Parasitic Zoonoses and Role of Wildlife: An Overview

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Abstract

A significant proportion of emerging human diseases caused by various infectious agents including parasites, are of wildlife origin. This disease emergence has resulted from increasing interaction between wildlife and humans or domestic animals. Several factors, mostly anthropogenic like human encroachment into wildlife habitat and changing ecosystems, have contributed to this trend. The heightened interest coupled with improved diagnostic techniques has led to increased information flow in the form of published reports and reviews. The objective of the present review is to compile an update and highlight some of the emerging and re-emerging parasitic zoonoses of wildlife origin which are of global concern. Brief notes on the present status of zoonotic parasites recorded in different wildlife species in India and the sporadic human case reports of such etiology, are also included. The creation of awareness among public at risk, and strategies for effective monitoring, surveillance and management of disease in wild populations should be implemented, in line with the ‘one health’ concept.

Key words: Zoonoses, Wildlife, Emerging diseases, Parasitic infections, Protozoa, Helminths and arthropods.

1. Introduction

The importance and recognition of free-ranging animals and birds as a major source of emerging human pathogenesis are increasing (Daszak et al., 2000; Polley, 2005). Zoonoses affect human health adversely and wildlife have historically played a role in their transmission, such as rats for bubonic plague, a bacterial disease, or wild canids for rabies virus. Ancient accounts and modern hypothesis suggest that Alexander the Great, who died in Babylon in 323 BC, died due to encephalitis caused by West Nile virus (Kruse et al., 2004) which has wild bird reservoir. In recent times, many human pathogens of varied taxonomies have been found to originate in animals, several of which were wild. Of the approximately 1500 presently known human disease agents, an estimated 65% to over 75% are of zoonotic origin (Mathews, 2009; Mackenstedt et al., 2015). Moreover, most emerging infectious diseases, bacterial, viral, rickettsial and parasitic, in humans are zoonoses with involvement of wildlife in their epidemiology. Several ecological factors, mostly those associated with human activities (anthropogenic), have influenced the epidemiology of zoonoses having wildlife reservoir. These include human population expansion, mobility and deforestation with elimination/shrinkage of wildlife habitat. As a consequence of human intrusions, there has been a shift in the interface between wildlife and people, from sporadic to more permanent and intense (Polley, 2005). Increased interactions between humans and their domestic animals on one hand, and the wildlife on the other, can create “spill-over” situations from domestic reservoir to sympatric wildlife (Thompson et al., 2009). Such “spill-over” can lead to creation of wildlife reservoir which may have potential for spill-back to humans and domestic animals. The role of wildlife as significant sources, reservoir and amplifiers of emerging as well as well-recognized zoonoses of public health significance has gained considerable attention in recent times (Thompson et al., 2009; Carmena and Cardona, 2014).
2. Zoonotic Protozoa Associated with Wildlife

Advances in molecular techniques have greatly aided in separating morphologically indistinguishable species and genotypes. These technologies are also greatly improving our ability to follow parasitic flow among host population and providing insight into transmission pathways.

2.1 Giardia

Several wildlife species are parasitized and are often considered reservoir of zoonotic diseases (Appelbee et al., 2005). Wildlife can harbour both host-adapted and zoonotic strains of Giardia. The zoonotic genotypes of G. duodenalis—Assemblage A and Assemblage B have been detected in several wildlife species that encompass nearly all mammalian orders. Studies in North America have identified marine mammals like seals, as a potential source of zoonotic transmission of Giardia. Cysts have also been detected in marine water samples. Shellfish like oysters and mussels have been demonstrated to harbour Giardia. Wildlife is considered an important contributor, together with humans, domestic animals and livestock, to the pool of parasites within the environment, but the significance of wildlife as a major source is uncertain.

Molecular typing has found most evidence to suggest that more often the spill-over is from domestic cycle to wildlife populations. For example, beavers in North America are susceptible to zoonotic strains of Giardia (Thompson et al., 2004) and were found to be getting infected from drinking water contaminated with Giardia cysts downstream from a sewage works. Similar examples of establishment and maintenance of a sylvatic cycle exist in the finding of Giardia in mountain gorillas in a national park in Uganda; and of G. duodenalis—Assemblage A in musk oxen among other ungulates indigenous to arctic tundra of Canada and Greenland (Thompson et al., 2009). Available evidence also suggests that wildlife, especially wild rodents and cervids, can act as amplifiers of G. duodenalis assemblages specific to other hosts (Otranto et al., 2015a).

