

Parasites and parasitic diseases of the camel in India: a review

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ABSTRACT

The camel (*Camelus dromedarius* L.) is subject to several parasites belonging to all 3 major groups, viz. protozoa, helminths and arthropods. Some of them are regularly associated with disease and have consequently been studied in depth. These include the protozoan *Trypanosoma evansi*, the cause of trypanosomosis, which ranks as probably the most serious infectious disease of camels. Gastrointestinal nematodes (GIN), particularly the stomach worm *Haemonchus*, have compelled the maximum attention due to pathogenicity. Sarcoptic mange is not only widely prevalent in India, but is a serious, debilitating and dreaded disease. An overwhelming majority of literature in India, following international trend, has been devoted to these 3 entities of parasitic diseases. Reports and research publications in recent years, indicate considerable advancements in various aspects, particularly in the diagnostic techniques for trypanosomosis, epidemiology and control of GIN and acaricidal therapy for sarcoptic mange. Other parasites in each category, less frequently reported, but potentially capable of adversely impacting the camel economy through morbidity and occasional disease, such as coccidia, hydatidosis, myiasis and tick infestations, have also been included in the review. Attempts were also made to define the existing information gaps and to identify the topics for inclusion in future investigations and surveillance of camelid parasites.

Key words: Arthropods, Camel, Helminths, Parasitic diseases, Parasites, Protozoa

The camel (*Camelus dromedarius* L.) is an integral part of the desert ecosystem wherein it plays a unique role as a low-cost provider of food, traction power, wool, hide and riding. In the present day scenario of global warming, desert expansion and scarcities of water, food and fuel, the camel can become more relevant owing to its high degree of adaptability. Over the last two decades, interest in the camelids is on the rise as evidenced by an increase in publications and a number of camel conferences held in different camel-rearing countries including India. There has been a corresponding increase in new knowledge about camel diseases, including those caused by parasites. This has contributed to advancements on various aspects of these problems. The present review is intended to highlight the recent literature on parasites and parasitic diseases of the camel in the Indian context.

Protozoan parasites

The flagellate *Trypanosoma evansi* is the aetiologic agent for trypanosomosis. It was first reported in 1880 among

camels from Dera Ghazi Khan, India (Gill 1991). Designated as surra, the disease was noted for its broad host range and a high degree of morbidity and mortality. The prevalence data was found to vary considerably between different geographical regions, depending on degree of endemicity, relative concentration of the vector flies and the sensitivity of the diagnostic test employed. Trypanosomosis was found endemic in 18 districts of Rajasthan (Raisinghani and Lodha 1989). Blood samples from 240 camels from western Rajasthan examined for *T. evansi* revealed 18 (7.5%) infected by the wet-blood/Giemsa stain smears and 76 (31.66%) positive for antigen, using double antibody sandwich ELISA (Pathak *et al.* 1993a). The highest incidence was recorded during high rainfall favourable to the breeding of vector flies. In another investigation (Singh *et al.* 1997), prevalence based on clinical observations was 20.37% in 530 camels in *T. evansi*-endemic areas of Bikaner district of Rajasthan. Singh *et al.* (2007) recorded prevalence as high as 25.9% of 108 camels in irrigated humid area of Rajasthan as against only 8.2% of 109 camels in non-humid arid area. The infection in camels runs a protracted course with progressive loss of work capability, general malaise and death, if untreated. Liberation of toxins and proteolytic enzymes leads to anaemia, immunosuppression, abortion and neonatal mortality (Pathak and Singh 2005).

