



An overview of parasites of Wildlife in India. I . Herbivores, primates and reptiles

M B CHHABRA¹ and K M L PATHAK²

Indian Council of Agricultural Research New Delhi 110 001 India

Received: 6 September 2012; Accepted: 3 November 2012

ABSTRACT

Despite India's wealth of biodiversity, knowledge on the parasites of its herbivorous wildlife, other than elephant, has remained patchy and disorganized. Initially, it was based mostly on chance findings and planned studies were few and far between. Even so, early workers relied on faecal examinations leading to only broad identification of the infecting parasites as coproculture was scarcely done. Collections at autopsy wherever done, brought out more specific prevalence data. Broadly, the parasitic fauna of Indian rhinoceros are *Fasciola*, amphistomes, *Anoplocephala*; 6 genera of nematodes, viz. *Killiluma*, *Chabertia*, *Necator*, *Bunostomum*, spirurid (unidentified) and *Strongylus*. The zebra and wild asses apparently share the parasitic spectrum of the domestic equids, including the pathogenic *Strongylus vulgaris*. In the order *Artiodactyla*, the forest-dwelling animals like the deer species, wild caprids, bovids and suids, all were found to have considerable commonality with their domestic counterparts regarding various helminth parasites, and even protozoa and arthropods. Eco-geographical (along with some other) factors seem to influence prevalences. Parasites of non-human primates are only partially identical to humans while those of Indian reptiles are unique to their hosts. The parasite records so far are by no means complete for most wild hosts. This review has attempted to highlight some of the more deficient areas for further systematic investigation while suggesting some guidelines.

Keywords: Parasites, Parasitic diseases, Primates, Reptiles, Wild herbivores

Conservation of wildlife is an essential component of environmental rejuvenation. India is blessed with great climatic diversity naturally favourable to a vast spectrum of animal species. The highly fragile ecosystem of the country still carries > 340 mammals, > 1200 birds, > 420 reptiles and > 140 amphibians (Jani and Patel 2001). Unfortunately, due to several man-made factors, majority of them have undergone enormous reduction in their numbers and some are endangered. Opinion on the importance of healthcare among aspects of wildlife conservation is now gathering momentum, and has found expression in an occasional book (Arora 1994). Although parasites and diseases caused by them are recognized as important health problems, wildlife parasitology in India is still in its infancy. In the absence of an adequate surveillance and monitoring system, there had been only sporadic reports and reviews (Chakraborty *et al.* 1994, Acharjyo 2000, Islam 2006) on the topic. Majority of these reports had information based on animals maintained in captivity in regional zoological gardens or parks. The flow

of information has been continuous in recent years and has considerably advanced our knowledge. The objective of this review is to update the comprehensive information in order to gain a composite nation-wide perspective on this highly relevant subject of wildlife parasites. In view of the vastness of the subject, it is proposed to be dealt in two parts. The first of these is devoted to wild herbivores excluding the Indian elephant, mithun and yak, which have already been covered in an earlier review (Pathak and Chhabra 2012). Non-human primates and reptiles have also been included in this part. Parasites and parasitic diseases in different species of these wild animals are discussed as hereunder.

Indian one-horned rhinoceros: The one-horned rhinoceros (*Rhinoceros unicornis*) taxonomically belongs to the mammalian order *Perissodactyla*. Majority of the Indian rhinos are found in Asom at the Kaziranga National Park (KNP) where the latest census (IANS 2012) has put their numbers at 2290. The major threat to their conservation is poaching due to the supposed medicinal properties of the horn. The liver fluke *Fasciola gigantica* as cause of fatal fascioliasis in a captive rhino calf in Asom was documented (Bhattacharjee and Halder 1971). The symptoms and pathological changes were similar to those observed in fascioliasis in other animals. Another case of fasciolosis due

Present address: ¹Professor and Head (Retd.) Veterinary Parasitology 2518, Sector D-2, Vasant Kunj, New Delhi 110 070 (chhabra.manmohan@gmail.com). ²Deputy Director General (Animal Sciences) (ddgas.icar@nic.in).

to *F. gigantica* has been reported from Pobitora wild life sanctuary (Arora and Chakraborty 2009). Other trematodes like amphistomes and schistosomes are also known to affect rhinos (Khan 1979). Chakraborty (1991) and Chakraborty *et al.* (1994) in Asom recorded *Paramphistomum* sp. and 2 other varieties of conical flukes in the small intestine, while Varadharajan and Pythal (1999) found both *Fasciola* and amphistomes on faecal examination of rhinos at a zoo in Kerala. Anoplocephalid tapeworms had also been recorded variously in captive rhinos (Chauhan *et al.* 1973, Arora 1986, Chakraborty 1991, Chakraborty *et al.* 1994). The last named found anoplocephalid infection at post mortem (p.m.) not only in small intestine but also in biliary system of the rhino. However, despite large number of parasites in the liver, much pathogenicity could not be observed by light microscopy. However, Scanning electron microscopic study showed tissue destruction in the biliary system. EDAX study showed significant variation in the concentration of elements in the affected biliary tissue (Chakraborty 1991). *Anoplocephala magna* was recovered from the small intestine and stomach of rhino on autopsy at a Zoological Park at Chhatbir in Punjab (Singh *et al.* 2006). In a survey of gastro-intestinal (g.i.) parasitic infections in free-ranging rhinos at KNP, Asom (Chakraborty and Islam 1993), 52 of 84 faecal samples (61.90%) were found positive. Paramphistomes (39 positive) were found predominant, followed by strongyle (17) and *Anoplocephala* (2). An investigation on the occurrence of *Gongylonema* infection in captive wild herbivores (Chakraborty 1994), was negative for these worms in 12 rhinos. A comprehensive study on captive wild herbivores of Asom State Zoo (Chakraborty *et al.* 1994) based on necropsy findings, noted 4 species of nematode parasites in rhino, viz. *Killiluma gordeyi*, *Chabertia* sp., *Necator americanus* and *Bunostomum* sp. Among cestodes, *Anoplocephala* was the commonest parasite of rhino (7/12), found in the bile duct in addition to small intestine. Hydatid cyst in the liver was the only other cestode. Varadharajan and Pythal (1999) found evidence of spirurid infection in rhinos in Kerala. Arora and Chakraborty (2009) have recorded occurrence of *Chabertia* species in free living rhino at Pobitora wildlife sanctuary of Asom. Recently, the occurrence of a nematode belonging to the genus *Strongylus* from a free-ranging rhino of KNP, Asom was reported (Sarmah *et al.* 2011). Faecal coccidia in 2 rhinos (Chakraborty and Islam 1993) and cysts of the protozoan *Balantidium coli* were seen in the intestine of a rhino (Chakraborty *et al.* 1994). Among arthropods, the tick *Amblyomma testudinarium* is known to parasitize Indian rhinos (Acharjyo 2000).

Out of 4 zebra (Fam. Equidae) examined at p.m., the lungworm *Dictyocaulus arnfieldi* in 2, *Habronema* in 1 and fly larvae *Gastrophilus intestinalis* (stomach bots) in 1, were recorded in Asom (Chakraborty *et al.* 1994). A study on strongylid helminths in Indian wild asses (*Equus hemionus khur*) in their natural habitat Little Rann of Kutch, based on

faecal examination of 84 animals in 4 flocks (Sengupta and Dey 2009), revealed positivity for 1 or more species of helminths. The pathogenic *Strongylus vulgaris* was present in 19.65% of samples. The other entities observed were *S. edentates*, *S. equinus*, *Gyalocephalus* sp., *Oesophagodontus* sp., *Poteriostomum* sp., *Triodontophorus* sp., *Cyathostomum* sp., *Trichostrongylus* sp. and *Strongyloides* sp.