2.2 Cryptosporidium

As was the case with Giardia, earlier wildlife were thought to harbour both host-adapted and zoonotic Cryptosporidium (Appelbee et al., 2005). Application of molecular tools revealed that majority of Cryptosporidium found in naturally infected wildlife, is different from those infecting human hosts. Humans are primarily infected with C. hominis and C. parvum. Other species, traditionally associated with animals including C. canis, C. meleagris and C. felis, have occasionally been identified in humans. Of these, C. meleagris is increasingly recognized as being an important human, rather than animal pathogen. Wildlife contributes to the overall pool of oocysts identified in environmental samples but their significance as source for human infection is uncertain. Cryptosporidium oocysts have been detected in marine water samples and occasionally in marine mammal hosts. Additionally shellfish like oysters and mussels have been demonstrated to harbour the parasites.

A study on the epidemiological and molecular relationships of Cryptosporidium spp. in people, primates and livestock in the region of a national park in Western Uganda (Salyer et al., 2012) concluded that the parasite may be transmitted frequently among species where people, livestock and wildlife interact intensively as a result of anthropogenic changes to forests. Even though taxonomy of Cryptosporidium has been unsettled, 30 species are currently recognized valid, of which at least 14 are predominantly zoonotic (Slapeta, 2013).

2.3 Toxoplasma

The presence of zoonotic protozoa including Toxoplasma in marine ecosystems, in a variety of marine mammals (Fayer et al., 2004) is of increasing interest, as there are vast populations dependent on marine mammals for food. Human encroachment into wildlife habitats can also play a role in the spread of Toxoplasma. It has happened in fatal infection of sea otters in USA due to terrestrial water run-off contaminated with cat faeces (Conrad et al., 2005). Similar is the case of Australian wildlife fauna, particularly marsupials in which Toxoplasma may have been introduced initially by humans and their cats, but is now widespread. However, molecular tools for genetic characterization of the parasite will reveal whether identical or separate genotypes/strains exist and interaction, if any, between domestic and wildlife cycles. Identification of genetic diversity including new strains/genotypes in wildlife, particularly in marine mammals (like whales, sea otters, seals, dolphins) and marsupials and avian species, is a priority. This will provide clues to whether distinct domestic and sylvatic parasitic gene pools exist and do they overlap indicating regions of probability of disease emergence (Wendte et al., 2011).

Wildlife is susceptible to infection which in most cases leads to chronic asymptomatic infection. Occasionally, there may be clinical consequence and death or effects on the nervous system leading to increased susceptibility to predation. In particular, identification of new, disease-causing strains in wildlife has raised concerns from both conservation
and public health perspectives (Wendte et al., 2011). The maintenance of *Toxoplasma* in wildlife ecosystems is considered to result from environmental contamination from wild or domestic felids (Thompson, 2013). Other wildlife contributes to maintain *Toxoplasma* in the environment via tissue cysts, which represents a source of infection for predators/scavengers, and of transmission to the offspring (Otranto et al., 2015a).

### 2.4 Leishmania and Trypanosoma

The vector-borne flagellate protozoan parasite *Leishmania* has numerous species and variants, some of which affect a variety of wildlife mammalian hosts. Recent evidence suggests that a species of *Leishmania* parasitizes kangeroos in Northern Territory of Australia, which could be a source of infection to humans (Rose et al., 2004). This finding presumes the presence of sandflies capable of vector-role in Australia for imported cases of regular human *Leishmania* species and poses a risk of transmission.

The closely related group of vector-borne flagellates of genus *Trypanosoma* has also been recorded in marsupials (Smith et al., 2008). This could have the potential to impact health of wildlife but also lead to establishment of a reservoir in wildlife for exotic pathogenic trypanosomes like *T. cruzi* and *T. brucei*. For the latter, human disease has primarily been the result of a spill-back from wildlife reservoirs. In consequence, wildlife conservation and biodiversity campaign have usually been in conflict with the re-emergence threat, as wildlife (alongside domestic animals) constitutes an important reservoir of *T. brucei rhodesiense* and *T. brucei gambiense* in sub-Saharan Africa (Stich et al., 2003).

