



Parasites and parasitic diseases of the Indian elephant, mithun and yak : An overview

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ABSTRACT

The Indian elephant, mithun and yak are utility animals. Each of them is a valuable natural resource and important constituent of India's unique biodiversity. However, their numbers have declined and their existence is facing several challenges, of which a major one is parasites and diseases caused by them. While much of the information on the parasites of Indian elephant dates back to the pre-mechanization British era, the setting up of dedicated Research Centres on Mithun and Yak by the Indian Council of Agricultural Research, has resulted in generation of considerable research data and regular flow of information in recent years. The elephant is unique regarding most of its internal (and a few external) parasites not being shared with other livestock hosts. As per updated information, the Indian elephant is parasitized by 39 helminths, made up by 8 trematodes including the most pathogenic *Fasciola jacksoni*, 2 cestodes and 29 nematodes including 3 filariid worms; among protozoa, only *Trypanosoma*, *Babesia* and ciliates are known; arthropods include the stomach bot *Cobboldia*, the louse *Haematomyzus* and atleast 4 genera of ticks. The mithun, being phylogenetically related to cattle, seems to share the same set of internal and external parasites. To date 12 nematode genera, 6 trematode genera and 2 cestodes have been recorded; protozoa comprised coccidia (8 *Eimeria* species identified so far), *Giardia*, *Cryptosporidium* and *Balantidium*. In addition, serological evidence of *Toxoplasma gondii* and *Neospora caninum* exists. Of arthropods, only ticks are reported. The parasites of yak are not fully explored. So far 11 nematode genera, 7 trematode genera and 3 cestodes (2 of them only as cysts) are on record. Among protozoa, only *Eimeria* (2 species identified) and in arthropods, warbles (*Hypoderma*), 6 genera of ticks, louse, flea and biting flies have been reported in India.

Key words: Indian elephant, Mithun, Parasites, Parasitic diseases, Yak

The Asian elephant (*Elephas maximus*) is found in India in both the free – living state and in captivity. Although the estimated number of captive elephants in the country is only 3400–3600 or 11–12% of the total elephant population according to the census report of 2000, they have been regarded as a component of livestock by authorities such as Bhalerao (1934). Found in several protected areas, mainly in north-eastern, southern, Himalayan foothills and the island regions, the domesticated and trained elephants are traditional utility animals, used in timber-logging and draught purposes by forest departments, zoological gardens, performance in circus and in temples/palaces for religious and ceremonial purposes. Like in other domesticated animals, elephants are highly prone to a variety of parasites which undermine their health status and work capacity. Almost all of those parasites are known to occur in their wild counterparts also. The

pioneering monograph of Bhalerao (1934) dealt only with the helminth parasites. Subsequently, an all-inclusive review on parasitic diseases (Arunachalam *et al.* 1996) and another one on helminth parasites of Indian elephants (Chakraborty 2003) were published. In the interim, a number of reports dealing with one or more parasites and association with disease, have piled up to justify a comprehensive update of the subject.

The mithun (*Bos frontalis*) is a unique bovine ruminants found in the hill regions of north-east India. It is a cross between the gaur (*Bos gaurus*) and the zebu (*Bos indicus*). Chromosomally identical with the gaur, mithun is also known as gayal (Gupta *et al.* 1999). This animal has importance in the economic, social, cultural and religious life of the tribal people. It has great potential for quality meat, milk and leather production. Apart from mithuns found in the free-ranging condition, a herd is also maintained at National Research Centre on Mithun (ICAR) in Nagaland. Available information on the parasites and parasitic diseases of mithuns is limited to sporadic and fragmentary reports and so far, there is no

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proper review. Likewise, the yak (*Bos poephagus*) is a livestock species of immense importance in the tribal cold desert areas of North Sikkim, Ladakh, Arunachal and other Himalayan regions, as provider of meat, milk, fibre and transport. Yet there is paucity of available information on its parasitic infections since the advent of a small compilation (RangaRao *et al.* 1994).

Parasites and parasitic diseases of the Indian elephant

Helminth parasites: In his classic monograph, Bhalerao (1934) had documented 26 helminth parasites of the elephant recorded till then from various parts of India. These included 6 trematodes, 2 cestodes and 18 nematode parasites.

Trematodes: The most common pathogenic distome of Asian elephant is *Fasciola jacksoni*, the liver fluke of elephant. Infection has also been reported in elephants of Guwahati zoo (Chakraborty and Choudhury 1992), Dudhwa National Park, Lakhimpur, Uttar Pradesh (Singh *et al.* 1994), in captive and wild elephants of Asom (Islam 1997), as the dominant prevalent parasite in 90 elephants from different temples of Gujarat (Jani 2008) and recently in a zoological park near Pune (Nighot *et al.* 2011). Islam (1997) made studies on several aspects of fascioliasis in Asian elephants. Prevalence in wild elephants was overall 33.78% while in captive elephants, it ranged between 18.18 to 62.28% according to locality. Young animals were most affected by the parasite and showed clinical signs of anorexia, constipation, diarrhoea, anemia and icterus, with death occurring in severe cases. The adult parasite caused massive liver damage. Accordingly to Jani (2008), additionally there was dehydration and habit of soil-licking. The pathology of *F. jacksoni* infection in the bile duct of elephant has been reported (Chakraborty and Choudhury 1991, 1992) by gross, histopathology, scanning electron microscopy (SEM) and energy dispersive X-ray microanalysis (EDAX). Grossly, the parasites were found attached to biliary epithelium and microscopically, the epithelial surface of the bile duct was covered by a necrotic tissue admixed with erythrocytes and ova of *F. jacksoni*. The liver parenchyma adjacent to the bile duct was replaced by fibrous tissue proliferation. SEM showed distortion of biliary epithelium which turned into a homogeneous mass. Singh *et al.* (1994) recovered flukes from the liver of a dead elephant and observed pathological changes, viz. haemorrhagic tracts, thickening of bile ductules, cellular infiltrations, cirrhotic changes and pseudo-lobulations. Recovery of parasite from the lung suggested aberrant migration. The egg of *F. jacksoni* is smaller and narrower than both *F. hepatica* and *F. gigantica* (Islam 2010).

Other trematodes parasitizing Indian elephants are the amphistomes, viz. *Gastrodiscus secundus*, *Pseudodiscus collinsi*, *P.hawkesii*, *Pfenderius papillatus*, *Pfenderius birmanicus* and *Tegumaea heterocaeca* (Bhalerao 1934, Dutta and Bordoloi 1989, Arunachalam *et al.* 1996, Muralidharan

and Keshavaprasad 2001). Of these, *G.secondus* and *P.collinsi*, both immature and mature forms, were recorded as concurrent infection from the caecum of 2 captive elephants at postmortem from the Kaziranga National Park, Assam (Islam *et al.* 1999). The accompanying lesions were oedema, pin-head haemorrhages and ulcerative patches on the caecal mucosa. Diarrhoea is a consistent sign of trematodiasis, while oedematous swelling on the inter-mandibular region or on lower abdomen is frequently seen in the rumen fluke infection (Chandasekharan *et al.* 1982) and in fascioliasis (Sarma *et al.* 2005). The amphistome *P.collinsi* was reported singly from elephant in Mysore (Muraleedharan and Keshava Prasad 2001) and again from Karnataka by Ananda *et al.* (2011). Amphistome eggs were found at faecal examination in 13 of 33 elephants of Uttarakhand (Banerjee *et al.* 2005), and in a zoological park in Punjab (Singh *et al.* 2006).