Deer species (and allied herbivores)

The deer belong to the order *Artiodactyla*, of which family *Cervidae* contains the genera like *Cervus*, *Axis* and *Muntiacus*. Family *Tragulidae* has genus *Tragulus*. Some other genera like *Antelope*, *Gazella*, *Tetracerus*, *Bos* and *Boselaphus* are placed in the family *Bovidae*. Apart from the deer species, *Artiodactyla* also includes some deer-like caprines such as Alpine ibex, Nilgiri tahr and Grey goral. These animals share most of the parasites and will therefore be dealt together for convenience.

Helminth parasites

Trematodes: Chauhan *et al.* (1973) reported the occurrence of amphistomes by faecal examination in spotted deer (*Axis axis*) and chinkara (*Gazella gazella*) at Lucknow zoo and in Sika deer (*Cervus nippon*) at Delhi zoo. At Lucknow zoo, p.m. examination of a spotted deer revealed 'heavy' infection with *Gastrothylax* sp. According to another report from Uttar Pradesh covering Jim Corbett National Park and Kanpur zoo (Gaur *et al.* 1979), infections with *Fasciola gigantica* were fairly high and it, along with amphistomes, appeared to be a well-established parasite of wild deer, notably of spotted deer and barasingha (*Cervus duvaucelli*) at the former location. Rao and Acharjyo (1984) also reported high incidence with *F. gigantica* at necropsy in spotted deer and black buck (*Antelope cervicapra*) and with *Gigantocotyle explanatum* in sambar (*Cervus unicolor*) at Nandankanan zoo, Odisha. Acharjyo (1985) described gross and histological pathology of hepatic amphistomiasis (*Gexplanatum*) in sambar. Other records of amphistomes include occurrence in the rumen of spotted deer of Nandankanan Bio-Park, Odisha (Padhi *et al.* 1987) of 3 species viz. *Paramphistomum cervi*, *Gastrothylax crumenifer* and *Fischoederius elongatus*, *Paramphistomum lobatum* in rumen-reticulum of a black buck at Bareilly, UP (Varma *et al.* 1990), *P. epiclitum* from rumen and *Gexplanatum* from bile duct of sambar at Delhi zoo (Varma *et al.* 1993). A more comprehensive report based on p.m. observation (Chakraborty *et al.* 1994) recorded *Fasciola* in spotted deer (18/33), serow (*Capricornis sumatrensis*) and mithun (*Bos frontalis*), while 6 genera of amphistomes in various deer species and related bovids were identified. Of the amphistomes, genus *Paramphistomum* was the commonest, found in all species of deer but most in spotted deer (26/33), sambar (31/42) and barking deer (*Muntiacus muntjak* 21/41). The other amphistome genera were *Gastrothylax* in spotted deer and sambar, *Fischoederius* in

spotted deer, barking deer, sambar and hog deer (*Axis porcinus*), *Carmyrius* in black buck and mithun, *Cotylophoron* in spotted deer only and *Gigantocotyle* in sambar. *Gastrothylax crumenifer* and *G. glandiformes* were reported from barasingha (Shrivastava *et al.* 1998). Faecal positivity found for amphistomes in spotted deer, sambar and black buck at Thiruvananthapuram zoo, Kerala (Varadharajan and Pythal 1999) in spotted deer, sambar and hog deer at Thrissur zoo, Kerala (Varadharajan *et al.* 2001), in nilgai and spotted deer in Uttarakhand (Banerjee *et al.* 2005) and in sambar at a zoological park in Punjab (Singh *et al.* 2006). At Thrissur zoo, additionally *Fasciola* was recorded in a Kashmiri goat (*Capra sibirica*). Chakraborty (2001) opined that although *F. gigantica* infected all captive cervids in the zoo, only spotted deer were pathologically affected, which found confirmation in records of clinical cases at a deer park in West Bengal (Jana and Jana 2001 a, b) with nodular lesions and fatal outcome in 2 of 12 spotted deer, and a recent outbreak of fascioliasis in spotted deer with 11 fatalities (Sahoo *et al.* 2010) out of 30 inmates of a deer park in Cuttak, Odisha. Gross and histological pathology was also recorded, marked by haemorrhages, ascites and migratory tracts on liver, necrosis and cellular infiltrations in bile ducts. Interestingly, *Dicrocoelium* was recorded from spotted deer at Maharajbagh zoo, Nagpur, Maharashtra (Dhoot *et al.* 2002). Additional recent record also exists of *Fasciola* in sambar deer at Periyar Wildlife Sanctuary, Kerala (Ravindran *et al.* 2011). No record of schistosomes in any deer species could be traced from literature and this aspect merits further exploration.

Cestodes: Mainly limited findings of larval cestodes at p.m., such as hydatid cyst in lungs of spotted deer at Nandankanan zoo, Odisha (Rao and Acharjyo 1984), in spotted deer and Ladakhi goat (*Capra ibex*) in Asom (Chakraborty *et al.* 1994), *Cysticercus* sp. In spotted deer, sambar, barking deer, black buck and nilgai (*Boselaphus tragocamelus*) in Asom (Chakraborty *et al.* 1994), and *Cysticercus tenuicollis* from mesentery of black buck at Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh (Varma *et al.* 1998) are available. *Moniezia* at p.m. was sighted in serow and Ladakhi goat (Chakraborty *et al.* 1994) and faecally as part of g.i. parasites in a sambar deer at Coimbatore Mini zoo (Varadharajan and Kandasamy 2000).

Nematodes: The prevalence of nematode parasites appeared more common than the trematodes and cestodes. Faecal eggs of bursate worms in several species of cervids, wild bovids and tragulids were reported from the zoos of Lucknow and Delhi (Chauhan *et al.* 1973). In addition, trichurid infection in nilgai, spotted deer and chinkara as well as *strongyloides* sp. in black buck were reported. A later report on findings from Jim Corbett National Park and Kanpur zoo (Gaur *et al.* 1979) used larval cultures and identified the stomach worm *Haemonchus contortus* as the predominant infection in wild deer, followed by other strongyles,