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Antigenic studies by chromatography revealed 7 distinct fractions in *T. evansi* (camel) antigen while SDS – polyacrylamide gel electrophoresis (PAGE) revealed protein bands of molecular weights ranging between 14 and 65 KDA (Pathak *et al.* 1994). Antigenic studies on *T. evansi* isolates from different parts of north India (Singh *et al.* 1994a, 1995) did not reveal antigenic variability of a high degree. While demonstration and identification of trypanosomes in the blood remains the basis of a reliable diagnosis, concentration techniques such as microhaematocrit centrifugation (MHCT) had been devised to overcome the problem of scanty parasitaemia. An antigen-detection variant of enzyme-linked immunoassay (Ag-ELISA) has been used by various workers for more efficient and accurate detection of *T. evansi* in dromedary camels (Singh *et al.* 1994b, Pathak *et al.* 1997b, Jain *et al.* 2000). Other serological tests evaluated in India include antibody detection immunoassay with crude antigen (Swarnkar *et al.* 1994), card agglutination test or CATT (Pathak *et al.* 1997b), and improved version of antibody – ELISA, viz. a DoT-ELISA (Shahardar *et al.* 2002), competition inhibition ELISA (Shahardar *et al.* 2003), Ab-ELISA with detergent solubilised antigen (Shahardar *et al.* 2004) and Ab-ELISA using highly purified antigen (gel-filtration anion-exchange fraction 1) for highest sero - detection (Shahardar *et al.* 2008). Lately, polymerase chain reaction (PCR) has been employed as a useful diagnostic tool for *T. evansi* in camels (Basagoudanavar *et al.* 1998). Higher sensitivity of this molecular technique compared to parasitological and serological methods, based on 217 camels in Rajasthan, was also reported by Singh *et al.* (2004). Efficacy of PCR vis-à-vis prevalent diagnostic tests for 100% detection of natural *T. evansi* infection in camels was further validated (Singh *et al.* 2007). PCR assay using ribosomal DNA target (Shahardar *et al.* 2007) has re-affirmed the sensitivity of this test for use on Indian camels. More recently, monoclonal antibody based assays, viz. Ag-latex agglutination test and Ag-ELISA test, were evaluated for *T. evansi* detection in animals including camels (12.50% positivity) in Haryana by Rayulu *et al.* (2009).

For treatment of surra in camels, a number of drugs have been used in the past, such as diminazene aceturate (Raisinghani and Lodha 1980). Of the currently available chemo-therapeutic agents, quinapyramine (mostly pro-salt) had been effectively used in curing trypanosomosis in camels (Raina *et al.* 1990) and for both therapeutic and prophylactic use (Pathak *et al.* 1997a). How far these drugs are able to produce constant trypanocidal concentrations in body cavity fluids is however, debatable. An arsenical, cymelarsan developed (Zelleke *et al.* 1992) for use in camels abroad is still to be marketed in India. It has the ability to cross the blood-brain barrier and has been recommended for acute and chronic surra as well as for resistant strains of the parasite in camels. Drug resistance in trypanosomosis does not appear to be a problem so far in India but requires monitoring.

Traditional knowledge regarding protection of animals from biting flies provides alternate approaches to control. Camel pastoralists are well aware of the vector flies and have developed strategies to avoid exposure of their animals to fly bites (Kohler-Rollefson 1994).

Coccidia: Gut-dwelling coccidia mainly *Eimeria* spp. are distributed widely among camel populations with high prevalence rates involving several species (Luckins 1992). Prevalence of *Eimeria* ranging from 14.18% in Gujarat (Pethkar and Momin 1990) to 25.19% in Rajasthan (Partani *et al.* 1999) had been recorded. In the latter report based on 897 faecal samples, higher prevalence (28.78%) in farm camels compared to field camels (21.6%) was recorded. Also a higher prevalence in rainy season and in camel calves below one year age was observed. The species encountered were *E. dromedarii*, *E. cameli*, *E. pellerdyi*, *E. rajasthanii* and *E. nollerii*. Raisinghani *et al.* (1987) presented a case report of a 6-month-old camel calf with diarrhoea and abdominal pain excreting *Isospora* oocysts at 2 000 oocysts/g of fluid faeces. The calf responded well to Neftin (Furazolidone) and was completely cured. Of the tissue-cyst forming coccidia, *Sarcocystis cameli* was observed in histopathology of heart muscle of a dromedary (Dadhich 2000).

The ciliate *Balantidium coli*, mainly cystic forms, was detected in 30.21% of 897 camel faecal samples in Rajasthan (Partani *et al.* 1998a). Higher incidence was recorded in farm camels than field camels. Four of the field camels had severe diarrhoea and were passing trophozoites. Other protozoa sporadically reported from the camel such as *Toxoplasma*, *Cryptosporidium* and *Trichomonas*, have yet to be recorded from India. Researchers should therefore, look out for their possible presence/emergence in India.