The schistosome *Bivitellobilharzia nairi*, occurring in the portal blood vessels was described by Sundaram *et al.* (1972). Later, Islam (1994) reported its occurrence in captive elephants from Kaziranga National Park and Assam State Zoo, Guwahati. Schistosomiasis in elephant is a chronic and wasting form of disease. The animal becomes progressively weak with pale mucous membranes and increased bile pigments in urine. Treatment by hexachlorophene (Distodin) at 10 mg/kg body weight (b.w.) orally in 10 elephants infected with 3 species of amphistomes was 100% effective (Chandrasekharan *et al.* 1982). Against fascioliasis, treatment with triclabendazole at 9 mg/kg (subject to a maximum of 7200 mg/animal) and oxcyclozanide @ 7.5 mg/kg (not exceeding 6.8g/animal) were 100 and 72.16% effective, respectively (Islam 1997). Oxcyclozanide bolus at 5 mg/kg b.w. was found effective treatment (Sarma *et al.* 2005) in 64 elephants infected with amphistomes and/or *Fasciola* in Asom.

Cestodes: Bhalerao (1934) had listed 2 cestodes occurring in elephants, viz. *Anoplocephala manubriata* found as adult tapeworm in the intestine and cystic *Echinococcus granulosus* in visceral organs. The former was subsequently recorded in an elephant in Kerala by Chandrasekharan *et al.* (1979a) who observed that the affected animal became anorectic, lost condition, ate mud and grit, and turned diarrhoeic. Oxcyclozanide (Zanil) @ 3.4 mg/kg. b.w. as a single dose in food resulted in elimination of tapeworm segments and relief in symptoms (Chandrasekharan *et al.* 1979a). According to Panicker (1992), other drugs that can be tried include Niclosamide @ 75–100 mg/kg. b.w. oral, hexachlorophene @ 10 mg/kg. b.w. oral, Mansonil @ 5 mg/kg b.w. and Praziquantel @ 2.5–4 mg/kg. b.w. Oribatid mites were suspected to be the intermediate hosts but conclusive evidence was provided by McAloon (2004) who found developmental stages of *A. manubriata* in 5 species of oribatids in Kerala.

Nematodes: As many as 18 species belonging to 12 genera

were documented as parasites of Indian elephants in early literature (Bhalerao 1934), majority of them inhabiting the g.i. tract. Subsequent records were largely confirmatory of one or more of these from different localities. Accordingly, *Grammocephalus elathratus* and *G. varedatus* of liver in Tamil Nadu (Mudaliar and Alwar 1954); *Quilonia travancra* and *Murshidia falcifera* from caecum of two zoo elephants in Odisha (Patnaik and Acharjyo 1970); *Equinurbia sipunculiformis* from a diarrhoeic elephant in Uttar Pradesh Terai (Chhabra and Srivastava 1971); *Amira pileata*, *Decrusia addicta*, *E. sipunculiformis*, *Q. travancra*, *Q. renniei*, *Murshidia murshida*, *M. falcifera* and *M. indica* (all strongyles, predominantly caecal worms) were enlisted by Sundaram *et al.* (1971) from Kerala; *Choniangium epistomum* (caecum) from Asom (Datta *et al.* 1972); *Bathmostomum sangeri* (intestine and caecum), *M. murshida*, *M. falcifera* and *D. addicta* (Sathianesan *et al.* 1979) from Kerala, *M. falcifera*, *Q. travancra* and *B. sangeri* (Chandrasekharan *et al.* 1982) from Kerala, the spirurids *Parabronema indicum*, *P. smithi* (Chandrasekharan 1989, Panicker 1992) also from Kerala and *A. pileata*, *D. addicta*, *Murshidia* sp. and *Q. renniei* (Easwaran *et al.* 2003) all from Kerala. In between, records of nematode parasites additional to Bhalerao (1934) were also made as *Strongyloides elephantis* from an Indian elephant (Greve 1969), the stomach worm *Haemonchus contortus* (Rahman *et al.* 1970) on postmortem examination of an elephant in Mysore, the hookworm *Grammocephalus hybridatus* (both immature and adult worms) from a nodule in the stomach (Rajasekhariah *et al.* 1975), from the liver (Pillay *et al.* 1976) and from the lungs (Chakraborty *et al.* 1994), *Q. sinhai* (Gupta and Trivedi 1984), *Q. guptai* (Gupta and Jaiswal 1984). The latter 2 were reported as new species from elephants in Uttar Pradesh. Also reported was trichostrongyle infection from Asom (Lahkar and Das 1988). *Oesophagostomum* sp. was recorded on the basis of faecal examination occasionally (Datta and Bordoloi 1989, Jani 2008). Prevalence of *Toxocara* sp. along with strongyles was found at a national park in Bengaluru (Reddy *et al.* 1992). Out of Bhalerao (1934) list, *Bunostomum foliatum* (gastric tumours) remained unconfirmed and *Toxocara lonchoptera* (bile duct) got redesignated as *Balascaris lonchoptera* (Chakraborty 2003). The clinical signs observed in g.i. nematode infections included anorexia, mud-eating tendency, colic, reduced intake of food and water, paleness of visible mucous membranes, foetid diarrhoea, anaemia and eosinophilia (Rajamohanam 1970, Lahkar and Das 1988, Chandrasekharan 1989, Suresh *et al.* 2001, Jani 2008). The pathologic effects of grammocephalosis on liver as observed by Pillay *et al.* (1976) consisted of pale, enlarged and fibrosed in consistency. The bile duct was thickened due to proliferation of connective tissue and hyperplasia, hepatic and kupfer cells loaded with bile pigments and sinusoids showed slight to moderate enlargement. In the opinion of Kalyanasundaram (1979), pathogenicity of

grammocephalosis is well marked and even a few worms can cause grave pathological symptoms. Chakraborty (2003) found strongylosis, predominantly severe *Murshidia* infection as the cause of fatality in an elephant calf.

Asian elephants are susceptible to g.i. parasitic infections in the wild (Watve 1995, Dharmarajan 2000, Vidya and Sukumar 2002) and/or maintained in damp unhygienic conditions that may result in enhanced susceptibility to parasitic disease (Chandrasekharan *et al.* 1995, Suresh *et al.* 2001, Jani 2008). An epidemiological study at a zoological park (Suresh *et al.* 2001) found strongylosis to be predominant in summer (52.63%). Specific identification could be facilitated by coproculture to demonstrate third stage larvae (Bhat and Manickam 1998). *In vitro* survivability of strongyloids larvae of elephants (Raman *et al.* 2001) revealed their viability for 4 to 7 months. Husbandry and variable treatment practices such as in temples in Kerala, also influenced the incidence of helminthic infections (Saseedran *et al.* 2003). Among ecological factors affecting the intestinal parasite loads, significantly higher loads were recorded during dry season in southern India (Vidya and Sukumar 2002). In Tamil Nadu, the prevalence of intestinal parasites was highest in summer followed by monsoon, significantly lower in males compared to females, and significantly higher in elephants maintained in the forest department system than the private system (Vanitha *et al.* 2011).