Strongyloides papillosus, *Oesophagostomum* sp. and a single case of *Bunostomum* sp. *Haemonchus contortus* was found associated with fatal gastritis in an 8-month-old black buck at a deer park in Hisar (Sadana *et al.* 1980). At Bannerghatta National Park, Bangalore, strongyle species in chinkara and spotted deer, and ascarids were recorded in sambar, spotted deer and barking deer (Jayagopala Reddy *et al.* 1992). *Haemonchus* sp. in spotted deer and *Oesophagostomum* sp. in nilgai were encountered at Maharajbagh zoo, Nagpur (Dhoot *et al.* 2002). Chakraborty (1992) recorded *Trichuris* sp. from mouse deer (*Tragulus meminna*), black buck and serow at p.m. in Asom State Zoo (ASZ). From the same location (ASZ), *Gongylonema* infection was reported from captive wild herbivores like spotted deer, sambar, mouse deer, nilgai and serow (Chakraborty 1994). The parasites were recovered at necropsy from the mucosa of oesophagus, cheek and base of tongue. They were associated with fibrinous inflammation and destruction/disruption of epithelium. Apart from the records of *Trichuris* and *Gongylonema* as above, Chakraborty *et al.* (1994) reported from ASZ, Asom, p.m. findings of *Haemonchus* in barking deer, black buck, serow and Ladakhi goat, *Trichostrongylus* in barking deer, *Setaria* in barking deer and sambar, *Oesophagostomum* in mouse deer, *Cooperia* in nilgai, *Diocotophyma* in kidney of black buck and mithun, and *Onchocerca* in spotted deer, black buck, nilgai and Ladakhi goat. Six genera of strongyles viz. *Oesophagostomum*, *Trichostrongylus*, *Ostertagia*, *Marshallagia*, *Nematodirus* and *Haemonchus* as well as *Strongyloides* sp. were recorded in the g.i. tract of Hangul (*Cervus elephas hanglu*) at Dachigam National Park in Kashmir (Shahardar *et al.* 1995). In different sanctuaries of Tamil Nadu, Bhat and Manickam (1998) reported *Strongyloides*, *Trichostrongylus* and *Cooperia* by copro-culture in spotted deer with observations on seasonal variations in worm burdens. Strongyles and spiruroids were found to be the predominant nematode infections by faecal examination in 5 deer species viz. spotted deer, sambar, hog deer, barking deer and black buck at the Thiruvananthapuram zoo in Kerala (Varadharajan and Pythal 1999). Additionally, spotted deer and sambar were found harbouring *Strongyloides* and ascarids, and hog deer had *Capillaria* sp. Similar observations were recorded at Coimbatore regarding spotted deer and Asomese goat faecally (Varadharajan and Kandasamy 2000) and in 5 common deer species and Kashmiri goat at Thrissur zoo, Kerala (Varadharajan *et al.* 2001). Strongyles, notably *Trichostrongylus* sp., were observed parasitizing blue bull, spotted deer and black buck at Rajkot Municipal Zoo in Gujarat (Parsani *et al.* 2001) while at Maharajbagh Zoo at Nagpur, Maharashtra (Dhoot *et al.* 2002), *Haemonchus* in spotted deer and *Oesophagostomum* sp. in nilgai were notable findings. Another report on helminth parasites of axis deer at Nagpur (Hussain *et al.* 2002b) found 5 genera including *Strongyloides*, *Trichuris*, *Nematodirus* and *Haemonchus*. Prevalence of *Muellerius*

capillaris in free ranging spotted deer in 3 National Parks (Ramaswamy and Arora 1991) and later, verminous pneumonia associated with this lungworm in a barking deer was reported from Himachal Pradesh (Sharma *et al.* 1996). The lungworm *Dictyocaulus* morphologically similar to *D. viviparus* was found in Kashmir stag or hangul (Nashiruddullah *et al.* 2005). The pathological changes and observations were similar to those observed in lungworm infections in sheep and goat (Nashiruddullah *et al.* 2007). Faecal samples of eighteen spotted deer stags (Mohan and Coumarane 2007) at the Department of Forest and Wildlife, Pudducherry revealed individual and mixed infections of *Cooperia* sp., *Capillaria* sp. and *Trichostrongylus* sp. Faecal infection in 4 species of deer, blue bull and Ladakhi goat at a zoological park in Punjab (Singh *et al.* 2006) revealed predominantly strongyles in all with *Trichuris* sp. as additional infection in ibex, blue bull and chinkara. Faecal examination of axis deer maintained in forested area of Vidharba region of Maharashtra (Meshram *et al.* 2008), revealed 178 (89%) of 200 faecal samples to be positive for parasitic eggs. Apart from routine *Trichuris* sp. strongyles and *Strongyloides* sp., *Trichostrongylus* sp., *Oesophagostomum* sp., *Haemonchus* and *Bunostomum* were identified. Parasitic infections in Periyar Wildlife Sanctuary in Kerala were mainly strongyle in gaur (*Bos gaurus*), Nilgiri tahr (*Nilgiritragus hylocrius*) and sambar with *Trichuris* sp. as additional in the last named (Ravindran *et al.* 2011).

Appearance of clinical signs suggestive of helminthiasis was not a regular feature in the wild mammals despite faecal samples found positive. However, suppression of haematological values and their post-treatment increase in axis deer was observed (Hussain *et al.* 2002a). Oral administration of effective anthelmintics such as fenbendazole against g.i. parasites in hangul (Shahardar *et al.* 1995) and in axis deer (Hussain and Sarode 2003) and oxclozanide against *Paramphistomum* sp. in zoo herbivores at Nandankanan, Odisha (Anonymous 2010) can be judiciously employed. Proper disposal of dung/excreta, hygienic practices and general measures of endoparasite management should be scrupulously followed (Anonymous 2010). In a study of over 50 faecal samples of wild animals including Sambar and chital, Gupta *et al.* (2011) found out that the parasitic profile was dominated by coccidia infection (60.0%) followed by *Strongyloides* (50.0%) in Sambar, whereas, *Amphistoma* (30.0%) and *Strongyloides* (30.0%) showed equal prevalence followed by *Trichuris* (20.0%) and *Fasciola* (10.0%). In Chital, the prevalence of *Strongylides* (60.0%) was the highest followed by *Trichuris* (53.3%) and *Fasciola* (6.7%).

Protozoan parasites: Trypanosomiasis (caused by *Trypanosoma evansi*) appears common and often fatal in deer species. Episodes such as death of 2 sambar at deer park, Nagpur (Pathak *et al.* 1988) and outbreaks among spotted deer at Bhilai zoo (Arora 1994) and in spotted deer and

sambar at a nature reserve in Rajasthan (Singh 1998), are on record. Of the 44 samples screened of wild captive herbivores (Shailaja *et al.* 2005) 11 were found positive for *Trypanosoma evansi* by conventional microscopic examination and 14 by PCR technique. Clinical trypanosomiasis concurrent with tuberculosis in black bucks at a deer park in Punjab and its successful treatment with quinapyramine therapy was reported (Gupta *et al.* 2009). Clinical theileriosis in a gaur calf (Khan 1981) and Concurrent *Babesia* and *Theileria* in a male American bison of Delhi zoo (Arora 1994) were reported. *Theileria cervi* was recorded in spotted deer (Harikrishnan *et al.* 2004). and in a black buck from a deer park in Punjab (Gupta *et al.* 2009). *Sarcocystis* was encountered in the heart muscle of 4-horned antelope (*Tetracerus quadricornis*) in Odisha (Rao and Acharjyo 1984), in sambar, nilgai and 4-horned antelope and mithun of Nandankanan zoo (Acharjyo and Rao 1988), in spotted deer, barking deer, Sambar, mouse deer, nilgai, serow and mithun of Guwahati zoo (Chakraborty *et al.* 1994) and in the cardiac muscle of a barasingha (*Cervus duvauceli branderi*) at Kanha National Park, MP (Shrivastava *et al.* 1999). The species recorded from chital (*Axis axis*) with dhole (*Cuon alpinus*) as definitive host, was identified as *S. axicuonis* (Jog *et al.* 2003 2005). Coccidian infection was commonly detected in mammals at Lucknow zoo (Chauhan *et al.* 1973) such as *Eimeria cheetali* from spotted deer and black buck, *E. ramgai* from mouse deer, *E. chinkari* from chinkara, *E. parahi* from hog deer, *E. chausinghi* from four-horned antelope and from nilgai, three species viz. *E. yakimovi*, *E. nilgaii* and *E. tragocamelus*. At Delhi zoo, the same authors (Chauhan *et al.* 1973) detected *E. arloingi* and *E. crandallis* in Ladakhi goat. Coccidia/*Eimeria* as part of g.i. parasites were observed, without species identification, in chinkara, sambar and ibex (Jayagopala Reddy *et al.* 1992) from Bangalore, in spotted deer, barking deer, nilgai, serow and mithun at ASZ, Guwahati (Chakraborty *et al.* 1994), in spotted deer, sambar and black buck from Kerala (Varadharajan and Pythal 1999), in spotted deer at Coimbatore Mini Zoo (Varadharajan and Kandasamy 2000) at Rajkot Municipal Zoo in Gujarat (Parsani *et al.* 2001), in nilgai and spotted deer in Uttaranchal (Banerjee *et al.* 2005) and in sambar at a zoological park at Chhatbir in Punjab (Singh *et al.* 2006) and more recently in sambar deer of Periyar Wildlife Sanctuary in Kerala (Ravindran *et al.* 2011). Another protozoan *Balantidium coli* was found by faecal cysts in blue bull at Muncipal zoo, Rajkot (Parsani *et al.* 2001).