Helminth parasites

Although they are usually reared under harsh environment unsuitable for propagation of internal parasites and their high (above the ground) browsing should make them less prone, the camels are known to harbour a fairly large range of helminth parasites. Epidemiological data from various reports based on faecal samples or postmortem examinations, indicate prevalence of multiple gastro-intestinal nematodes (GIN) with *Haemonchus* spp. as the predominant infection. Lodha and Raisinghani (1979) reported *Nematodirella dromedarii* (Fam: Trichostrongylidae) for the first time from Indian camels, with prevalence in the arid zones of Rajasthan. Indian studies on GIN of camels (Pathak *et al.* 1993b, Partani *et al.* 1996) reported high prevalence during rainy and low during summer seasons. In the latter report, the overall incidence was 85.39%, made up of predominantly strongyles (82.37%), followed by *Nematodirella*, *Strongyloides* and *Trichuris*. Amongst the strongyle infections, *H. longistipes* was the main contributor (86.43%) followed by *Trichostrongylus* spp. (13.56%). Intensity of infection in terms of EPG varied from 50 to 28,000 (mean 874.15±73.83).

Camels owned by villagers had higher prevalence than farm camels. Vardharajan (2002) reported 80% positivity in 35 samples at Thrissur, Kerala. The infections encountered were Strongyles, strongyloides, ascarid and *Trichuris*. The experimental transmission and establishment of *H. longistipes* and *Trichostrongylus colubriformis* of camel origin in sheep as reported by Kumar and Yadav (1993) and in goats by Singh *et al.* (1993) are interesting epidemiological observations which however, call for a validation.

Clinically, camels carrying infection of trichostrongylid and *Trichuris* (EPG 1 000–2 000) were observed having a rough hair coat, dull and lustreless eyes, pale conjunctiva, weakness and emaciation (Chandel *et al.* 1992). Drastic reduction in appetite and pica were also observed (Tanwar *et al.* 2005). Haematological changes in natural mixed infections of GIN (*H. longistipes*, *Trichostrongylus* spp., *Strongyloides papillosus*, *Nematodirella* spp. and *Trichuris* spp.) with EPG of 1 400–28 000, included significantly lowered TEC, Hb, PCV and TLC, indicating normocytic normochromic anaemia with eosinophilia, neutrophilia and monocytosis (Partani *et al.* 1995c). Biochemical observations revealed significantly low total serum proteins. A direct correlation between EPG and the severity of clinical symptoms was noted (Partani *et al.* 1998b). The most severely affected camels had EPG of 7 500–28 000 mainly due to strongyles, especially *H. longistipes*. Much of the same haematobiochemical observations were recorded by later workers (Suchitra Sena *et al.* 2000) also. Other gastrointestinal helminths reported from India include *Stilesia vittata*, tapeworms recovered at the necropsy of culled camels for cyclophyllid cestodiasis (Ranga Rao and Sharma 1995).

Information on treatment of gastrointestinal helminths of camels is scanty, haphazard and generally extrapolated from studies carried out in cattle and small ruminants (El Bihari 1985). Reported camel-specific anthelmintic trials include ivermectin (Kumar and Yadav 1991, Sharma 1991), oxfendazole (Sharma 1991), albendazole (Gallohra and Gill 1987, Bansal *et al.* 1989, Partani *et al.* 1995a), mebendazole (Yadav and Kumar 1990), thiophanate (Yadav and Singh 1991), levamisole (Kumar and Yadav 1991, Partani *et al.* 1995a), fenbendazole (Kumar and Yadav 1991, Partani *et al.* 1995a, Joshi *et al.* 2001, Vardharajan 2002, Tanwar *et al.* 2005). Benzimidazole compounds had been found particularly effective against *Trichuris* infection (Lodha *et al.* 1977, Bansal *et al.* 1989) while Partani *et al.* (1995b) reported suspected resistance of *Strongyloides* spp. to fenbendazole.

Extra-intestinal nematodes: This sub-group includes *Onchocerca fasciata* which is a camel - specific parasite, causing nodules (worm nests) in the subcutis of head and neck, shoulders and abdomen (El Bihari 1985). Onchocercal nodules often get mistaken for tubercular granulomas. Despite common prevalence in Saudi Arabia and Egypt, there seems to be no report from India so far. Of the filarids, Pathak

et al. (1998) identified microfilariae of *Dipetalonema evansi* in 118 (14.89%) of 792 dromedaries in western Rajasthan. Except for a few cases of scrotal swellings (possibly hydrocele), no clinical signs were observed.

Extra-intestinal cestodes: A case of echinococcosis in a single camel at postmortem was reported (Gupta 1979). Another report of postmortem examination of camels showed hydatid cysts (*Echinococcus granulosus*) camel strain in 56.5% (Ranga Rao and Sharma 1995). These authors also reported lesions associated with *Cysticercus* spp. These are solitary reports of 2 important and widespread cestode infections, pointing to the obvious need for greater surveillance for them in this country. Schistosomes were sighted in the pulmonary vessels of a camel (Sharma and Dadhichi, 1998).