For the treatment of g.i. nematodiasis, a variety of anthelmintics have been tried with varying degree of success. The range included tetramisole (Sundaram *et al.* 1971, Datta *et al.* 1972), thiabendazole (Chandrasekharan *et al.* 1972a), Methyridine (Chandrasekharan *et al.* 1979b), thiophanate (Chandrasekharan *et al.* 1979c) and oxybendazole (Sathianesan *et al.* 1979). Comparative efficacy of 6 anthelmintics against strongylosis (Chandrasekharan *et al.* 1982) indicated mebendazole @ 3–4 mg/kg, levamisole at 3 mg/kg and morantel tartrate 5 mg/kg b.w. were 100% effective. Fenbendazole as single oral treatment at 5 mg/kg b.w. (Roy and Mazumdar 1988) or 2 doses of 50 g (Tripathy *et al.* 1997) was efficacious against murshidiasis in 200 elephants and 12 g in 200 ml water in 2 divided doses at 3 days interval against trichostrongyle infection (Lahkar and Das 1988). Fenbendazole at 5 mg/kg was later found (Rao *et al.* 1992, Singh *et al.* 2006) equally effective against strongyles and amphistomes, while a similar dose of albendazole (Suresh *et al.* 2001) led to complete recovery from strongylosis.

Elephants also suffer from cutaneous filariasis caused by *Indofilaria pattabiramani* (Alwar *et al.* 1959) and *I. elephantis* (Chandrasekharan *et al.* 1972b). The condition is characterized by cutaneous nodules oozing blood. *Stephanofilaria* was first recorded by Bhattacharjee (1967) and subsequently identified by Chatterjee (1984) and Tripathy *et al.* (1989) as indistinguishable from *S. assamensis*. The clinical manifestations were chronic progressive dermatitis

in the region of toes, heels of hind feet and right abdominal wall (Tripathy *et al.* 1989). Examination of skin scrapings and oozing blood over the lesion, revealed the presence of microfilariae. Histopathological examination of affected skin revealed hyperkeratosis, acanthosis, granulomatous reactions and perivascular cuffing. Clinical cure was achieved by application of 8% metrifonate ointment in vaseline and Himax base. Islam and Lahkar (1996) recorded the eyeworm *Thelazia* from the nictitating membrane of the right eye of a captive elephant.

Arthropod parasites

The stomach bots, larvae of *Cobboldia elephantis* flies, occur commonly in Indian elephants. They have been reported from Asom (Datta *et al.* 1972, Chakraborty *et al.* 1994), Tamil Nadu (Joseph *et al.* 1987) and Odisha (Panda *et al.* 2005). The flies lay their eggs on hairs in various parts of the body and at the root of the tusks in males. Affected animals become emaciated, anaemic and temperature becomes subnormal (Datta *et al.* 1972). Severe infestations with thousands of larvae may cause severe gastritis with vomiting, abdominal discomfort and often prove fatal (Panda *et al.* 2005). Drugs used against bots in other animals, like dichlorvos, trichlorphon and ivermectin @ 0.2 mg/kg b.w. may be tried. The elephant louse *Haematomyzus elephantis* had been reported from Andhra Pradesh and Karnataka (Raghavan *et al.* 1968, Jagannath *et al.* 1979). Infestations were associated with dermatitis, dryness of skin and scale formation on the neck, ears, parts of the abdomen and region near the tail. Singh *et al.* (2006) and Godara *et al.* (2009) reported its occurrence in a zoological park in Punjab and a herd at Jaipur, Rajasthan, respectively. They provided morphological characteristics, clinical signs (which in heavy infestations included pruritis, hyperplasia and hair loss) and suitable treatment by sponging with butox (deltamethrin) 1: 500 aquatic dilution. Ticks reported from Karnataka (Jagannath *et al.* 1979) were *Rhipicephalus haemaphysaloides*. From Kerala (Panicker 1992), additional records included *Boophilus* sp., *Haemaphysalis* sp. and *Ornithodoros savignyi*. Contrary to these, Ajith Kumar *et al.* (2011) failed to find any tick infestations on elephants in Wayanad ghats of Kerala. Elephants are also attacked by the biting flies like *Tabanus* and *Stomoxys* as evidenced by the incidence of trypanosomiasis (*T.evansi*) in them.

Protozoan parasites

Trypanosoma evansi is known to infect the elephant. The affected animal becomes dull, depressed, disinclined to move, has intermittent fever, pale mucous membranes, lachrymation, oedematous swellings on dependent parts and passes scanty, turbid urine (Panicker 1992, Arunachalam *et al.* 1996). Among other protozoa, occasionally recorded from the Indian elephant, mention may be made of *Babesia* sp. (Arunachalam *et al.* 1996), intestinal ciliates (Vardharajan

and Pythal 1999) and coccidia (Banerjee *et al.* 2005). The reported seroprevalence of *Toxoplasma gondii* antibodies in captive elephants in Sri Lanka (Dangolla *et al.* 2006) should spur interest to explore its presence in neighbouring south India.

Parasites and parasitic diseases of mithun

As mithuns are phylo-genetically related to cattle and are kept under environmental conditions similar with cattle, there is strong likelihood that they may be subject to parasitisms similar to those known in cattle. Chakraborty (1992) found *Trichuris* spp. a common occurrence in captive herbivores including mithun. Captive mithuns at the Thiruvananthapuram zoo in Kerala were found to have amphistomes and coccidial oocysts on faecal examination (Vardharajan and Pythal 1999). Several other reports dealing with g.i. helminths in mithuns are available (Modi *et al.* 1995, Rajkhowa *et al.* 2003b). A coprological survey of g.i. helminth infections in mountainous regions of Bhutan and Arunachal Pradesh (Tandon *et al.* 2005) recorded in mithuns 12 nematode genera, viz. *Trichuris*, *capillaria*, *Strongyloides*, *Toxocara*, *Ascaris*, *Oesophagostomum*, *Bunostomum*, *Mecistocirrus*; *cooperia ostertagia*, *Thelazia* and *Dictyocaulus*, 4 trematodes, viz. *Fasciola*, *Gastrodiscoides*, *Gastrothylax* and *Paramphistomum*; and 2 cestodes, *Moniezia* and *Taenia* spp. In a study on intestinal parasitism in mithuns of 4 north eastern states, 70.27% of 37 animals were faecally positive (Rajkhowa *et al.* 2005b). Of the 16 helminth species belonging to 15 genera, the 7 strongyle genera accounted for the maximum (54.05%) incidence. These were *Oesophagostomum radiatum*, *Bunostomum phlebotomum*, *Trichostrongylus* sp., *Nematodirus* sp., *Haemonchus placei*, *Mecistocirrus* sp. and *Cooperia* sp. The infection rate in young animals (1–3 months) was higher and they were mostly found parasitized with *Strongyloides papillosus*, *Toxocara vitulorum* and coccidia. In older animals, the longworm *Dictyocaulus* sp. was also recorded. The other entities included 5 trematodes viz. *Fasciola*, *Fascioloides*, *Paramphistomum*, *Schistosoma bovis* and *S.indicum*. The only cestode was *Moniezia expansa*. In other epidemiological studies at the National Research Centre on Mithun, on 53 animals significantly higher nematode and cestode worm burden was found in calves below 1 year in age than those in 1–3 years and older than 3 years age groups (Chamuah *et al.* 2006 2009). Prevalence of strongyle infection was higher in monsoon season in calves below 1 year of age. Amphistome infection was higher in winter. On the basis of morphological characters of ova and larvae, *T.vitulorum*, *S.papillosus*, *Trichuris* sp., *Trichostrongylus* sp., *Oesophagostomum* sp., *Haemonchus* sp., *Cooperia* spp. and *Bunostomum* sp. were recorded in faecal samples. *S.papillosus* and *T.vitulorum* were recorded only in calves below 1 year. The study also recorded *Eimeria* (mainly *E.bovis*) in age groups of below 1 year and 1–3 years.