*Trypanosoma cruzi* has exhibited marked genetic diversity reflected in differences in host specificity which include a wide range of wildlife species. Socio-economic factors and close proximity to wildlife habitats provide the reservoir of *T. cruzi* infection (Karesh et al., 2012). The emerging problem with Chagas disease is globalization (Hotez et al., 2012) through migration of millions of infected persons to non-endemic regions.

### 2.5 Plasmodium knowlesi

*P. knowlesi* is regarded as the most important vector-borne zoonotic protozoan in Southeast Asia (Conlan et al., 2011). First identified in Calcutta in 1931 from a primate, it was rediscovered as a common human pathogen in 2004 (Singh et al., 2004) with long-tailed macaque, *Macaca fascicularis* as the wild host. During an investigation of malaria patients in peninsular Malaysia, 120 of 208 patients tested positive by PCR-assay for *P. knowlesi*. Since then, human *P. knowlesi* infections have been reported from wide areas of SE Asia including Thailand, Myanmar, Indonesia, Philippines and Vietnam (Conlan et al., 2011). These authors opined that the rapid increase in frequency of reports may not likely represent an emerging disease, but represents an emerging awareness of *P. knowlesi*. Further work from Sarawak, Malaysia suggests that *P. knowlesi* has another simian wildlife host viz. pig-tailed macaque (*M. nemestrina*). Transmission to humans who visit the forest canopy, occurs through the bite of *Anopheles latens* mosquitoes (Vythilingam et al., 2006). Simian malaria is virulent and fatalities in humans have been recorded (Galinsky and Barnwell, 2009).

### 2.6 Sarcocystis spp.

This is one of the ‘new’ parasitic zoonoses arising as a result of human activity (Thompson, 2013). Human muscular sarcocytosis is a zoonotic infection of which an initial cluster of symptomatic cases was reported in 1999 affecting 7 US servicemen on manoeuvres in a rural remote Malaysian jungle (Arness et al., 1999). In 2011, GeoSentinel Surveillance System, United States identified 32 cases of suspected acute muscular sarcocytosis in travellers returning from Tioman Island off the east coast of peninsular Malaysia (Sonenburg et al., 2012). By November 2012, the number of patients identified in the ongoing outbreak associated with travel to Tioman Island had reached 100 (Esposito et al., 2012). Sarcocyst formation provoked eosinophilic myositis in this outbreak, and muscle biopsy demonstrated organisms consistent with sarcocytosis (Tappe et al., 2013). According to these workers, the source of infection in Malaysia remains to be elucidated but seems to be persisting. Further, food or water contaminated with oocysts or sporocysts from faeces of the animal host, yet to be identified, are the most likely source of infection.

### 3. Zoonotic Helminths Involving Wildlife

Emphasis here is on some prominent examples of clearly defined transmission pathways or those which pose significant threat to human health and well-being.

#### 3.1 Echinococcus spp.

Echinococcosis is one of the 17 neglected tropical diseases listed by the WHO, has a cosmopolitan distribution and can be transmitted through a variety of domestic, synanthropic and sylvatic cycles. Bases on available epidemiological and molecular evidence, *E. canadensis* G8-G10, *E. felidis*, *E. multilocularis*, *E. oligarthrus*, *E. shiquicus* and *E.
vogeli are primarily transmitted in the wild (Carmena and Cardona, 2014). E. granulosus which has a domestic cycle infecting livestock and dogs, and to which humans are susceptible to the cystic stage has established a widespread prevalence in Australia cycling between macropod marsupials and the wild canids, “dingo” and foxes. The prevalence of E. granulosus in wild dogs encroaching into peri-urban and urban areas is as high as 46.3% (Jenkins et al., 2008) and 45.8% in foxes. The wild canids also act as “spill-back” reservoir of infection (Thompson et al., 2009). Wild animals are also potential sources of human infection with E. granulosus, E. vogeli and possibly, E. shiquicus and wild felids for E. oligarthrus (Polley, 2005). In Canada, G8 and G10 forms (cervid strains) are endemic and are maintained by sylvatic cycle between wild cervids, primarily moose, and wild carnivores, primarily wolves. Domestic dogs may become infected through consumption of organs of E. granulosus infected cervids. Emergence of these parasitic zoonoses is of public health concern because indigenous communities hunt wild cervids for food and also maintain large numbers of free-roaming dogs (Himsworth et al., 2010).

