruddullah 2000b). Clinical symptoms of intermittent dysentery and anorexia were associated with the infection which was successfully treated with piperazine citrate @ 100mg/kg b.w. for 3 consecutive days. Faecal ascarid eggs as well as worm passed in vomitus of this host species in ASZ, Asom (Nashiruddullah and Chakraborty 2001) were observed. Hookworms *Ancylostoma caninum* in Nandankanan (Rao and Acharjyo 1995) and *A. malayanum* (Islam and Nashiruddullah 2000b) were also infecting black bears. Among arthropods, the species was found infected with the flea *Ctenocephalides felis* at p.m. at ASZ, Asom (Nashiruddullah and Chakraborty 2001). The tick *Haemaphysalis obesa* has found listing (Geevarghese *et al.* 1997). In the sloth bear (*Melurus ursinus*), *Hymenolepis* spp. in Nandankanan by faecal examination has been reported (Mahali *et al.* 2010). *Ancylostoma caninum* at necropsy from Nandankanan (Rao and Acharjyo, 1984) was found. Nematode eggs in faeces of sloth bear were observed as trichurid from Lucknow Zoo (Chauhan *et al.* 1973), strongyle in Thiruvananthapuram Zoo (Varadharajan and Pythal 1999), strongyle and spirurid in Thrissur Zoo (Varadharajan *et al.* 2001) and ascarid from MCZ, Chhatbir in Punjab (Singh *et al.* 2009).

Parasites and parasitic diseases of zoo/wild birds

Helminths: The birds in zoo are often subject to the additional stress of caged captivity and overcrowding, conditions which are conducive for the development of parasites. The incidence of helminthic parasites in all birds was found higher than in carnivores, omnivores and herbivores (Dhoot *et al.* 2002). As such, despite a regular deworming regime, parasitic infections varying between 25 and 99% have been reported in zoo birds at various locations in India (Parsani *et al.* 2007a). Majority of the studies were based on faecal examination of pooled samples from cages

housing the birds. The pioneering work of Patnaik and Acharjyo (1970) on the helminth parasites of birds, as part of vertebrates in Baranga Zoo, Odisha, stands out for authenticity being based on p.m. examination and also for its host-wise listing. Out of 80 birds in 18 species belonging to 6 major orders viz. Ciconiformes (5), Gruiformes (1), Falconiformes (3), Galliformes (4), Columbiformes (1) and Passeriformes (4), 71 (88.75%) were found infected with 28 different helminths (5 trematodes, 12 cestodes, 10 nematodes and one acanthocephalan). The trematodes were all Echinostomatids; the cestodes were Davaineids, Dilepidids and Hymenolepidids; the nematodes comprised Subuluroids, Spiruroids and Filaroids, and the lone acanthocephalan being *Centrorhynchus globocaudatum* from a barred jungle owl. The trematodes were recorded in ciconiformes birds such as white ibis (*Threskiornis melanocephala*), black ibis (*Pseudibis papillosa*), open billed stork (*Anastomus oscitans*) and one bird of order Gruiformes, viz. sarus crane (*Grus antigone*). One of the trematodes *Chaunocephalus ferox* found in open bill stork was associated with intestinal nodular disease (Patnaik *et al.* 1970). Helminthic eggs in faecal samples of several avian species at Lucknow and Delhi Zoos, were detected by Chauhan *et al.* (1973) who identified one or more of spiruroid, ascarid and capillarid types. The Indian peafowl (*Pavo cristatus*), Burmese peafowl (*Pavo munticus*) and guineafowl (*Numida meleagris*) were found infected with all 3 types. Other than these, *Strongyloides avium* was found in golden pheasant (*Chrysolophus pictus*) and in parakeet (*Psittacula eupatsia*) and hymenolepid in saras (*Grus antigone*) and common crane (*Grus grus*). All of these parasitoses were without apparent clinical symptoms. Prevalence of g.i. parasites in captive birds at Bannerghatta National Park, Bengaluru (Jayagopala Reddy *et al.* 1992) by faecal examination was nematodes (31%) comprising *Ascaridia* sp., strongyle and *Capillaria* sp. in almost equal proportion, followed by the tapeworm *Hymenolepis* 6.9%. In birds maintained at the zoos in Gujarat, faecal positivity of the order of 48.11% was recorded (Patel *et al.* 2000). Nematode eggs of ascarid and capillarid type were observed. During p.m. examinations, *Ascaridia galli* and the cestode *Cotugnia digonopora* were recovered from 3 pigeons, while *A. galli* alone was found in parrot, peacock and cockatiel. A study in Maharajbagh Zoo at Nagpur (Dhoot *et al.* 2002) observed that while *Ascaridia* and *Capillaria* were predominant in birds, *Raillietina tetragona* and *Subulura brumpti* were recorded from cockatoo (*Cockatoo galleria*) and *R. tetragona* and *Davainea* sp. in peafowl. Kashid *et al.* (2002) in 6 different locations of Maharashtra found an incidence of 88.33% parasitic infections in peacocks, predominantly helminthic in nature. Faecal screening for endoparasites among free-ranging peafowl at Tirunelveli and Kanyakumari in Tamil Nadu (Subramanian *et al.* 2003) revealed a range of nematodes (*Heterakis*, *Ascaridia*, *Capillaria*, *Syngamus*, *Strongyloides*), an acanthocephalan