Arthropod parasites (ectoparasites)

This group of camel parasites and the injury and disease associated with them are more prevalent and more serious than is generally recognised.

Sarcoptic mange caused by the acarine *Sarcoptes scabiei* var *cameli* is a serious, highly prevalent condition, often regarded as the second most important disease of the dromedary, after trypanosomosis (Pegram and Higgins 1992). It is known to predispose camels to other infections and is a good measure of herd health. It also has zoonotic significance as cases of transmission to humans, particularly handlers, caretakers and riders had been reported (Raisinghani and Kumar 1990, Tika Ram *et al.* 1991, Basu *et al.* 1996a, Parmar *et al.* 2005a). Commonly associated with poor management and malnutrition, infection had been recorded throughout the year (Raisinghani and Kumar 1990), and in all seasons (Suchitra Sena *et al.* 1999a). The problem was more common in older (over 5 years age) camels (Parmar *et al.* 2005a).

Clinical signs observed included pruritis manifested as rubbing and scratching resulting in loss of hair. The early lesions were hyperaemic papules often appearing on the medial aspects of the thigh or inguinal region, head and neck, flanks, udder and shoulders (Rathod *et al.* 2006). The lesions became red, moist and oozy spreading to surrounding areas (Kumar *et al.* 1992). Scabby patches formed within a few days. In chronic cases, alopecia, scab-formation, cutaneous hypersensitivity, proliferation of connective tissue lead to thickened corrugated skin, keratinisation and chalk-like covering of the scurf (Raisinghani and Kumar 1990, Suchitra Sena *et al.* 1999b, Mal *et al.* 2000). Extensive lesions on the ventral surface of the body, most frequently on the perianal and perineal regions (Parmar *et al.* 2005b), head, neck, facial region particularly nostrils, lips and orbit, brisket and medial aspect of limbs were observed (Dixit *et al.* 2009). Histological examination of skin revealed epidermal hyperplasia, hyperkeratosis and mites embedded in some affected follicles (Mathur *et al.* 2005a). Necrotizing dermatitis with cellular infiltrates made up of eosinophils and mast cells in the

epidermis together with neutrophils and macrophages (Parmar and Singh 2008). Haematological changes noted were significant decrease in TEC, TLC, haemoglobin, neutrophils and monocytes, alongside a significant increase in lymphocytes (Mal *et al.* 2000). Mineral values suffered a significant decline in Fe level while Na levels were increased (Mal *et al.* 2002). A later report from another group (Mathur *et al.* 2005b) ran contrary in some of the above parameters. Lymphocyte counts showed increased levels. Differences in haemato-biochemical changes observed were found to be related to the winter and summer seasons (Mal *et al.* 2006). Post-treatment improvement in haemato-biochemical profile of camels suffering from mange were noted (Rathod *et al.* 2008). Another study recorded significantly higher levels of IgE in camels suffering from mange than in healthy animals (Kataria and Kataria 2004).

Despite the traditional acaricidal treatments being laborious and often problematic, they had been much in use with varying degree of success. Diazinon 0.1% and fenvalerate 0.05% were found 60 and 80% effective, respectively, after 2 applications at 10 days interval and 100% effective after 3 applications (Chhabra and Singh 1991). Similarly, the synthetic pyrethroid deltamethrin 0.005% spray was fully effective after 3 applications (Pathak *et al.* 1991, Makkar *et al.* 1993, Kumar *et al.* 2005). Amitraz 0.05% after 2 applications resulted in partial (Singh *et al.* 1996) and after 3 applications, in complete clinical and parasitological recovery (Kumar *et al.* 2005). Several reports had attested the utility and efficacy of ivermectin S/C injection at dose level of 200 µg/kg body weight as systemic endectocide (Chellapa *et al.* 1989, Raisinghani *et al.* 1989, Makkar *et al.* 1991, Kumar *et al.* 2005). Parenteral doramectin at 200 µg/kg body weight I/M injection was not only effective (Singh and Gahlot 2000) but required single treatment as against two required when using ivermectin and also had much longer residual protection (Singh *et al.* 2001). According to a later report, even doramectin required a second dose at 2 weeks interval for effective cure (Singh *et al.* 2007). Various indigenous and plant-based formulations had been used as alternatives to toxic chemicals (Chhabra *et al.* 1994, Pathak *et al.* 1995, Suchitra Sena *et al.* 1999a, Dixit *et al.* 2002, 2004a, b). Although deficient in efficacy vis-à-vis chemicals and synthetic acaricides, phyto therapeutic agents have obvious advantages in terms of cost, safety, cultural acceptability, biodegradability, absence of undesirable residues and resistance problem (Chhabra and Saxena 1998). More recently, application of a herbal formulation containing onion, garlic, lemon, turmeric and camphor in oil base (Rathod *et al.* 2006) on mange-affected camels gave better results than ivermectin, deltamethrin and amitraz. The use of neem (*Azadirachta indica*) and tobacco (*Nicotiana tabacum*) on the other hand (Dixit *et al.* 2006) failed to give satisfactory results.