E. multilocularis primarily maintained in a wild cycle involving foxes and arvicolid rodents. Spill-over to humans results in severe disease, alveolar echinococcosis (Hegglin and Deplazes, 2013). It has emerged as a major urban zoonosis as a result of various anthropogenic factors like deforestation, landscape changes and agricultural practices which have led to more favourable conditions for the increase in rodent populations. The parasite can be introduced into non-endemic areas via travelling dogs or translocated wild animals (Davidson et al., 2012). Synanthropic fox populations and those from surrounding rural areas that also exploit anthropogenic food sources (Deplazes et al., 2004). In central Europe, E. multilocularis predominantly cycles between voles and wild animals including red foxes (Vulpes vulpes) as main definitive hosts. Fox population increase (4-fold 1980 to 1995) in Switzerland as a consequence of antirabies vaccination may have resulted in an emerging epidemic of alveolar echinococcosis, 10-15 year later (Schweiger et al., 2007).

3.2 Opisthorchis felineus

The parasite occurs in domestic (cats and dogs) and wild mammals (red foxes, pole cats). These hosts acquire the infection by fish-eating and contribute to maintaining parasite’s life cycle by passing embryonated eggs in faeces. Proximity of fresh water bodies increases the chances of being taken up for further development in a suitable snail intermediate host. Fish-eating wildlife can propagate O. felineus on their own but may also represent a source of infection for feral cats and stray dogs thereby increasing the chances of human infection. Infection by O. felineus is of public health concern in Asia and Eastern Europe, and is re-emerging in Italy (De Liberato et al., 2011; Pozio et al., 2013).

3.3 Trichinella spp.

Nematode worms of the genus Trichinella are one of the most widespread zoonotic pathogens worldwide (Pozio, 2007). Cultural eating habits of raw or undercooked meat of infected animals represent the main factor favouring human infection (Pozio, 2013). Globally, most Trichinella infections occur in wildlife documented in 66 countries as against 43 countries for domestic animals. A wide range of wildlife fauna (mammals, reptiles, birds) may be carriers of Trichinella. For example, Trichinella sp. larvae have been detected in bears, foxes, wild boars, weasels, raccoon dogs and a variety of rodents in China (Wang et al., 2007) where it is one of the most important food-borne zoonoses, with several outbreaks and deaths reported each year. As such, there is a constant challenge of spillover from wildlife to domestic foci and human infections from hunted wildlife are on the rise (Thompson, 2013).

3.4 Baylisascaris procyonis

The common ascarid nematode of raccoons (and dogs), poses serious threat to humans in North America and in Europe where raccoons introduced in early 20th century, have become well-adapted. In the course of thriving in Europe, some populations of raccoons have adapted to peri-urban and urban areas. The eggs of B. procyonis passed in raccoons’ faeces may remain infectious for four months in humid soil and water (Kazakos, 2001). Humans may acquire infection by uptake of embryonated eggs from contaminated environment. In humans, the larval stages may cause ocular and visceral larva migrans, which may become fatal if larvae invade the central nervous system. B. procyonis as parasite and the clinical disease it causes in man, are likely underdiagnosed (Sorvillo et al., 2002). The synanthropic behaviour of raccoons has exacerbated the public health significance of B. procyonis in USA also (Kellnar et al., 2012). At the same time, the parasite’s low host-specificity and the pathogenic effect of its migrating larvae is considered to be potential threat to vulnerable species of wildlife (Page, 2013).

3.5 Thelazia callipaeda

Commonly known as the “Oriental eyeworm”, T. callipaeda infests primarily dogs in the Asian Far
East. However, in recent years the parasite has been increasingly detected in dogs, red foxes, wolves and beech martens, in several countries of Europe (Otranto et al., 2015b). Human infection is prevalent in highly endemic areas like China (Shen et al., 2006) and has lately also been described in some southern European countries (Otranto and Dutto, 2008; Fuentes et al., 2012).

3.6 *Toxocara* sp.

Domestic and wild canids (dogs and foxes) and felids are natural hosts for *T. canis* and *T. cati*, respectively. In Europe, human behaviour and urbanization has resulted in thinning boundaries between wild canids and felids, and their domestic counterparts (Otranto et al., 2015a). *T. canis* roundworms have been recorded from red foxes, golden jackals and wolves in various countries of Europe (Otranto et al., 2015b) and in wild dogs and foxes in Australia (Mackenstedt et al., 2015). It is speculated that foxes play a major role in the maintenance of the wildlife cycle due to their predatory nature: preying on paratenic hosts, including rodents, birds and invertebrates. Moreover, their urbanization and increased population in Europe strengthens the risk they pose. *T. canis* can cause ocular and visceral larva migrans.