Arthropod parasites: The deer species are subject to attacks of haematophagous flies as evidenced by the incidence of trypanosomiasis in them. Myiasis of fly larvae in wounds is also likely but not reflected in reports. Hippoboscids of the genus *Lipoptena* have been reported as *L. indicum* from barking deer (Rao *et al.* 1964) and *Lipoptena* sp. from spotted deer and hog deer (Chhabra and

Chander 1969) in Uttar Pradesh. Occurrence of the sheep ked *Melophagus ovinus* in a wild hog deer was recorded from KNP, Asom (Islam and Lahkar 1996). The deer warble *Hypoderma diana* (Islam *et al.* 2003) was recorded from hog deer in 2 national parks in Asom. Fleas recorded include *Ancistropsylla* sp. from sambar and barking deer in the Nilgiris (Joseph and Mani 1980) and *Vermipsylla* sp. fleas from swamp deer at Nandankanan in Odisha (Anon 2010). According to Sridhar (2011) cervids are also infested by several biting and sucking lice as well as mange mites, although reports on these are scarce. In their checklist of Indian ticks, Geevarghese *et al.* (1997) listed *Amblyomma testudinarium* parasitizing sambar deer, *Haemaphysalis birmaniae* in barking deer and serow, *H. spinigera* and some other *Haemaphysalis* spp. common in a variety of wild mammals including deer. Also prevalent among Artiodactyla are *Rhipicephalus haemaphysaloides* and *Otobius megnini* (Geevarghese *et al.* 1997). *Linguatula serrata* larvae in a sambar deer were found at Thekkady, Kerala (Easwaran *et al.* 2003). Order Artiodactyla also includes the giraffe (*Giraffa camelopardalis*) in Fam. *Hippopotamidae* and wild boar (*Sus scrofa*) under the Family Suidae. In their studies on parasites of captive wild herbivores in ASZ, Asom, Chakraborty (1992) found *Trichuris* sp. with gross and microscopic pathology, and later, Chakraborty *et al.* (1994) reported ascarids, *Gongylonema*, *Trichuris*, hydatid cyst and *B. coli* at p.m. examination of giraffes. Varadharajan and Pythal (1999) recorded strongyles and coccidia in hippopotamus at Thiruvananthapuram zoo and Varadharajan *et al.* (2001) encountered strongyles, *Fasciola*, spirurid and ascarids by faecal concentration technique in captive hippos at Thrissur, Kerala. Gaur *et al.* (1979) found 7 of 10 wild boars at Zoological Park, Kanpur (U.P.) faecally positive. *Oesophagostomum* sp. was found in 5, while 2 had *Ascaris suum* and *Fasciolopsis buski*. At Nandankanan zoo, Odisha, 6 of the captive wild boars at necropsy were found infected with *Stephanurus dentatus* in liver and kidneys while one had hydatid cyst in peritoneal cavity (Rao and Acharjyo 1984). Easwaran *et al.* (2003) recorded *Gastrodiscoides hominis* and *Gnathostoma hispidum* in the wild boar at Thekkady, Kerala. Nine different helminthic infections by faecal examination were found in free-ranging wild boars (67/91 found positive) in Uttarakhand (Banerjee *et al.* 2005). Predominated by *Macrocanthorhynchus*, others in descending order were *Metastrongylus*, *Trichuris*, strongyles, *Capillaria*, *Ascaris*, *Physocephalus*, *Fasciolopsis* and *Strongyloides*. Besides these, coccidia (26) appeared fairly common. Ascariasis was also reported from captive wild boars at Zoological Park, Hyderabad (Rao and Hamza 2007) and at MC Zoological Park, Chhatbir, Punjab (Singh *et al.* 2009) while *Macrocanthorhynchus hirudinaceus* was found in a dead wild boar at a forest range in Tamil Nadu (Krithiga *et al.* 2010). In the latter report, granuloma formation and nodular lesions at the adhering site in small intestine were

observed. Faecal examination of 8 wild boars in Periyar Wildlife Sanctuary in Kerala (Ravindran *et al.* 2011) revealed strongyle ova presumed to be *Stephanurus dentatus* since many worm specimens were also frequently observed in the internal organs of the same animals. Also observed were *Ascaris suum*, *Strongyloides* sp., spirurid, coccidian oocysts and cysts of *B. coli*.

Several tick species have been listed as infesting wild boar (Geevarghese *et al.* 1997) viz. *Dermacentor auratus*, *Haemaphysalis* (5 species recorded from various parts of the country), *Hyalomma dromedarii* and *Nosomma monstrosum*. Easwaran *et al.* (2003) identified *Amblyomma* sp. from this host at Thekkady, Kerala. These authors also reported the pig louse *Haematopinus suis*.

Marsupials

There is a solitary report in recent Indian literature on clinical coccidiosis in Eastern Grey kangaroos (*Macropus giganteus*) at A. Anna Zoological Park near Chennai, Tamil Nadu (Thiruthalinathan *et al.* 1998). Three joeys born in captivity became dull, anorectic and weak, but one of them additionally developed signs of colic, enteritis and died within 24 h. Oocysts, passed in the faeces by all three, were tentatively identified as *Eimeria cunnamullensis*. Necropsy of the dead joey revealed enteritis, oedema and haemorrhages on the mucosa of caecum and colon. The other two joeys were treated with amprolium along with supportive therapy. Coccidiosis appeared to be a fairly common condition among a variety of wild mammals.

Non-human (N.H.) primates

Early-on, *Trichuris* sp. was documented as one of the most commonly encountered parasites in N.H. primates, by itself (Rao *et al.* 1972) or with *Strongyloides*, hookworm and *Ascaris* (Chauhan *et al.* 1973, Gaur *et al.* 1979). At Nandankanan Zoo, Odisha, Rao and Acharjyo (1984) found tapeworms in one slow loris, roundworms in another and parasitic nodules in a slender loris, but did not identify them. Histopathological studies of *Oesophagostomum* spp. Infection in intestine of a hollock gibbon (*Hylobates hoolock*) of Guwahati zoo was described (Goswami *et al.* 1994). Later, Goswami and Chakraborty (1996) recorded pathology of 14 N.H. primates naturally infected with *Oesophagostomum aculeatum*, *Enterobius vermicularis*, *Trichuris trichura*, *Dirofilaria* sp., *Fasciola gigantica* and *Cysticercus* at p.m. examination. Enteritis was present in all. *Trichuris* sp. reported in the faecal samples of Nilgiri langur (*Semnopithecus johnii*) in Silent Valley National Park (Joseph *et al.* 1999, Xavier *et al.* 2000) finds easy dissemination in the hosts' feeding habits and contamination through defecation from tree tops. Chakraborty and Goswami (2001) recorded 5 nematodes 2 cestodes and one trematode parasite in a necropsy study of 85 captive N.H. primates of ASZ, Asom. The parasites identified were *Trichuris trichurina*