According to a status report of internal parasitoses in mithun calves up to 9 months of age in Nagaland (Rajkhowa *et al.* 2007) infections determined by faecal analysis were *S.papillosus* (100%), *T.vitulum* (53%), *O.radiatum* (52%), *Cooperia* spp. (46%), *H.placei* (43%), *B.phlebotomum* (41%), *Ostertagia* spp. (39%) and *M.expansa* (48%). The clinical effects recorded were similar to those observed in other herbivorous mammals, such as the pathology of *F.gigantica* infected biliary epithelium in mithun (Chakraborty 2001). Haematological changes recorded in mithuns with g.i. nematodiosis (Rajkhowa *et al.* 2003b, 2004) included lowered values of Hb, PCV, TEC, TLC, total proteins and albumin. Microfilaraemia in mithuns of Nagaland (Rajkhowa *et al.* 2005a) possibly related to *Parafilaria bovicola*, is also on record. Anthelmintic treatment with a single dose of ivermectin at 0.2 mg/kg b.w. administered to animals with high faecal egg counts and showing clinical symptoms (Rajkhowa *et al.* 2003b) resulted in significant improvement in clinical and haemato-biochemical parameters by day 14 post-treatment. The study on internal parasitoses in mithun calves (Rajkhowa *et al.* 2007) also recorded protozoan infections with *Eimeria* spp. (63%), *Cryptosporidium parvum* (52%), *Balantidium coli* (22%) and *Giardia* spp. (11%) mostly concurrent with helminthiasis in multiple infections with 3–4 different parasites. *Eimeria* spp. identified were *E.bovis*, *E.zuernii*, *E.cylindrica*, *E.ellipsoidalis*, *E.auburnensis*, *E.alabamensis*, *E.bukidnonensis* and *E.subspherica* (Rajkhowa *et al.* 2004, 2007). The occurrence of another species *E.canadensis* had been recorded (Agrawal 2001) from a zoo in Lucknow. Eimerian infections were highest in calves aged 3–6 months. Clinical coccidiosis (Chamuah *et al.* 2009) was also reported. The main clinical signs were haemorrhagic diarrhea, tenesmus, anaemia and unthriftiness. The prevalence of *C.parvum* in mithuns (Rajkhowa *et al.* 2006a) by a commercial enzyme-linked immunosorbent assay kit was overall 56%, higher (94%) in diarrhoeic animals in comparison to non-diarrhoeic group (51%). The prevalence was highest in young calves aged 8–15 days. Haemoprotozoan diseases like theileriosis, recorded in a gaur calf (Khan 1981), babesiosis in a crossbred mithun (Das *et al.* 1999) and trypanosomiasis (Rajkhowa *et al.* 2003a) were occasionally reported with clinical manifestations resembling those in cattle. In clinical babesiosis (Das *et al.* 1999), high body temperature (41°C), haemoglobinuria and anaemia were observed, as well as response to combination therapy with diminazene aceturate and oxytetracycline. Seroprevalence of *Toxoplasma gondii* antibodies in captive mithuns (Rajkhowa *et al.* 2006b) at 28% and in their free-ranging counterparts (Rajkhowa *et al.* 2008a) at 42% was recorded by modified direct agglutination test. Antibodies to *Neospora caninum* in captive and free-ranging mithuns of Nagaland (Rajkhowa *et al.* 2008b) was detected in overall 10% by a commercially available ELISA test. Mithuns were

also subject to arthropod parasites like ticks *Boophilus microplus* (Rajkhowa *et al.* 2005c) with highest infestation during monsoon and lowest in winter. *Rhipicephalus* and *Haemaphysalis* spp. were also recorded. Acaricides like deltamethrin, amitraz and ivermectin were evaluated for their efficacy against ticks (Rajkhowa *et al.* 2005d) and deltamethrin (1.25%) at 2 ml/litre of water was found to have the highest (100%) efficacy.

Parasites and parasitic diseases of Indian yak

The parasitic fauna of the yak have remained relatively unexplored except for the occurrence of hydatid cysts (Katiyar and Sinha 1987, Rai *et al.* 1989, Ansari and Rai 1991). Found mainly in lungs and/or liver and occasionally in other organs, the prevalence was 42–96% (Ranga Rao *et al.* 1994). In a comprehensive study of yak and its hybrids in Ladakh, Sikkim and Himalayan regions of Indo-Nepal border in Uttar Pradesh (Ranga Rao *et al.* 1994) based on necropsy and coprological examination of eggs and faecal culture, 3 liver flakes, 4 amphistomes, 1 cestode and 9 nematodes were recorded. These were listed as *Fasciola hepatica*, *F.gigantica*, *Gigantocotyle explanatum*, *Cotylophoron cotylophorum*, *Gastrothylax crumenifer*, *Fiscoederius cobboldi*, *Paramphistomum cervi*, *Moniezia Trichostrongylus*, *Ostertagia*, *Cooperia*, *Nematodirus*, *Biunostomum*, *Chabertia*, *Haemonchus*, *Mecistocirrus* and *Toxocara (Neoascaris) vitulorum*. Apart from these, cysts of *Coenurus* spp., hydatid cysts and adult *Setaria cervi* from peritoneum were recovered. Coprological examination revealed a high prevalence of *Strongylate* spp. (76.4%). Prevalence of g.i. parasites in the cold desert area of North Sikkim (Bandyopadhyay *et al.* 2010) based on faecal examination of 348 yaks, revealed *Haemonchus* spp. as the predominant (6.89%) followed by *Nematodirus* spp. (1.72%), *Cooperia* spp. (1.43%) and *Dicrocoelium* spp. (0.29%). Another recent study on g.i. parasites of domesticated yak (Rahman *et al.* 2010) recorded overall occurrence of strongyles (17.36%), *Strongyloides* spp. (4.34%), *Toxocara* spp. (2.25%), *Trichuris* spp. (2.88%), amphistomes 0.52% and *Moniezia* spp. (3.07%). On coproculture of positive samples, *Haemonchus*, *Bunostomum*, *Oesophagostomum* and *Nematodirus* spp. were identified. A solitary record of a filariid worm *Parafilaria bovicola* (Yadav *et al.* 2007) from yak in Arunachal Pradesh exists. The pathology of liver, lung and caecum of yak infected with *Fasciola*, *Dicrocoelium*, *Echinococcus* and *Trichuris* has been documented (Ansari *et al.* 1989). Anthelmintic studies in yaks were not available since Roy *et al.* (1986). Among protozoan parasites, coccidian are common (Ranga Rao *et al.* 1994, Rahman *et al.* 2010). The former author identified *Eimeria braziliensis* and *E.zuernii*. Cases of babesiosis in yak in Arunachal Pradesh (Saud *et al.* 2005) with pyrexia, anaemia and haemoglobinuria, confirmed by blood smear examination and treated with diminazene aceturate, have been reported.