3.7 *Ancylostoma* sp.

*A. caninum* and *Uncinaria stenocephala* are cosmopolitan hookworms of dogs and other canids. Wild carnivore populations like the red foxes, golden jackals and wolves in several European countries, play role as reservoirs for one or both of these hookworm species. *A. ceylanicum* and *A. brasiliense* also occur but in more tropical areas (Palmer et al., 2007). The hookworms are zoonotic as their larvae while migrating through the skin in human hosts, may result in cutaneous larva migrans, also known as ‘creeping eruptions’ (Bowman et al., 2010). *A. ceylanicum* is able to cause patent enteric infection in humans, as in dingoes of Cairns district of Queensland, Australia (Smout et al., 2013). It is likely that wildlife species acting as hosts for these parasites may be contributing to the contamination of environment and thus promoting transmission among wildlife, dogs and humans, particularly dog-walkers (Smith et al., 2014).

3.8 *Dirofilaria* spp.

*D. immitis* and *D. repens* are common parasites of domestic carnivores, such as dogs and cats as well as of wild carnivores and humans (McCall et al., 2008). While *D. immitis* has worldwide distribution, *D. repens* is endemic in most of the old world. Both species are zoonotic and human cases of infection by *D. repens* are increasingly reported in Europe (Otranto et al., 2015b). *D. immitis* infections have been reported in a variety of wild felids in their natural habitats as well as in captivity. However, microfilaraemia in them was inconsistent or insufficient to suggest a reservoir role. On the other hand, wild canids appeared more consistent as reservoir hosts for *Dirofilaria*. For example, coyotes in USA, and jackals and wolves in Europe were found to harbour microfilariae and/or adult worms.

4. Outbreaks of Parasitic Zoonoses from Wild-life Sources

Several outbreaks have been recorded from time to time, mainly of protozoan and helminthic etiology, in various countries. It is of interest and relevance to enlist here some recent instances (Table 1).

5. Arthropod Zoonoses and Wildlife

Polley (2005) had listed several arthropod parasites which have wildlife host(s) and human infections may be acquired by flow through the environment: other people and/or domestic animals, as well as wildlife. Most of them were various myiasis-causing flies whose hosts include wildlife mammals and birds, and larvae invade skin, wounds and nasal chambers. Pentastomids like *Linguatula* and *Armilifer* are parasites of canids and snakes, respectively and the route of human infections is through ingestion of infective eggs on food or in water. Several mite species and fleas originating from wild mammals and birds may spread to humans by direct contact or through fomites. The most important and widespread is *Sarcoptes scabiei* or scabies mite which is a genuine emergence resulting from higher incidence or increased detection. *S. scabiei* has been recovered from approximately 100 species of free-ranging mammals (Bornstein et al., 2001). Human infections from wildlife may be acquired the usual way, that is, close contact with infected animals or fomites. Scabies is also regarded as a potentially significant threat to the health and even existence of certain endangered wildlife populations (Pence and Ueckermann, 2002). Ticks, mosquitoes and fleas are important vectors in the transmission of pathogens including parasites, several of which are zoonotic. The ticks especially *Ixodes* spp. are highly important vectors in Europe. Three species of *Babesia*, *B. microti*, *B. venatorum* and *B. capreoli* were detected in ticks in the natural environment, while *B. venatorum* was more frequent in the pasture and the urban habitats. Significantly, *B. venatorum* may infect human and roe...
Table 1: Some Recent Outbreaks of Parasitic Zoonoses from Wildlife Sources