(9.41%), filarial parasite (7.05%), *Enterobius vermicularis* (4.70%), *O. aculeatum* (4.70%), *Cysticercus* sp. (4.70%) and an unidentified cestode (1.70%). The occurrence of *Fasciola gigantica* in the bile duct of a common langur was also observed. Coproscopic examination revealed the presence of other parasites viz. *Ancylostoma* sp., *Ascaris* sp., *Strongyloides* sp. Survey of g.i. parasites in Nilgiri langur by faecal exam (Rajendran *et al.* 2004) revealed high prevalence of nematode infection viz. strongyles (100%), *Trichuris* (25%), *Strongyloides* (18.75%) and spirurids (18.75%). Identical prevalence of helminthic infections in 35 species of macaques at Thrissur zoo in Kerala (Varadharajan *et al.* 2001) was recorded, with *Hymenolepis* and *Metagonimus* as additional findings in Bonnet macaque (*Macaca radiata*). Study of helminthic fauna of free-living primates in a wild life sanctuary in Kerala (Subramanian *et al.* 2006) found faecal positivity of strongyles, *Strongyloides*, trichurids and spirurids. Arora and Chakraborty (2009) included hydatid cysts and *Fasciola gigantica* infection in the liver of common langurs (*Presbytis entellus*), while Singh *et al.* (2009) recorded *Trichuris* sp. *Hymenolepis diminuta* and *Strongyloides* sp. in two types of macaques and two types of langurs in MC Zoological Park at Chhatbir, Punjab. These workers found therapy with proprietary combination of pyrantel pamoate, praziquantel and fenbendazole as efficacious. Further, regular faecal examination, assessment of parasitic load and administration of desired anthelmintics were recommended for control.

Presence of *Strongyloides* spp., *Trichuris* spp., *Entamoeba histolytica* spp., *Ascaris* spp., *Entamoeba coli* and *Spirometra* spp was observed by Parmar *et al.* (2012) in a study of faecal samples of the non-human primates (including hanuman langur and rhesus macaque) of Gujarat state. Nath and colleagues in a study on 22 faecal samples of non-human primates in the same year, observed eggs of *Oesophgostomum* sp. and *Trichuris* sp. in 3 samples.

Among protozoa, the zoonotic *Entamoeba histolytica* infection was found in 29.3% of 116 rhesus monkeys (*Macaca mulatta*) at PGI, Chandigarh (Jindal *et al.* 1977). *Toxoplasma* antibodies in rhesus monkeys at the same centre were also reported (Chhabra *et al.* 1976). *B. coli* had been commonly found in the stool samples of 200 macaques and langurs (Acharjyo 2000). *Entamoeba coli* had also been recorded by faecal presence in chimpanzees and bonnet macaques (Acharjyo 2000). Clinical balantidiosis in an orangutan (*Pongo pygmaeus*) at a zoological park in Hyderabad was reported (Bhaskara Rao *et al.* 1992). Three protozoan infections viz. *Entamoeba* sp., *Balantidium* sp. and *Giardia* sp. were recorded from ASZ, Asom (Chakraborty and Goswami 2001). Among arthropods, sarcoptic mange in a large number of Hanuman langurs (*Semnopithecus entellus*) around Jodhpur, Rajasthan (Chhangani *et al.* 2001) and its treatment, is on record. Demodicosis associated with alopecia in a rhesus monkey (*Macaca mulatta*) has been reported from

Pune (Nighot *et al.* 2011). Geevarghese *et al.* (1997) had listed some tick species of genus *Haemaphysalis* as parasitizing monkeys viz. *H. bispinosa*, *H. obesa*, *H. cuspidata*, *H. kinneari*, *H. wellingtoni* and *H. turturis*.

Reptiles

Patnaik and Acharjyo (1970) recorded at p.m. examination at Baranga Zoo in Odisha, *Bothridium pythonis* and *Ophidascaris filaria* from Indian python (*Python molurus*) while *Polydelphis attenuata* and *Kalicaphalus willeyi* were found in Russel's Viper (*Vipera russeli*). The Indian rock python (*Python molurus*) is distributed all over India. Pythons are predominantly parasitized by the pathogenic ascarid *Ophidascaris ajagaris* (Sarode *et al.* 1991). Muralleedharan *et al.* (1990) found a python infected with *O. filaria*. If in large numbers, it can damage the intestinal wall and even cause occlusion of the g.i. tract (Dehingia and Choudhury 1991). Pythons in captivity may also harbour a cestode *Bothridium pithonis* (Abdul Rahman *et al.* 1980, Muralidharan *et al.* 1990). Islam and Kheria (2003) recorded *B. pithonis* in a free-living python at KNP, Asom. In Chennai Snake Park, *Strongyloides* and strongyles were detected (Jayathangaraj *et al.* 2006) in a spectacled cobra (*Naja naja*). A gharial (*Gavialis gangeticus*) of Chambal River Reserve was found infected with *Ascaris* and had ulcerative nodular growth in its stomach at postmortem (Arora and Chakraborty 2009). In a rat snake (*Ptyas mucosa*) in Namakkal district of Tamil Nadu, one g.i. nematode, later identified as *Kalichephalus* sp. (Fam. *Strongylidae*) was recovered at p.m. (Arunachalam *et al.* 2010). Tick infestation due to *Aponomma* sp. was also recorded. Common snakes of Western Ghats of Karnataka were screened faecally for g.i. parasites (Ananda *et al.* 2011a). The rock python showed strongyle, *Strongyloides*, *Capillaria* and ascarid eggs, king cobra had only the first three types and spectacled cobra had faecal positivity for only strongyle and ascarid eggs. In a case report (Ananda *et al.* 2011b), *Ascaridia* infection in an Indian rock python was described at autopsy. There were petechial haemorrhages, ulceration and necrotic foci on the mucosa throughout the small intestine. Great numbers of the nematodes were found in the large intestine of the python. The tapeworm *Ophiotaenia burgeria* was recorded in a spectacled cobra near Puducherry (Das *et al.* 2012 a). Of the arthropods on reptiles, only ticks find mention in Indian literature. Geevarghese *et al.* (1997) in their checklist of Indian ticks, listed *Aponomma gervaisi* occurring on python and Indian monitor lizard, *A. lucasi* on cobra in addition to the two earlier names reptiles, *A. laevi* on python, cobra and rat-snake, while *Amblyomma helvolum* was recorded from monitor lizard only. However, *Amblyomma* sp. was found on a Red Sand Boa (*Erix johani*) near Puducherry (Das *et al.* 2012 b). At Alipur Zoo, Kolkata, a number of snakes like cobra and rat snake died just after hibernation (Sur *et al.* 2001) due to heavy infestation with ticks.

CONCLUSION

Parasites and morbidity / disease caused by them, constitute major hazards for the vulnerable wildlife which is stressed by captivity and/or shrinking natural habitat. An effective monitoring and surveillance system needs to be put in place to generate more data. For conservation and rehabilitation of wildlife in zoo/sanctuary, provision of adequate veterinary / health care is mandatory. Although wildlife science/ healthcare has been introduced in the veterinary curriculum and some colleges now have an independent department for teaching and research of this emerging but important discipline, there is a continuing shortage of zoo veterinarians and trained ancillary manpower. There is a Central Zoo Authority in New Delhi which provides financial support for projects as well as several NGO's which are contributing to the conservation and welfare of wildlife as a common cause. The growth in information on parasites has been disproportionately favourable to helminths, whereas protozoa (particularly haemoprotozoa) and arthropods in general need greater exploration. A standard p.m. protocol should be scrupulously carried out and all organs / tissues should be thoroughly searched for parasites. Pathological changes, both gross and histological should be recorded and correlated. Serodiagnosis for blood protozoa and biotechnological tools should be standardized for use on wild herbivores and skin-scrapings for mange mites can be a routine procedure. Many of the g.i. parasites of wild ruminants are shared with the domestic stock. Therefore, domestic animals should not be let out for grazing in the forest ranges. The prevalence of schistosomes in wild ruminants is a grey area and should receive greater attention. Well-designed anthelmintic / acaricide trials should be promoted.