and an unidentified cestode egg. Acuarid worms identified as *Skrjabinocara squamata* were recovered at necropsy from the gizzard and proventriculus of 3 cormorants (*Phalacrocorax niger*) in Chennai (Tamil Nadu) by Selvaraj *et al.* (2003). Assessment of parasitic infections in captive zoo birds in Ahmedabad, Baroda, Junagadh and Rajkot (Parsani *et al.* 2003, 2007a) revealed 57.32% of 232 pooled faecal samples positive while eggs of *Ascaridia* sp. and *Capillaria* sp. were predominant, *Trichostrongylus* sp., *Strongyloides* sp., spiruroid, *Dispharynx* sp. and *Heterakis* were also identified. Cestode infection (*Raillietina* sp.) was observed only in Columbiformes birds and trematode (*Lypersoma*) infection in Ciconiformes and Falconiformes birds. The authors speculated that fish fed to the birds of these 2 groups might have acted as a source of fluke infection. The absence of alarming infection levels could be credited to regular deworming schedule every 3 months for 3 days in drinking water. Chemotherapy of nematodiasis (heavy infection with *Ascaridia columbae* and *Capillaria obsignata*) in pigeons (Parsani *et al.* 2007b) with albendazole @30 to 45 ml/100 birds for 3 days in drinking water (group 1) and fenbendazole 10% @ 1 ml/15 birds for 3 days (group 2) gave reduction in EPG of 89% and 90%, respectively. Parasitic infections among captive birds at Sayaji Bagh, Baroda through faecal examination, showed 73.01% positively (Parsani and Momin 2009). Trematode infection was high (80.69%) in carnivorous birds. At Maharajbagh zoo, Nagpur, high positivity in pigeons with g.i. helminths, viz. *Capillaria* sp., *Ascaridia* sp. and *Heterakis* sp. was reported (Borghare *et al.* 2009) while a later report from the same location also recorded *Prosthogonimus* sp. (Gawande *et al.* 2010). Fatal *Ascaridia galli* infection in guinea fowl (*Numida meleagris*) was reported from Jammu region (Sudhan *et al.* 2009). Postmortem examination of intestinal tract of the common myna (*Acridotheres tristis*) at Namakkal, Tamil Nadu (Ponnudurai *et al.* 2009) yielded *Diplotriaena* (5) and *Raillietina* spp. (6). Extensive nodular lesions on the wall of small intestine of Greater Adjutant stork (*Leptoptilos dubius*), an endangered bird, induced by the echinostomatid parasite *Balfouria monogama* were observed at postmortem in Asom (Islam *et al.* 2009a). The extensive pathological changes indicated that the parasite was highly pathogenic. Another nodular fluke *Chaunocephalus ferox* was recovered from a carcass of open billed stork (*Anastomus oscitans*) from KNP, Asom (Islam *et al.* 2009b). The flukes had produced extensive nodules on the small intestine wall and histopathological evidence suggested that they were highly pathogenic. *Contracaecum spiculigerum*, an ascarid nematode was encountered at p.m. examination in a wild spotted billed pelican (*Pelecanus philippensis philippensis*) in KNP, Asom (Islam and Talukdar 2009). Free-ranging Lesser Adjutant storks are also affected with trematodes (Arora and Chakraborty 2009) which can induce nodular lesions. The bile duct and liver of Brahminy duck (*Tadorna ferruginea*)