<table>
<thead>
<tr>
<th>Parasitic zoonoses</th>
<th>Wildlife source</th>
<th>Route of human infection</th>
<th>Locality</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leishmaniasis</td>
<td>Hares (Lepus spp.)</td>
<td>Sand fly bite</td>
<td>Spain</td>
<td>Arce et al., 2013; Millan et al., 2014 Jacobson et al., 2003</td>
</tr>
<tr>
<td></td>
<td>Black rats (Rattus rattus) and several wild carnivores</td>
<td>Sand fly bite</td>
<td>Northern Israel</td>
<td>Jacobson et al., 2003</td>
</tr>
<tr>
<td>Toxoplasmosis</td>
<td>Cougars</td>
<td>Water contaminated with infected oocysts</td>
<td>Victoria (B C), Canada</td>
<td>Bowie et al., 1997</td>
</tr>
<tr>
<td>Simian malaria</td>
<td>Macaques</td>
<td>Mosquitoes (Anopheles latens) bite</td>
<td>Malaysia</td>
<td>Singh et al., 2004</td>
</tr>
<tr>
<td>Muscular sarcocytosis</td>
<td>Unknown definitive host</td>
<td>Food or water contaminated with faeces of infected predator animal</td>
<td>Tioman Island (off the east coast of Malaysia)</td>
<td>Esposito et al., 2012; Sonenburg et al., 2012; Tappe et al., 2013</td>
</tr>
<tr>
<td>Diphyllobothriasis</td>
<td>Perch fillets (raw)</td>
<td>Eating raw/marinated fish</td>
<td>Switzerland</td>
<td>Jackson et al., 2007</td>
</tr>
<tr>
<td>Eosinophilic meningitis</td>
<td>Rats (Rattus norvegicus and R. ratus)</td>
<td>Ingestion of infected larvae on salad</td>
<td>Jamaica (Caribbean)</td>
<td>Lindo et al., 2002; Slom et al., 2002</td>
</tr>
<tr>
<td>Baylisascariasis</td>
<td>Raccoons</td>
<td>Ingestion of infected eggs from environment</td>
<td>California, USA</td>
<td>Russerie et al., 2003</td>
</tr>
<tr>
<td>Trichinellosis</td>
<td>Bear</td>
<td>Consumption of infected meat</td>
<td>Sasketchewen (Canada)</td>
<td>Schellenberg et al., 2003; Houze et al., 2009</td>
</tr>
<tr>
<td>Trichinellosis</td>
<td>Wild pig</td>
<td>Consumption of uncooked infected pork</td>
<td>Thailand</td>
<td>Khumjui et al., 2008; Kusolsuk et al., 2010</td>
</tr>
</tbody>
</table>

In India, various reports on parasitic prevalence base on coproscopy or autopsy, have been documented on wild animals and birds in captivity of zoological gardens or free-ranging in national parks/sanctuaries. The information has been compiled in two comprehensive reviews recently (Chhabra and Pathak, 2013a and 2013b). Based on these records, the zoonotic parasites are listed here (Table 2). More recently, Moudgil et al. (2015) have reviewed the parasites in wild felids, confirming that most of the parasitic species in these hosts are of public health significance. Toxoplasma oocysts in the felid faeces were a conspicuous absence/omission. Apart from these, some specific instances of zoonotic transmission from wildlife sources, deserve a mention. A case report of amoebic dysentery in a two month old dog at Anand in Gujarat (Jani and Dave, 1992) wherein the apparent source was a naturally affected monkey excreting blood-tinged stools containing Entamoeba histolytica cysts. Plasmodium knowlesi malaria which has been reported endemic in a vast territory of SE Asia including Burma/China border and for which the macaque reservoir M. fascicularis are found in Indian Nicobar Island and Bangladesh (Cox-Singh and Singh, 2008) is a potential threat. Several findings of hydatid cysts with protoscolices in wild herbivores, mainly cervids, were reported (Arora and Chakraborty, 2009). A cluster of 15 human cases of eosinophilic meningoencephalitis/meningitis due to larval migration of Angiostrongylus cantonensis from eating raw flesh of a deer are reservoir hosts of the parasite (Mackenstedt et al., 2015).