REFERENCES

- Abdul Rahman S, Seshadri S J and Gajendergad M R. 1980. Parasites from an Indian rock python (*Python molurus*). *Mysore Journal of Agricultural Sciences* **14**: 230–32.
- Acharjyo L N. 1985. Cited by Archarijyo LN. 2000.
- Archarijyo L N. 2000. Incidence of parasitic diseases among wild mammals and their control in Indian Zoos. Lead paper. *Proceedings of XI National Congress of Veterinary Parasitology*, Bhubaneswar. 4–6 February 2000. Pp. 10–26.
- Acharjyo L N and Rao A T. 1988. Cited by Archarijyo LN. 2000.
- Ananda K J, Naravi Y and Ramesha K. 2011a. Studies on gastrointestinal parasites of common snakes of Western Ghats of Karnataka. *Compendium XXI National Congress of Veterinary Parasitology*, Mumbai. 5–7 January 2011. Pp. 119.
- Ananda K J, Kaavitha Rani B and Ganganaik S. 2011b. *Ascaridia* infection in an Indian rock python: A case report. *Compendium XXI National Congress of Veterinary Parasitology*, Mumbai. 5–7 January 2011. Pp. 124.
- Anonymous. 2010. Ecto and endo parasites of captive animals and birds of Nandankanan Zoo. *Project Report. Nandankanan Zoological Park & Odisha Veterinary College*, Bhubaneswar. Pp. 1–63.
- Arora B M. 1986. Some health problems encountered in captive and semi-captive rhinoceros. *Zoos' Print* **1**: 9–17.
- Arora B M. 1994. *Wildlife Diseases in India*. 1st edn. Periodical Book Agency, D-42, Vivek Vihar, Delhi – 95. Pp. 100–175.
- Arora B M and Chakraborty A. 2009. *Colour Atlas of Wildlife Diseases and Disorders*. 1st edn. International Book Distributing Company, Lucknow (UP), India.
- Arunachalam K, Radha P, Ramy A, Senthivel K and Harikrishnan TJ. 2010. A report on endo and ecto parasitism in an Indian rat snake (*Ptyas mucosa*) from Namakkal district of Tamil Nadu. *Newsletter South Asian Reptile Network*. #9. January 2010: 10.
- Banerjee P S, Garg R, Yadav C L and Ram H. 2005. Parasitic infections in some wild animals of Uttaranchal. *Indian Journal of Animal Sciences* **75**: 206–08.
- Bhaskara Rao P, Rao D, Kumar N, Madhekar and Ramachandra Rao P V. 1992. Balantidiosis in Orangutan (*Pongo pygmaeus*). *Indian Veterinary Journal* **69**: 460–61.
- Bhat M N and Manickam R. 1998. Coproculture and study of seasonal variation in parasitic burden in spotted deer (*Axis axis*) in different sanctuaries in Tamil Nadu. *Indian Veterinary Journal* **75**: 469–71.
- Bhattacharjee M L and Halder B R. 1971. The occurrence of *Fasciola gigantica* in the liver of an Indian rhinoceros. *British Veterinary Journal* **127**: L VII–VIII.
- Chakraborty A. 1991. 'Incidence and etipathology on the mortality of captive wild herbivores in Asom.' Ph.D Thesis (Veterinary Pathology). *Asom Agricultural University*, Khanapara, Guwahati.
- Chakraborty A. 1992. *Trichuris* sp. Infection in wild captive herbivores. *Journal of Veterinary Parasitology* **6**: 37–40.
- Chakraborty A. 1994. Occurrence and pathology of *Gongylonema* infection in captive wild herbivores. *Veterinary Parasitology* **52**: 163–67.
- Chakraborty A. 2001. Pathology of *Fasciola gigantica* infection in captive wild herbivores with special reference to SEM and EDAX study. *Indian Veterinary Journal* **78**: 43–47.
- Chakraborty A and Goswami P K. 2001. Parasities of non-human primates of Asom State Zoo. *Journal of Veterinary Parasitology* **15**: 121–24.
- Chakraborty A and Islam S. 1993. A survey of gastro-intestinal parasitic infection in free-living rhinoceros of the Kaziranga National Park. *Indian Journal of Animal Sciences* **63**: 155–56.
- Chakraborty A, Gogoi A R and Chaudhury B. 1994. Prevalence of parasitic infection in captive wild herbivores in a zoo in Asom. *International Journal of Animal Sciences* **14**: 149–52.
- Chauhan P P S, Bhatia B B, Arora G S, Agrawal R D and Ahluwalia S S. 1973. A preliminary survey of parasitic infections among mammals and birds at Lucknow and Delhi zoos. *Indian Journal of Animal Sciences* **43**: 163–68.
- Chhabra M B and Chander S. 1969. On a species of Lipoptena (Diptera, Hippoboscidae, Melophaginae) from Indian spotted deer and hog deer. *Indian Veterinary Journal* **46**: 38–41.
- Chhabra M B, Mahajan R C, Ganguly N K and Chitkara N L. 1976. Prevalence of *Toxoplasma* antibodies in rhesus monkeys in India. *Tropical and Geographical Medicine* **28**: 101–103.
- Chhangani A K, Mathur B R J and Mahnot S M. 2001. First record of mange (sarcoptic mange) in free-ranging Hanuman Langur (*Semnopithecus entellus*) and its treatment around Jodhpur (Rajasthan), India. *Intas-Polivet* **2**: 261–65.