were found affected by another trematode *Opisthorchis brahmini* (Arora and Chakraborty 2009).

Protozoa: The most prevalent protozoan infections are coccidia. Chauhan *et al.* (1973) identified *Eimeria dubeyi* and *E.vanmurghavi* from Red jungle fowl (*Gallus gallus*), *Isospora choudarii* from Grey jungle fowl (*G.sonneratii*), *E.gorakhpuri* from guinea fowl, *E.mayurai*, *E.pavonis*, *E.mandali* and *I.mayuri* from peafowl, *E.teetari* from Black partridge (*Francolinus francolinus*) and chakor partridge (*Caecabis chakor*), *E.pictus* from Golden pheasant (*Chrysolophus pictus*) and Silver pheasant (*Lophura nyathemera nippone*), *E.meleagridis* or *E.adenoeides* in Amherst pheasant (*Chrysolophus amherstiae*), *E.tropicalis* from white pigeon (*Columba Livia*), *E.grusi* from saras (*Grus antigona*), *I.koreani* from Korean pheasant (*Phasianus colchicus*), *E.choudari* from ring dove (*Streptopelia decasto*) and *I.mandari* from Mandarin duck (*Aix glericulata*). Coccidia were also observed in captive peacocks, rock pigeon, parrot (*Psittacula krarneri*), Silver pheasant and Grey jungle fowl at a zoological park in Bangalore (Jayagopala Reddy *et al.* 1992). In a study on g.i. parasites of captive birds of 138 species at a zoo in Ahmedabad, Parsani *et al.* (2003) found 85.48% of 138 group faecal samples positive for coccidian oocysts. A later study (Parsani *et al.* 2007a) covering 4 zoos in Gujarat, found 69.17% of 232 pooled faecal samples (cage-wise) of different wild birds, positive for *Eimeria* oocysts. However, the species were not identified. In free-ranging Indian peafowl in Tamil Nadu (Subramanian *et al.* 2003), both *Eimeria* and *Isospora* oocysts were identified. Coccidia species in the Blue rock pigeon (*Columa livia*) known to occur in India, viz. *E.columbae*, *E.kapotei*, *E.labbeana*, *E.tropicalis* and *Wenyonella columbae* were extended with a new species named *E.janovyi* (Bandopadhyay *et al.* 2006). Of these, *E.columbae* and *E.tropicalis* can provoke catarrhal enteritis and cause losses in young birds. Another pathogenic protozoan *Trichomonas gallinae* was found common in pigeons (Bhattacharya *et al.* 1997). In 50 zoo and wild pigeons, examination for *T.gallinae* infection by oesophageal swabs and crop contents under phase contrast microscope showed higher (70%) positivity for oesophageal swabs than from crop content samples (Parsani *et al.* 2007c). Clinical trichomonosis in a 25-day-old pigeon squab and its treatment with metrogyl suspension (Lali *et al.* 2010) was reported. An outbreak of pigeon malaria (*Haemoproteus columbae*) in which 25 pigeons died at a zoo in Hyderabad (Rao *et al.* 1992) was reported. The haemosporids identified as intraerythrocytic gametocytes, were found associated with *Ornithostrongylus quadriradiatus* infection in intestinal contents. The birds showed anorexia, torticollis, debility, weight loss and anaemia, treatment with chloroquine sulphate 5 ml/litre of drinking water for 3 days followed by albendazole in water, stopped mortality and brought about recovery. Recently, prevalence of *Haemoproteus* in 266 rock pigeons was reported at 55.63%