The arthropod, warble fly *Hypoderma lineatum* was initially reported from yak in Bhutan (Chaudhury 1970) but later on, also from Arunachal Pradesh (Sarvanan *et al.* 2006a). Six genera of ticks viz. *Boophilus*, *Ixodes* (2 species), *Haemaphysalis* (3 species), *Rhipicephalis*, *Amblyomma* and *Dermacentor* were recorded from Arunachal Pradesh and Sikkim (Geevarghese *et al.* 1997, Sarvanan *et al.* 2008). Interestingly, the incidence of tick infestation was more in yak hybrids than in yaks. Incidence of common ectoparasites, viz. ticks, lice, flies (larva) and fleas (Sarvanan *et al.* 2006b, 2009) overall was 27.96%, higher in field than in organized farm conditions. Apart from the ticks earlier named, lice *Damalinea* spp., flea identified as *Ctenocephalides felis* and various flies such as *Tabanus*, *Sarcophaga*, *Lucilia*, *Calliphora*, *Chrysomyia* and *Hypoderma* were collected. Cypermethrin as spray was effective against ectoparasites like lice (Sarvanan *et al.* 2006b).

Knowledge of parasites and parasitic diseases of marginal livestock as exemplified by elephant, mithun and yak, is still in its infancy and only baseline data are available so far. The elephant is particularly prone to a variety of parasites of which *Fasciola jacksoni* stands out as the most pathogenic as well as prevalent entity. There is need to explore its transmission cycle with the objective of minimizing losses. Diagnosis of parasitic diseases needs to be upgraded across the host species with enhanced use of modern molecular techniques such as PCR-based diagnosis as standardized for haemoprotozoan infections like trypanosomiasis in captive wild herbivores (Shailaja *et al.* 2005). There are several obvious information gaps at present. In all the 3 host species, the ectoparasites have not been adequately explored and there is no record of sarcoptic mange or myiasis except for *Hypoderma* larvae in the yak. In Indian elephant, coccidia, if any, are yet to be reported and the relatively low incidence of trypanosomiasis may be due to low preference of biting fly vectors for the pachyderm. The apparent absence of trypanosomiasis in Indian yak may be due to yak habitat of cold desert being inhospitable to the breeding of vector flies. *Theileria* infections reported from yak in China has not been recorded in Indian yak and coccidian species of this animal have also not been studied fully. In the mithun, entities like *Theileria* and *Sarcocystis* have not been recorded so far. Keeping in mind the known host-specificity of coccidia, the *Eimeria* species identified in the mithun although morphologically indistinguishable from those in cattle, should be checked by cross-transmission studies for the possibility of being host-specific varieties in transition to evolving as distinct species. Similarly, *Cryptosporidium parvum* recorded from mithun should be characterized by genotyping as at least 2 other species, *C.bovis* and *C.andersoni* are known to occur in Indian bovines. The high positivity in young calves calls for rearing them away from adults. The seroprevalence of *Toxoplasma* is of zoonotic significance as mithun is also a meat animal.

REFERENCES

- Agarwal R D. 2001. Occurrence of *Eimeria canadensis* Bruce 1921 from Gayal (*Bos frontalis*). *Indian Veterinary Journal* **78**: 346.
- Ajith Kumar K G, Ravindran R, Chandy G, Johns J, Syamala K and Priya M N. 2011. Tick fauna of wild life of Western Ghats region of Wayanad, Kerala. *Proc. XXI National Congress of Veterinary Parasitology*. 5–7 January, 2011, Mumbai. pp. 123–24.
- Alwar V S, Seneviratna P and Gopal S. 1959. *Indofilaria pattabiramani* N.sp. A filarid from the Indian elephant (*Elephas maximus*) causing haemorrhagic dermatitis. *Indian Veterinary Journal* **36**: 409–14.
- Ananda K J, Naik S G and Naravi Y. 2011. Amphistome infection in an Indian elephant: A case report. *Proceedings of XXI National Congress of Veterinary Parasitology*. pp. 119. 5–7 January, 2011, Mumbai.
- Ansari M Z and Rai M K. 1991. Studies on occurrence and incidence of hydatid disease in yak in Sikkim. *Indian Veterinary Journal* **68**: 112–14.
- Ansari M Z, Rai M K and Chauhan H V S. 1989. Pathology of liver, lung and caecum of yaks (*Bos poephagus*) infected with *Dicrocoelium*, *Fasciola*, *Echinococcus* and *Trichuris*. *Indian Journal of Animal Sciences* **59**: 552–54.
- Arunachalam K, Sudheer S, Subramaniam N, Kumaravelu N and Sangaralingam S. 1996. Parasitic diseases of Indian elephants. *Zoos' Print* **11** (4): 1–4.
- Bandyopadhyay S, Pal P, Bhattacharya D, Bera A K, Pan D and Rahman H. 2010. A report on the prevalence of gastro-intestinal parasites in yaks (*Bos poephagus*) in the cold desert area of North Sikkim, India. *Tropical Animal Health and Production* **42**: 119–21.
- Banerjee P S, Garg R, Yadav C L and Ram H. 2005. Parasitic infections in some wild animals in Uttaranchal. *Indian Journal of Animal Sciences* **75**: 206–08.
- Bhalerao G D. 1934. *Helminth Parasites of the domesticated animals in India*. Imperial Council of Agricultural Research. Scientific monograph No. 6 pp. 1–365.
- Bhat M N and Manickam R. 1998. Coproculture and demonstration of third stage larvae of *Murshidia* sp. in elephants (*Elephas maximus*). *Indian Veterinary Journal* **75**: 1140–42.
- Bhattacharjee M L. 1967. Stephanofilarial dermatitis in an Indian elephant. *Current science* **36**: 584–85.
- Chakraborty A. 1992. *Trichuris* sp. Infection in wild captive herbivores. *Journal of Veterinary Parasitology* **6**: 37–40.
- 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. 2003. Helminth parasites of Indian elephant (*Elephas maximus*). *Helminthology in India*. pp. 263–84. (Ed) Sood M L. International Book Distributors, Dehra Dun.
- Chakraborty A and Chaudhury B. 1991. Intussusception and tibia fracture in elephant – necropsy findings of two cases. *Zoos' Print* **6**: 9–10.
- Chakraborty A and Chaudhury B. 1992. Pathology of *Fasciola jacksoni* infestation in elephants. *Indian Journal of Veterinary Pathology* **16**: 98–101.
- Chakraborty A, Gogoi A R and Chaudhury B. 1994. Prevalence of parasitic infection in captive wild herbivores. *International Journal of Animal Sciences* **65**: 421–24.