- Das S S, Chaitanya V and Kumar D. 2012 a. Occurrence of *Ophiotaenia burgeria* in a spectacled cobra, *Naja naja* near Puducherry. Abstr. II. 18. XXII National Congress of Veterinary Parasitology. Mathura (UP), India. 15–17 March 2012. pp. 27.
- Das S S, Chaitanya V and Kumar D. 2012 b. Occurrence of *Amblyomma* sp. tick on the skin of Red Sand Boa (*Erix johnei*) near Puducherry. Abstr. II. 09. XXII: National Congress of Veterinary Parasitology. Mathura (UP), India. 15–17 March 2012. pp. 23.
- Dehingia A S and Choudhury K D. 1991. Parasitic occlusion of gastro-intestinal (g.i.) tract in a python (*Python molurus molurus*). A case report. *Zoos' Print* 6(11): 16.
- Dhoot V M, Upadhye S V and Kolte S W. 2002. Prevalence of parasitism in wild animals and birds of Maharajbagh zoo, Nagpur. *Indian Veterinary Journal* 79: 225–27.
- Easwaran K R, Ravindran R and Pillai K M. 2003. Parasitic infection of some wild animals at Thekkady in Kerala. *Zoos' Print Journal* 18: 1030.
- Gaur S N S, Sethi M S, Tiwari H C and Prakash O. 1979. Prevalence of helminthic parasites in wild and zoo animals in Uttar Pradesh. *Indian Journal of Animal Sciences* 49: 159–61.
- Geevarghese G, Fernandes S and Kulkarni S M. 1997. A checklist of Indian ticks (Acari: Ixodoidea). *Indian Journal of Animal Sciences* 67: 566–74.
- Goswami P K and Chakraborty A. 1996. Studies on prevalence of pathological conditions of captive non-human primates. *Zoos' Print* 11(10): 10.
- Goswami P J, Islam S and Mukit A. 1994. Pathology of naturally acquired *Oesophagostomum* infection in captive hoolock gibbon (*Hylobates hoolock*) from Asom. *Zoos' Print* 9(11): 17–18.
- Gupta A, Dixit A K, Dixit P, Mahajan C and Shrivastava A B. 2011. Incidence of gastrointestinal parasites in wild ruminants around Jabalpur, India. *Zoo's Print Journal* 3: 1226–28.
- Gupta M P, Kumar H and Singla L D. 2009. Trypanosomosis concurrent to tuberculosis in black bucks. *Indian Veterinary Journal* 86: 727–28.
- Harikrishnan T J, Ramasamy V and Gopalakrishnamurthy T R. 2004. *Theileria cervi* in a deer: A report. *Journal of Veterinary Parasitology* 18: 97.
- Hussain K and Sarode D B. 2003. Efficacy of Panacur (Fenbendazole) against gastrointestinal nematodes in axis deer (*Axis axis*). *Blue Cross Book* 20: 19–20.
- Hussain K, Sarode D B, Dakshinkar N P, Rode AM, Kothekar M D and Maske D K. 2002 a. Haematobiochemical studies on Axis deer with natural gastrointestinal infection. *Indian Veterinary Journal* 79: 20–22.
- Hussain K, Sarode D B, Dakshinkar N P, Rode A M, Kothekar M D and Maske D K. 2002b. Prevalence of helminthic infection in axis deer at Nagpur. *Indian Veterinary Journal* 79: 1313–14.
- IANS. 2012. 250 more rhinos in Kaziranga (News item). *Times of India* (daily). April 10 2012. TOI Publ., New Delhi, Bennett, Coleman & Co. Ltd.
- Islam S. 2006. Parasites and parasitic diseases of wild life. *Proceedings of XVII National Congress of Veterinary Parasitology*, Puducherry – 605 009, India. November 15–17. Pp. 43–52.
- Islam S and Kheria T C. 2003. *Bothridium pithonis* (Blainville 1824) in a free-living Indian rock python (*Python molurus*). *Journal of Veterinary Parasitology* 17: 163–64.
- Islam S and Lahkar B C. 1996. Occurrence of *Melophagus ovinus* in a wild hog deer (*Cervus porcinus*) from the Khaziranga National Park, Asom, India. *Zoos' Print* 11(10): 14.
- Islam S, Sarmah P C and Kalita M. 2003. Observations on cutaneous myiasis due to *Hypoderma diana* Brauer 1858 in hog deer. *Journal of Veterinary Parasitology* 17: 105–08.
- Jana D and Jana M. 2001a. Fascioliasis in captive spotted deer in West Bengal. *Indian Veterinary Journal* 78: 743–44.
- Jana D and Jana M. 2001b. Nodular lesions in the liver of a captive spotted deer. *Indian Veterinary Journal* 78: 752–53.
- Jani R G and Patel P R. 2001. Glimpses of Indian Wildlife Wealth: An overview. *Intas-Polivet* 2: 129–33.
- Jayagopala Reddy N R, Jagannath M S, D'Souza P E, Abdul Rahman S and Basavarajappa K. 1992. Prevalence of gastrointestinal parasites in wild mammals and captive birds at Bannerghatta National Park, Bangalore. *Indian Journal of Animal Sciences* 62: 1046–48.
- Jayathangaraj M G, Ramesh S, Basith S A and Rajarathinam R. 2006. A case of mouth rot and helminthiasis in a spectacled cobra (*Naja naja*). *Zoos' Print Journal* 21: 2142.
- Jindal B B, Vinayak V K and Chhuttani P N. 1977. Intestinal parasitosis of rhesus monkeys (*Macaca mulatta*) in health and disease. *Bulletin Postgraduate Institute of Medical Education & Research*. VII: 110–13.
- Jog M M, Marathe R R, Goel S S, Ranade S P, Kunte K K and Watve M G. 2003. *Sarcocystis* infection in chital (*Axis axis*) and dhole (*Cuon alpinus*) in two Indian protected areas. *Zoos' Print Journal* 18: 1220–22.
- Jog M M, Marathe R R, Goel S S, Ranade S P, Kunte K K and Watve M G. 2005. *Sarcocystis* of chital (*Axis axis*) and dhole (*Cuon alpinus*): ecology of a mammalian prey-predator-parasite system in Peninsular India. *Journal of Tropical Ecology* 21: 479–82.
- Joseph S A and Mani K R. 1980. *Cervus unicolor niger* – The Indian Sambar, a new host for *Ancistropsylla nepalensis* Lewis 1968. *Cheiron* 9: 200–02.
- Joseph G K, Pillai K M, Xavier F, Michael B and Amrithraj M. 1999. A coprological survey of parasites in two endangered primates of Silent Valley National Park, Kerala. *Indian Forester* 125: 1027–30.
- Khan A M. 1979. Incidence of different parasites in wildlife of Nehru Zoological Park, Hyderabad. *Summer Institute on Pathology of diseases of Wildlife*, UAS, Bangalore. 16–29 May 1979.
- Khan M G A. 1981. Theileriasis in a gaur calf (*Bos gaurus*). *Indian Veterinary Journal* 58: 72–73.
- Krithiga K, Kowsigan A, Jeyathilakan N and Balachandran C. 2010. A report on the incidence of *Macrocanthorhynchus hirudinaceus* in a wild boar. *Tamil Nadu Journal of Veterinary and Animal Sciences* 6: 289–90.
- Meshram M D, Shirale S Y and Khillare K P. 2008. Incidence of helminthic infection in Axis deer. *Veterinary World* 1: 10.
- Mohan M and Coumarane K. 2007. Endoparasitic Infection of spotted deer (*Axis axis*) in Puducherry. *Zoo's Print Journal* 22: 2952.
- Muraleedharan K, Iswaraiah V, Ziauddin KS and Srinivasan K. 1990. A survey of gastrointestinal parasites of animals of zoological gardens of Mysore. *Mysore Journal of Agricultural Sciences* 24: 250–56.
- Nashiruddullah N, Darzi M M, Mir M S, Kamil S A and Shahardar R A. 2005. Recovery of *Dictyocaulus* species from the lungs of