Ticks: *Hyalomma dromedarii*, the most commonly

prevalent and camel-specific hyalommine species, is a desert-adapted 2 (occasionally 3) – host tick. It has been reported as the predominant tick species on camels in India (Khan and Srivastava 1994, Singh and Chhabra 1999). In arid north India, the season for adult tick abundance appeared to be winter (Singh and Chhabra 1999) due to intact hair coat facilitating lodgement of ticks and overcrowding of animals in the indoor night shelters resulting in increased contact and spread. In the months preceding winter (August to October), the nymph stage predominated (Chhabra 1992). Most mammalian tick species will parasitize camels where the animals mingle. Accordingly, in India the common cattle tick *H. anatolicum* was the second most frequent tick (after *H. dromedarii*) parasitizing camels (Singh and Chhabra 1999). The most frequent attachment sites for adult ticks were groin, perineum, udder, axilla and facial region while nymphs of *H. dromedarii* were found hidden in areas well-covered by hair coat, particularly along the back, around the hump and intermandibular region. Histopathology of tick (*Hyalomma*)-infested camel skin (Patel *et al.* 1992, Basu *et al.* 1996b) indicated inflammatory reaction characterized by congestion, oedema, hyperplasia and cellular infiltration around the site of insertion of mouth parts.

There are very few reports on tick-specific acaricidal trials in camels. Fenvalerate 2 400 ppm was fully effective in inhibiting egg laying when applied on engorged female *H. dromedarii* ticks (Singh and Chhabra 1991) and Amitraz 250 ppm had efficacy in two sprays 10 days apart (Singh *et al.* 1992). Similarly, efficacy of deltamethrin at 25 ppm was reported (Singh *et al.* 1992).

Cephalopina titillator (Camel nasal bot fly) is an oestrid fly of which the larvae are obligate parasites specifically of the camel. It is widely distributed in camel raising areas causing naso-pharyngeal myiasis. The prevalence rate is generally very high, with one report from India (Lodha and Chaudhry 1962). Successful treatment through use of ivermectin @ 0.2 mg/kg body weight in clinical cases has been reported (Sharma 1992).

Despite an impressive volume of recent literature on the parasites and parasitic diseases of the camel in India, there is an obvious need for further work on several aspects. A shift from the pastoral to intensive farm-rearing with resultant confinement, overcrowding, stress, lack of exercise and absence of high-browsing, is likely to create conditions conducive for increase in some of the presently less-menacing parasites like coccidia. There is a glaring paucity of reports on hydatidosis which is a widespread helminthic infection of public health significance. Likewise, scant attention seems to have been paid to arthropods other than sarcoptic mange. The best example of this apathy is *Cephalopina*, the camel nasal bot which is not only cosmopolitan in prevalence but is also considerably pathogenic in its effects. Office Internationale des Epizoties (OIE, Paris), which is a world organization for Animal Health, in its report of the adhoc group meeting on

camelid diseases has listed as significant diseases (Group I), 3 out of the viral, 8 of the bacterial and 5 out of the parasitic diseases of the dromedary camels (OIE 2008). Of the 5 parasitic diseases included in the significant category, trypanosomosis is at the top with recommendation for preparation of an ELISA kit for diagnosis and melarsomine for treatment. Next in the list is sarcoptic mange for which differential diagnosis from other skin diseases (*Psoroptes*, ringworm, etc) is recommended along with development of good drug or a vaccine. Out of helminthic diseases, only hydatidosis (echinococcosis) is listed and the remaining 2 slots are allotted to Tick infestation and cephalopinos. The last named entity has ample potential for researchers in India who can try out some herbal nasal douche or at least tobacco powder with which Kenyan workers have claimed successful expulsion of larvae with sneeze.

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