- Chamuah J K, Das M and Rajkhowa S. 2006. Seasonal incidence of gastrointestinal parasites in Mithun. *Indian Veterinary Journal* **83**: 1051–53.
- Chamuah J K, Das M R, Rajkhowa S, Islam S and Rajkhowa C. 2009. Coccidiosis in Mithun. *Indian Veterinary Journal* **86**: 419–20.
- Chandrasekharan K. 1989. Prevalence of infectious diseases in elephants in Kerala and their treatment. *The Asian Elephant – Proceedings of the Symposium*. Kerala Agricultural University, Trichur, January 16–18. Pp. 148–65.
- Chandrasekharan K, Pythal C and Sundaram R K. 1972a. A clinical note on the use of thiabendazole (Thibendole) against murshidiiasis in Indian elephants *Elephas maximus*. *Kerala Journal of Veterinary Science* **3**: 56.
- Chandrasekharan K, Sundaram R K and Peter C T. 1972b. On *Indofilaria elephantis* from Indian elephants *Elephas maximus*. *Indian Veterinary Journal* **49**: 857–62.
- Chandrasekharan K, Rajamohan K and Sundaram R K. 1979a. A case of cestode infection in an Indian elephant. *Kerala Journal of Veterinary Science* **10**: 57–58.
- Chandrasekharan K, Pythal C, Radhakrishnan K and Sundaram R K. 1979b. Methyridine as an effective anthelmintic against strongylosis in elephants. *Kerala Journal of Veterinary Science* **10**: 163–66.
- Chandrasekharan K, Sathianesan V, Pythal C and Sundaram R K. 1979c. Anthelmintic activity of thiophanate (Nemafax) in elephants and zoo animals. *Kerala Journal of Veterinary Science* **10**: 167–70.
- Chandrasekharan K, Cheeran J V, Nair K N M, Ramanujam K N and Radhakrishnan K. 1982. Comparative efficacy of 6 anthelmintics against strongylosis in elephants. *Kerala Journal of Veterinary Science* **13**: 15–20.
- Chandrasekharan K, Radhakrishnan K, Cheeran J V, Muraleedharan K N and Prabhakaran T. 1995. Review of the incidence, ecology and control of common diseases of Asian elephants with special reference to Kerala. *A Week with Elephants*. Pp. 439–49. (Eds) Daniel J C and Datye H S. *Proceedings of the International Seminar on the conservation of Asian Elephant*. June 1993. Oxford University Press, Oxford.
- Chatterjee A. 1984. Association of *Stephanofilaria* indistinguishable from *S. assamensis* with lesions on the feet of Indian elephants (*Elephas maximus*). *Indian Journal of Animal Health* **23**: 29–35.
- Chaudhury R P. 1970. Occurrence of warble fly – *Hypoderma lineatum* infection in yaks in Bhutan. *Journal of Parasitology* **56**: 377.
- Chhabra M B and Srivastava P S. 1971. On *Equinurba sipunculiformis* (Baird 1959) Lane 1914 from an Indian elephant (*Elephas indicus*) in U.P. tarai. *Orissa Veterinary Journal* **6**: 43.
- Das B C, Sarkar M, Das D N, Mohanty T K, Mondal D B and Pal R N. 1999. Babesiosis in a crossbred mithun. (*B. frontalis*) – A case study. *Indian Veterinary Journal* **76**: 443–44.
- Dangolla A, Ekanayake D K, Rajapakse R P, Dubey J P and Silva I D. 2006. Seroprevalence of *Toxoplasma gondii* antibodies in captive elephants (*Elephas maximus maximus*) in Sri Lanka. *Veterinary Parasitology* **37**: 172–74.
- Datta B, Chakravarti A K and Raquib A. 1972. A successful treatment of *Choniangium epistomum* and *Cobboldia elephantis* larvae infection in elephants with tetramisole (Nilverm ICI). *Indian Veterinary Journal* **49**: 1158–59.
- Dharmarajan G. 2000. 'Epidemiology in wild and domestic herbivores at the Madumalai Wildlife Sanctuary, Tamil Nadu.' M.V.Sc. Thesis, Tamil Nadu University of Veterinary and Animal Sciences, Chennai, Tamil Nadu. pp. 1–75.
- Dutta G C and Bordoloi G C. 1989. Prevalence of helminthic infections in elephant of Tiger Project of Manas, Assam. *Zoos' Print* **4** (3): 14.
- Easwaran K R, Ravindran R and Pillai K M. 2003. Parasitic infections of some wild animals at Thekkady in Kerala. *Zoos' Print Journal* **18** (2): 1030.
- Geevarghese G, Fernandes S and Kulkarni S M. 1997. A checklist of Indian ticks (Acari: Ixodoidea). *Indian Journal of Animal Sciences* **67**: 566–74.
- Godara R, Singh S, Dev R and Sharma R L. 2009. Occurrence of *Haematomyzus elephantis* in semi-arid Rajasthan. *Journal of Veterinary Parasitology* **23**: 69–71.
- Greve J H. 1969. *Strongyloides elephantis* sp. from an Indian elephant *Elephas indicus*. *Journal of Parasitology* **55**: 498–99.
- Gupta V and Jaiswal R K. 1984. On a new nematode *Quilonia guptai* sp. nov. (Strongyloidea: cyathostomidae, yamaguti 1961) from an Indian elephant. *Indian Journal of Helminthology* **36**: 139–42.
- Gupta S F and Trivedi K K. 1984. Nematode parasites of Vertebrates IV. A new nematode parasite *Quilonia sinhai* (sp. nov. Strongyloidea: Cyathostomidae) from an Indian elephant. *Indian Journal of Helminthology* **36**: 61–67.
- Gupta S C, Gupta N and Nivsarkar A E. 1999. *Mithun – A Bovine of Indian Origin*. Directorate of Information and Publication on Agriculture, ICAR, New Delhi. Pp. 1–124.
- Islam S. 1994. Occurrence of *Bivitellobilharzia nairi* in captive Asian elephants (*Elephas maximus*) from Kaziranga National Park and Assam State Zoo, Guwahati. *Zoos' Print* **9** (9): 10–11.
- Islam S. 1997. Studies on some aspects of fascioliasis in Asian elephants (*Elephas maximus*). *Journal of Veterinary Parasitology* **11**: 109.
- Islam S. 2010. Egg characteristics of *Fasciola jacksoni* in Asian elephant. *Indian Veterinary Journal* **87**: 308–09.
- Islam S and Lahkar B C. 1996. A new elephant host record of eye worm *Thelazia* with some clinical observations. *Zoos' Print* **11** (4): 12.
- Islam S, Mukit A and Das M. 1999. Pathology of concurrent *Gastrodiscus secundus* and *Pseudodiscus collinsi* infection in two captive Asian elephants (*Elephas maximus*). *Journal of Veterinary Parasitology* **13**: 151–52.
- Jagannath M S, Pillai K R S and Hiregaudar L S. 1979. On the occurrence of *Rhipicephalus haemaphysaloides* Supino 1897 on an Indian elephant (*Elephas meximus*). *Indian Veterinary Journal* **56**: 978.
- Jani R G. 2008. Prevalence and haemato-biochemical studies of gastro-intestinal parasites of Indian elephants (*Elephas maximus*) *Veterinary World* **1**: 296–98.
- Joseph S A, Karunamoorthy G and Lalitha C M. 1987. A study on the incidence of myiasis in domestic animals of Tamil Nadu. *Cheiron* **16**: 175–78.
- Kalyanasundaram R. 1979. Parasitic diseases of elephants. *Proceedings of the summer institute on Diseases of Wildlife*. University of Agricultural Sciences, Bangalore. 14 May – 2 June (Sect. D). pp. 1–4.
- Katiyar R D and Sinha A K. 1987. Hydatid disease in livestock in