6. Indian Scenario

In India, various reports on parasitic prevalence base on coproscopy or autopsy, have been documented on wild animals and birds in captivity of zoological gardens or free-ranging in national parks/sanctuaries. The information has been compiled in two comprehensive reviews recently (Chhabra and Pathak, 2013a and 2013b). Based on these records, the zoonotic parasites are listed here (Table 2). More recently, Moudgil et al. (2015) have reviewed the parasites in wild felids, confirming that most of the parasitic species in these hosts are of public health significance. Toxoplasma oocysts in the felid faeces were a conspicuous absence/omission. Apart from these, some specific instances of zoonotic transmission from wildlife sources, deserve a mention. A case report of amoebic dysentery in a two month old dog at Anand in Gujarat (Jani and Dave, 1992) wherein the apparent source was a naturally affected monkey excreting blood-tinged stools containing Entamoeba histolytica cysts. Plasmodium knowlesi malaria which has been reported endemic in a vast territory of SE Asia including Burma/China border and for which the macaque reservoir M. fascicularis are found in Indian Nicobar Island and Bangladesh (Cox-Singh and Singh, 2008) is a potential threat. Several findings of hydatid cysts with protoscolices in wild herbivores, mainly cervids, were reported (Arora and Chakraborty, 2009). A cluster of 15 human cases of eosinophilic meningoencephalitis/meningitis due to larval migration of Angiostrongylus cantonensis from eating raw flesh of a
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parasite</th>
<th>Human disease</th>
<th>Disease syndrome</th>
<th>Wildlife species (Potential reservoir)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Giardia</em> spp.</td>
<td>Giardiasis</td>
<td>Foul smelling diarrhea</td>
<td>Non-human primates</td>
</tr>
<tr>
<td>2</td>
<td><em>Entamoeba histolytica</em></td>
<td>Amoebiasis</td>
<td>Dysentery</td>
<td>Non-human primates</td>
</tr>
<tr>
<td>3</td>
<td><em>Balantidium coli</em></td>
<td>Balantidiasis</td>
<td>Diarrhoea and other abdominal symptoms</td>
<td>One-horned rhino, blue bull (<em>Boselaphus tragocamelis</em>), giraffe, non-human primates</td>
</tr>
<tr>
<td>4</td>
<td><em>Babesia</em> spp.</td>
<td>Babesiosis</td>
<td>Pyrexia, anaemia, muscular pain</td>
<td>American bison (in zoo), wild felids, mongoose</td>
</tr>
<tr>
<td>5</td>
<td><em>Toxoplasma gondii</em></td>
<td>Toxoplasmosis</td>
<td>Abortion, congenital disease, chorio-retinitis</td>
<td>Non-human primates</td>
</tr>
<tr>
<td>6</td>
<td><em>Dicrocoelium</em> spp.</td>
<td>Dicrocoeliasis</td>
<td>Digestive disorders</td>
<td>Spotted deer (<em>Axis axis</em>)</td>
</tr>
<tr>
<td>7</td>
<td><em>Paragonimus</em> spp.</td>
<td>Paragonimiasis</td>
<td>Pulmonary disease, cough, thoracic pain</td>
<td>All wild felids (Bengal tiger, lion, panther, golden cat, civet cat, striped hyaena, mongoose</td>
</tr>
<tr>
<td>8</td>
<td><em>Nanophyetus salmincola</em></td>
<td>Nanophyetiasis</td>
<td>Occasionally gastrointestinal symptoms and eosinophilia</td>
<td>Lion, leopard, panther, Indian civet, palm civet, jackal</td>
</tr>
<tr>
<td>9</td>
<td><em>Echinostoma</em> spp.</td>
<td>Echinostomiasis</td>
<td>Abdominal distress and eosinophilia</td>
<td>Wild/zoo birds, wild cat (<em>Felis silvestris</em>), palm civet</td>
</tr>
<tr>
<td>10</td>
<td><em>Fasciola hepatica/ F. gigantica</em></td>
<td>Fascioliasis</td>
<td>Hepato-biliary</td>
<td>Wild cervids, Kashmiri goat (<em>Capra sibirica</em>), non-human primates, elephant</td>
</tr>
<tr>
<td>11</td>
<td><em>Fasciolopsis buski</em></td>
<td>Fasciolopsiasis</td>
<td>Mainly gastrointestinal symptoms</td>
<td>Wild boar</td>
</tr>
<tr>
<td>12</td>
<td><em>Gastrodiscoides hominis</em></td>
<td>Gastrodiscoidiasis</td>
<td>Enteritis in heavy infections</td>
<td>Wild boar, non-human primates</td>
</tr>
<tr>
<td>13</td>
<td><em>Echinococcus</em> spp.</td>
<td>Hydatidosis</td>
<td>Depends on location of metacestode, mostly hepatic or pulmonary</td>
<td>Jackal, wolf, leopard cat (<em>Prionailurus bengalensis</em>),</td>
</tr>
<tr>
<td>13a</td>
<td>Hydatid cyst</td>
<td>Hydatidosis</td>
<td>Depends on location of metacestode, mostly hepatic or pulmonary</td>
<td>One-horned rhino, spotted deer, mountain goat (ibex), giraffe, non-human primates</td>
</tr>
<tr>
<td>14</td>
<td><em>Diphyllobothrium</em> spp.</td>
<td>Diphyllobothriasis</td>
<td>Gastro-intestinal symptoms, <em>B.12</em> anaemia</td>
<td>Wild cat, leopard, panther, striped hyaena</td>
</tr>
<tr>
<td>15</td>
<td><em>Hymenolepis diminuta</em></td>
<td>Hymenolepiasis</td>
<td>Gastro-intestinal symptoms</td>
<td>Non-human primates</td>
</tr>
<tr>
<td>16</td>
<td><em>Spirometra</em> spp.</td>
<td>Sparganosis</td>
<td>Depends on location of larvae, eye, CNS, kidney</td>
<td>Wild cat, leopard, panther, non-human primates</td>
</tr>
<tr>
<td>17</td>
<td><em>Dipylidium caninum</em></td>
<td>Dipylidiasis</td>
<td>Digestive disorders</td>
<td>Wild dog, striped hyaena fox, jackal, panther, leopard</td>
</tr>
<tr>
<td>18</td>
<td><em>Anycyclostoma caninum</em></td>
<td>Cutaneous larva migrans</td>
<td>Creeping eruptions</td>
<td>Wild dog, fox, hyaena, wolf, bear, lion, panther, civet</td>
</tr>
<tr>
<td>18a</td>
<td><em>A. braziliense</em></td>
<td>Cutaneous larva migrans</td>
<td>Creeping eruptions</td>
<td>Leopard cat, Bengal tiger, hyaena</td>
</tr>
</tbody>
</table>