- a Kashmir red deer (*Cervus elaphus hanglu*). *Veterinary Record* **157**: 591–92.
- Nashiruddullah N, Darzi M M, Mir M S, Shahardar R A, Kamil S A, Mir M S and Mir A. 2007. Pathology of spontaneous *Dictyocaulus* sp. infection in hangul (*Cervus elaphus hanglu*), sheep and goat. *Journal of Veterinary Parasitology* **21**: 37–40.
- Nath B G, Islam S, Chakraborty A. 2012. Prevalence of parasitic infection in captive non-human primates of Asom State zoo, India. *Veterinary World* **5**: 614–16.
- Nighot N K, Jadhav R V, Mote C S and Bansal N. 2011. Alopecia related to demodicosis in the rhesus monkey (*Macaca mulata*). *Compendium XXI National Congress of Veterinary Parasitology*, Mumbai, 5–7 January 2011. Pp. 121.
- Padhi B C, Mohanty A K, Misra S C and Panda D N. 1987. A note on the occurrence of amphistomes in the rumen of spotted deer (*Axis axis*) at the Nandankanan Biological Park, Barang, Odisha. *Indian Veterinary Journal* **64**: 893.
- Parmar S M, Jani R G and Mathakiya R A. 2012. Study of parasitic infection of non-human primates of Gujarat state, India. *Veterinary World* **5**: 362–64.
- Parsani H R, Momin R R, Moradia M G and Singh V. 2001. A survey of gastrointestinal parasites of captive animals at Rajkot Municipal Corporation Zoo, Rajkot, Gujarat. *Zoos' Print Journal* **16**: 604–06.
- Pathak K M L and Chhabra M B. 2012. Parasites and Parasitic diseases of the Indian Elephant, Mithun and Yak. *Indian Journal of Animal Sciences* (In press).
- Pathak V P, Gamorkar A G and Paikne D L. 1988. Occurrence of trypanosomiasis in sambars (*Rusca unicolor*). *Indian Veterinary Journal* **65**: 930.
- Patnaik M M and Acharjyo L N. 1970. Notes on the helminth parasites of vertebrates in Baranga Zoo (Odisha). *Indian Veterinary Journal* **47**: 723–30.
- Rajendran S, Saseedran P C, Subramanian H, Chitra R and Yuvaraj N. 2004. A survey of gastrointestinal parasitic infection in Nilgiri Langur (*Semnopithecus johnii*) at Kallaked-Mundanthurai Tiger Reserve, Tamil Nadu. *Zoos' Print Journal* **19**: 1454.
- Ramaswamy K and Arora B M. 1991. Prevalence of *Muellerius capillaris* in free-ranging spotted deer (*Cervus axis*) in India and its experimental cross-transmission to goats. *Journal of Wildlife Diseases* **27**: 102–04.
- Rao A T and Acharjyo L N. 1984. Diagnosis and classification of common diseases of captive animals of Nandankanan Zoo in Odisha (India). *Indian Journal of Animal Health* **23**: 148–52.
- Rao C K, Chakravarty A K, Ghose J N, Krishnaswami A K and Raghavan G S. 1972. Prevalence of intestinal parasitic infection in autopsied monkeys and their handling hazards. *Journal of Communicable Diseases* **4**: 133–39.
- Rao P B and Hamza P A. 2007. Ascariasis in wild boars – A case report. *Zoos' Print Journal* **22**: 27.
- Rao S R, Hiregoudar L S and Alwar V S. 1964. (fide Chhabra MB and Chander S. 1969.)
- Ravindran R, Ajith Kumar K G and Abdul Gafoor V M. 2011. Parasitic infections in wild animals of Kerala. *Zoos' Print Journal* **26**: 34.
- Sadana J R, Majahan S K and Paul Gupta R K. 1980. On the occurrence of *Haemonchus contortus* in a black buck (*Antelope cervicapra*). *Haryana Veterinarian* **19**: 142–43.
- Sahoo M, Mohapatra H K, Parhi N K and Panda S K. 2010. An outbreak of fascioliosis in spotted deer (*Axis axis*). *Indian Journal of Veterinary Pathology* **34**: 117–19.
- Sarmah P C, Islam S and Bhattacharjee K. 2011. A note on the occurrence of *Strongylus* Muller 1780 in a free ranging one-horned rhino (*Rhinoceros unicornis*) from Kaziranga National Park, Asom, India. *Journal of Veterinary Parasitology* **25**: 149–51.
- Sarode D B, Sukalika S B and Gorde S V. 1991. Infection of *Ophidascaris ajgaris* in an Indian python (*Python molurus molurus*). *Zoos' Print* **6**(11): 18.
- Sengupta P P and Dey S. 2009. Strongylid helminths in Indian Wild asses. *Indian Veterinary Journal* **86**: 460–62.
- Shailaja V, Venkatesha M D, Renukaprasad C, Jaykumar S R and Krishnappa G. 2005. Standardization of polymerase chain reaction (PCR) diagnosis of trypanosomiasis in captive wild animals. *Intas Polivet* **6**: 207–08.
- Shahardar R S, Mir A S, Mir M M, Pandit B A and Ahmed M A. 1995. Efficacy of fenbendazole against gastrointestinal nematodes of Kashmiri deer (Hangul). *Indian Veterinary Journal* **72**: 782.
- Sharma A K, Joshi V B, Sharma M, Katoch V, Singh S P, Katoch R C, Batta M K and Asrani R K. 1996. Concurrent Chlamydial and verminous pneumonia in a barking deer (*Munpiacus muntjak*). *Indian Veterinary Journal* **73**: 876–78.
- Shrivastava A B, Chaudhry R K, Shrivastava H O P and Malik P. 1998. Occurrence of *Gastrothylax* species in barasingha (*Cervus duvauceli branderi*). *Indian Veterinary Journal* **75**: 645–46.
- Shrivastava A B, Sharma R K, Choudhry R K and Malik P. 1999. *Sarcocystis* in a barasingha deer (*Cervus duvauceli branderi*). *Journal of Zoo and Wildlife Medicine* **30**: 454–55.
- Singh D P. 1998. Epidemiological study on *Trypanosoma evansi* infection among free living wild animals in India. *Journal of Protozoology Research* **8**: 139–43.
- Singh P, Gupta M P, Singla L D, Sharma S, Sandhu B S and Shirma D R. 2006. Parasitic infections in wild herbivores in the Mahendra Choudhury Zoological Park, Chhatbir, Punjab. *Zoos' Print Journal* **21**: 2459–61.
- Singh P, Singla L D, Gupta M P, Sharma S and Sharma D R. 2009. Epidemiology and chemotherapy of parasitic infections in wild omnivores in the Mahendra Choudhury Zoolgoical Park, Chhatbir, Punjab. *Journal of Threatened Taxa* **1**: 62–64.
- Sridhar R. 2011. Diseases and pathology of Cervids (deer). Proceedings of National Workshop for Zoo Veterinarians on *Protocol for the Veterinary Care and Safety of Wild animals during transportation with special reference to deer species*. Department of Wildlife Science, Madras Veterinary College, TANUVAS, Chennai. Pp. 79–83.
- Subramanian H, Ajithkumar C, Rajendran S, Saseedaran P C and Anil K S. 2006. Gastrointestinal parasitic infection in lion-tailed macaque. *Journal of Veterinary Parasitology* **20**: 189–90.
- Sur S K, Ghosh G L and Chatterjee D. 2001. Use of deltamethrin on tick infested snakes. *Zoos' Print Journal* **16**: 410.
- Thiruthalinathan R, Latha B R and Swaminathan D. 1998. Coccidiosis in Eastern Grey Kangaroos. *Indian Veterinary Journal* **75**: 375–76.
- Varadharajan A and Kandasamy A. 2000. A survey of gastrointestinal parasites of wild animals in captivity in the V.O.C. Park and Mini Zoo, Coimbatore. *Zoos' Print Journal* **15**: 257–58.
- Varadharajan A and Pythal C. 1999. Parasites of Wildlife-I. A preliminary investigation on the parasites of wild animals at

- the Zoological Garden, Thiruvananthapuram, Kerala. *Zoos' Print Journal* **14**: 159–64.
- Varadharajan A, Pythal C and Subramanian H. 2001. Investigation on the prevalence of helminth parasites of wild mammals in the Thrissur Zoo, Kerala. *Cheiron* **30**: 12–15.
- Varma T K, Arora B M, Malviya H C and Prasad A. 1993. On the occurrence of *Paramphistomum epiclitum* Fischoeder 1904 from rumen and *Gigantocotyle explanatum* (Creplin 1947) Nasmark 1937 from the bile-duet of sambar (*Cervus unicolor*). *Indian Journal of Animal Sciences* **63**: 630.
- Varma T K, Panda M R and Arora B M. 1998. *Cysticercus tenuicollis* from mesentery of a black buck (*Antelope cervicapra*). *Indian Veterinary Journal* **75**: 377–78.
- Varma T K, Prasad A, Arora B M and Malviya H C. 1990. On the occurrence of *Paramphistomum lobatum* Srivastava and Tripathi 1980 from rumen and reticulum of black buck. *Indian Journal of Animal Sciences* **60**: 430–32.
- Xavier F, Joseph G K, Michael B and Bijula K. 2000. A coprological survey of parasites of seven mammal groups at Silent Valley National Park, Kerala. *Zoos' Print Journal* **15**: 279–80.