- Sikkim. *Livestock Advisor* **6**: 57–58.
- Khan M G A. 1981. Theileriasis in a gaur calf. *Indian Veterinary Journal* **58**: 72–73.
- Lahkar B C and Das M R. 1988. A note on successful treatment of elephant (*Elephas maximus*) with panacur (fenbendazole). *Indian Veterinary Journal* **65**: 538.
- McAloon F M. 2004. Oribatid mites as intermediate hosts of *Anoplocephala manubriata*, cestode of the Asian elephant in India. *Experimental and Applied Acarology* **32**: 181–85.
- Modi G S, Prasad B N, Sinha A K and Sinha B K. 1995. Parasitic infections in herbivorous zoo animals. *Indian Journal of Veterinary Research* **4**: 45–50.
- Mudaliar G and Alwar V S. 1954. A check list of parasites (class Nematoda) in the Department of Parasitology. *Madras Veterinary College Laboratory* **24**: 77. (fide Chakraborty A. 2003.)
- Muraleedharan K and Keshavaprasad B S. 2001. *Pseudodiscus collinsi* in an Indian elephant. *Intas-Polivet* **2**: 202–03.
- Nighot N K, Jadhav R V, Umrigar K, Nevase S N and Rokade J J. 2011. *Fasciola* infection in captive Asian elephant (*Elephas maximus*): A case report. *Proceedings XXI National Congress of Veterinary Parasitology*. 5–7 January, 2011. Mumbai. pp. 121.
- Panda S K, Panda D N and Parhi N H. 2005. Occurrence of *Cobboldia elephantis* (Cobbold 1866) larvae in a wild elephant. *Journal of Veterinary Parasitology* **19**: 163–64.
- Panicker K V. 1992. Prevalence of infectious diseases in elephants in Kerala and their treatment. *The Asian Elephant – Ecology, Biology, Disease, Conservation and Management*. 1992. Kerala Agricultural University, Thrissur. pp. 148–50.
- Patnaik M M and Acharjyo L N. 1970. Notes on the helminth parasites of vertebrates in Baranga zoo (Orissa). *Indian Veterinary Journal* **47**: 723–30.
- Pillay K R S, Rahman S A, Hegde K S and Rajasekaran D. 1976. Grammocephalosis in an Indian elephant in Mysore. *Indian Veterinary Journal* **53**: 670–71.
- Raghavan R S, Reddy R R and Khan G A. 1968. Dermatitis in elephants caused by the louse *Haematomyzus elephantis* (Piagot 1869). *Indian Veterinary Journal* **45**: 700–07.
- Rahman S A, Pillay K R S, Prema B V and Narayanaswamy M. 1970. *Haemonchus contortus* (Rudolphi, Cobbold 1898) from an Indian elephant in Mysore. *Current Science* **39**: 356–57.
- Rahman H, Pal P and Bandyopadhyay S. 2010. Occurrence of gastrointestinal parasites in domestic yaks in Sikkim. *Indian Journal of Animal Sciences* **80**: 195–98.
- Rai M K, Ansari M Z, Sahai B N and Chauhan H V S. 1989. Prevalence of helminth parasites of yak (*Bos poephagus*) in Sikkim India, detection of secondary hydatidosis and histopathology of hydatid cysts parasitizing liver and lungs. *Rivista di parasitologia* **50**: 79–87.
- Rajamohan K. 1970. Acute parasitic enteritis in an elephant. *Kerala Journal of Veterinary Science* **1**: 73–74.
- Rajasekariah G R, Hegde K S and Pillay K R S. 1975. Unusual occurrence of *Grammocephalus hybridatus* Wethuysen 1938 in verminous nodule in the stomach of an Indian elephant (*Elephas maximus*). *Mysore Journal of Agricultural Sciences* **9**: 141–45.
- Rajkhowa S, Bujarbaruah K M, Hazarika G C and Rajkhowa C. 2003a. Observations on trypanosomiasis in mithun. *Indian Veterinary Journal* **80**: 934–36.
- Rajkhowa S, Bujarbaruah K M, Rajkhowa C and Kapenlo-Thong. 2003b. Haematobiochemical changes in mithuns with gastrointestinal nematodiasis. *Indian Veterinary Journal* **80**: 1064–66.
- Rajkhowa S, Bujarbaruah K M and Rajkhowa C. 2004. Haematobiochemical changes in ascariasis of mithun calves. *Indian Veterinary Journal* **81**: 571–72.
- Rajkhowa S, Bujarbaruah K M, Rajkhowa C and Hazarika G C. 2005a. Microfilaraemia in mithuns (*Bos frontalis*) of Nagaland. *Indian Journal of Animal Sciences* **75**: 27–28.
- Rajkhowa S, Bujarbaruah K M, Rajkhowa C and Thong K. 2005b. Incidence of intestinal parasitism in mithun (*Bos frontalis*). *Journal of Veterinary Parasitology* **19**: 39–41.
- Rajkhowa S, Rajkhowa C, Bujarbaruah K M and Hazarika G C. 2005c. Seasonal dynamics of *Boophilus microplus* infestation in the mithuns (*Bos frontalis*) of Nagaland. *Indian Journal of Animal Sciences* **75**: 25–26.
- Rajkhowa S, Rajkhowa C, Bujarbaruah K M and Hazarika G C. 2005d. Comparative efficacy of certain acaricides against tick infestations in mithun. *Indian Veterinary Journal* **82**: 601–03.
- Rajkhowa S, Rajkhowa C and Hazarika G C. 2006a. Prevalence of *Cryptosporidium parvum* in mithuns (*Bos frontalis*) from India. *Veterinary Parasitology* **142**: 146–49.
- Rajkhowa S, Sarma D K and Rajkhowa C. 2006b. Seroprevalence of *Toxoplasma gondii* antibodies in captive mithuns (*Bos frontalis*) from India. *Veterinary Parasitology* **135**: 369–74.
- Rajkhowa S, Rajkhowa C and Hazarika G C. 2007. Status of parasitic infection in mithun (*Bos frontalis*) calves in the north-eastern hill region of India. *Indian Journal of Animal Sciences* **77**: 568–69.
- Rajkhowa S, Rajkhowa C and Chamuah J. 2008a. Seroprevalence of *Toxoplasma gondii* antibodies in free-ranging mithuns (*Bos frontalis*) from India. *Zoonoses and Public Health* **55**: 320–22.
- Rajkhowa S, Rajkhowa C, Dutta P R, Paihem Michui and Das R. 2008b. Serological evidence of *Neospora caninum* infection in mithun (*Bos frontalis*) from India. *Research in Veterinary Science* **84**: 250–53.
- Raman M, Jayathangaraj M G and Mailk P K. 2001. *In vitro* survivability of strongylid larvae of elephants. *Indian Journal of Animal Sciences* **71**: 1043–44.
- Ranga Rao G S C, Sharma R L and Hemaprasanth. 1994. Parasitic infections of Indian yak *Bos (poehagus) grunniens* – an overview. *Veterinary Parasitology* **53**: 75–82.
- Rao D S T, Yathiraj S, Choudhuri P C and Reddy P K. 1992. Treatment of helminthiasis in elephants. *Indian Journal of Animal Sciences* **62**: 1155–56.
- Reddy N R J, Jagannath M S, D'Souza P, Rahman S A and Basavarajappa K. 1992. Prevalence of gastrointestinal parasites in wild mammals and captive birds at Bannerghata National Park, Bangalore. *Indian Journal of Animal Sciences* **62**: 1146–48.
- Roy S and Mazumdar B K. 1988. Anthelmintic activity of Fenbendazole (Panacur) against *Murshidia murshida* in zoo elephants. *Indian Veterinary Journal* **65**: 531–32.
- Roy S, Mazumdar B K, Chakraborty A and Banerjee A K. 1986. Efficacy of three thio- allophanates against strongyle infection in yaks (*Bos mutus*). *Indian Journal of Veterinary Medicine* **6**: 128–29.
- Sarma K K, Thomas S and Sarma M. 2005. Trematode infection in Asian elephants and its treatment with Neozide. *Intas-Polivet* **6**: 318–19.
- Sarvanan B C, Pourouchottamane R, Ramesha K P and