and of *Plasmodium* as 6.76% (Gupta *et al.* 2011). A study on the prevalence of *Toxoplasma* antibodies in sera of chickens, pigeons, turkeys, geese and quails, found the highest positivity in pigeons (Geetha *et al.* 2002).

Arthropods: Phthirapteran ectoparasites are common on Indian birds (Singh *et al.* 1998, Saxena *et al.* 2007, Khan *et al.* 2009). Four species of lice were found prevalent in wild pigeons in Rampur, Uttar Pradesh (Khan *et al.* 2009) viz. *Columbicola columbae*, *Companulotes bidentatus compar*, *Calpocephalum turbinatum* and *Hohorstiella lata* in descending order of prevalence. The common myna (*Acridotheres tristis*) was found heavily infested with *Menacanthus eurysternus* (Chandra *et al.* 1990). *Menacanthus stramineus* had been found on free-ranging peafowl in Tamil Nadu (Subramanian and Raman 2002) and on bush-dwelling grey partridge (*Perdix perdix*) in Tamil Nadu (Ponnudurai *et al.* 2003). Brown francolin (*Francolinus pondicerianus*) in Uttarakhand (45.83% of 14%) were found infested with 2 species i.e. *M.kalatitar* and *Goniocotes jirufi* (Singh *et al.* 2009). More recently, prevalence of *Myrsidea salimalii*, an amblyceran louse was found infesting striated babblers (*Turdoides earlei*) in Uttar Pradesh (Ahmad *et al.* 2011). Ectoparasites on free-ranging peafowls included the lice *Menacanthus* sp., flea *Ctenocephalides felis orientalis* and tick *Haemaphysalis* sp. (Subramanian and Raman 2002). Mite infestation (*Dermanyssus gallinae*) in 6.52% psittacid and phasianid birds at Baroda, Gujarat was found (Parsani and Momin 2009). In their checklist on Indian ticks, Geevarghese *et al.* (1997), listed some records from birds viz. *Amblyomma testudinarium* in jungle fowl, *Haemaphysalis bispinosa*, *H. cuspidata* and *H.turturis* from several bird species, *H.canestrini* from jungle fowl, *H.wellingtoni* from gallinaceous birds, *Argas (Persicargus) persicus* from Indian myna, pigeon and pheasant. Also listed was *A.robertsi* from cormorant, heron, egret, open-billed stork and ibis.

Consistent with the current interest in the conservation and rehabilitation of wildlife, provision of adequate health care is imperative. Effective monitoring and surveillance system for diseases must include parasites in their ambit. In carnivores several of the helminthic disease conditions are of zoonotic significance which imparts added urgency to appropriate measures for their surveillance and control. For epidemiological studies, necropsy procedure should supplement faecal examination wherever feasible. All organs/tissues should be thoroughly searched and pathological changes, both gross and histological, should be recorded and correlated. The haemoprotozoan diseases of carnivores such as trypanosomiasis and babesiosis are frequently fatal and call for greater vigilance on part of health managers. The key to prevention of a recurrence of the infamous Nandankanan episode of 2000 (wherein loss of 12 tigers to trypanosomiasis occurred within a short time), lies in a presumptive diagnosis from clinical signs confirmed by blood

examination, and prompt treatment. Control of vectors like haematophagous flies and ticks is another issue which is often overlooked but needs to be addressed in endemic areas. In caged zoo birds, regular anthelmintic treatment schedule must be put in place. Greater attention to management of pathogenic echinostomatids of birds through control of snail intermediate hosts is also desired. Free-ranging birds often fly over long distances and may disseminate pathogens/parasites to new regions.

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