- Bhattacharya M. 2006a. A case of *Hypoderma* infestation in yak. *Indian Veterinary Journal* **83**: 1105.
- Sarvanan B C, Yadav S C, Borkataki S and Pourouchottamane R. 2006b. Lice infestation in yak. *Indian Veterinary Journal* **83**: 1321.
- Sarvanan B C, Bandyopadhyay S, Pourouchottamane R, Kataktalware M A, Ramesha K P and Sarkar M. 2008. Incidence of ixodid ticks infesting yak (*Poephagus grunniens* L.) and its hybrids in Arunachal Pradesh and Sikkim. *Indian Journal of Animal Sciences* **78**: 159–60.
- Sarvanan B C, Pourouchottamane R, Kataktalware M A, Sarkar M and Ramesha K P. 2009. Common ectoparasites infesting yaks. *Indian Veterinary Journal* **86**: 860–61.
- Saseedran P C, Rajendran S, Subramanian H, Sasikumar M, Vivek G and Anil K S. 2003. Incidence of helminthic infection among annually dewormed captive elephants. *Zoos' Print Journal* **19** (3): 1422.
- Sathianesan V, Chandrasekharan K, Sundaram R K and Pythal C. 1979. Anthelmintic efficacy of oxybendazole against the common strongylids in elephants. *Kerala Journal of Veterinary Science* **10**: 153–56.
- Saud N, Sheikh I U, Pourouchottamane R and Bhattacharya M. 2005. Haematology of babesiosis in yaks. *Indian Veterinary Journal* **82**: 110–11.
- Shailaja V, Venkatesha M D, Renukaprasad C, Jaykumar S R and Krishappa G. 2005. Standardization of polymerase chain reaction (PCR) for diagnosis of trypanosomiasis in captive wild animals. *Intas-Polivet* **6**: 207–08.
- Singh K P, Srivastava V K, Prasad A and Pandey A P. 1994. Pathology due to *Fasciola jacksoni* in Indian elephants (*Elephas indicus*). *Indian Journal of Animal Sciences* **64**: 802–04.
- Singh P, Gupta M P, Singla L D, Sharma S, Sandhu B S and Sharma D R. 2006. Parasitic infections in wild herbivores in the Mahendra Choudhury Zoological Park, Chhatbir, Punjab. *Zoos' Print Journal* **21** (11): 2459–61.
- Sundaram R K, Chandrasekharan K and Madhavan Pillai K. 1971. Tetramisole (Nilverm) as an anthelmintic against gastro-intestinal nematodes of elephants. *Kerala Journal of Veterinary Science* **2**: 55–58.
- Sundaram R K, Padmanabha Iyer R, Peter C T and Alwar V S. 1972. On *Bivitellobilharzia nairi* (Mudaliar and Ramanujachari 1944) Dutt and Srivastava 1955 (Trematoda: Schistosomatidae) parasitic in Indian elephants (*Elephas maximus*) with a redescription of the species. *Indian Veterinary Journal* **49**: 1–10.
- Suresh K, Choudhuri P C, Nalini Kumari K, Hafeez Md and Hamza P A. 2001. Epidemiological and clinic-therapeutic studies of strongylosis in elephants. *Zoos' Print Journal* **16** (7): 539–40.
- Tandon V, Kar P K, Das B, Sharma B and Dorjee J. 2005. Preliminary survey of gastro-intestinal helminth infection in herbivorous livestock of mountainous regions of Bhutan and Arunachal Pradesh. *Zoos' Print Journal* **20** (5): 1867–68.
- Tripathy S B, Das P K and Acharjyo L N. 1989. Treatment of micro-filarial dermatitis in an Asian elephant (*Elephas maximus*): A case report. *Indian Journal of Indigenous Medicine* **6**: 31–33.
- Tripathi S B, Acharjyo L N and Parhi N K. 1997. Use of fembendazole against murshidiasis in a zoo elephant. *Indian Journal of Veterinary Medicine* **17**: 48–49.
- Vanitha V, Thiyagesan K and Baskaran N. 2011. Prevalence of intestinal parasites among captive Asian elephants *Elephas maximus*: effect of season, host, demography and management systems in Tamil Nadu, India. *Journal of Threatened Taxa* **13**: 1527–34.
- 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*. **I-XIV** (3–12): 159–16.
- Vidya T N C and Sukumar R. 2002. The effect of some ecological factors on the intestinal parasite loads of the Asian elephant (*Elephas maximus*) in southern India. *Journal of Bioscience* **27**: 521–28.
- Watve M G. 1995. Helminth parasites of elephants: Ecological aspects. *A week with elephants*. pp. 289–95. (Eds) Daniel J C and Datye H. Bombay Natural History Society, Bombay and Oxford University Press, New Delhi.
- Yadav S C, Sarvanan B C, Borkataki S and Baruah K. 2007. A record of *Parafilaria bovicola* from yak (*Poephagus grunniens*, L.) in India. *Journal of Veterinary Parasitology* **21**: 37–38.