Table 2: Zoonotic parasites prevalent in wildlife in India (Based on authentic records: mostly autopsy)
<table>
<thead>
<tr>
<th></th>
<th>Parasite</th>
<th>Disease</th>
<th>Clinical Signs</th>
<th>Vectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td><em>Toxocara canis</em>/<em>T. cati</em></td>
<td>Visceral larva migrans</td>
<td>Eosinophilia, granulomatous reactions, ocular, neurological</td>
<td>Wild canids and felids</td>
</tr>
<tr>
<td>20</td>
<td><em>Strongyloides</em> spp.</td>
<td>Strongyloidiasis</td>
<td>Pruritis, oedema, abdominal and pulmonary</td>
<td>Bengal tiger, lion, panther, palm civet, wild boar, non-human primates, wild ass, cervids, rock python</td>
</tr>
<tr>
<td>21</td>
<td><em>Trichostrongylus</em> spp.</td>
<td>Trichostrongyliasis</td>
<td>Occasionally gastrointestinal symptoms and anaemia</td>
<td>Wild ass, cervids</td>
</tr>
<tr>
<td>22</td>
<td><em>Capillaria aerophila</em></td>
<td>Capillariasis</td>
<td>Pulmonary: cough, dyspnoea, eosinophilia</td>
<td>Fox, dog, wild cat, leopard</td>
</tr>
<tr>
<td>23</td>
<td><em>Gnathostoma springerum</em></td>
<td>Gnathostomiasis</td>
<td>Cutaneous or visceral, serpiginous eruptions, intraocular</td>
<td>Bengal tiger, leopard, wild cat</td>
</tr>
<tr>
<td></td>
<td><em>G. hispidum</em></td>
<td></td>
<td></td>
<td>Wild boar</td>
</tr>
<tr>
<td>24</td>
<td><em>Dirofilaria immitis</em></td>
<td>Dicrofilariosis</td>
<td>Occasional granulomas, cough, chest pain</td>
<td>Wild canids (wild dog, fox, jackal, wolf), hyaena, wild felids (golden cat, Bengal tiger, clouded leopard, lion, panther), non-human primates</td>
</tr>
<tr>
<td>25</td>
<td><em>Trichinella spiralis</em></td>
<td>Trichinosis</td>
<td>Intestinal, abdominal, fever, myalgia, headache</td>
<td>Wild boar</td>
</tr>
<tr>
<td>26</td>
<td>Myiasis-causing flies</td>
<td>Myiasis</td>
<td>Depends on tissue or organ invaded by larvae</td>
<td>Cervids and other herbivores</td>
</tr>
<tr>
<td></td>
<td>&amp; haematophagous flies</td>
<td></td>
<td></td>
<td>Zebra</td>
</tr>
<tr>
<td>27</td>
<td><em>Sarcoptes scabiei</em></td>
<td>Scabies</td>
<td>Itching, dermatitis</td>
<td>Non-human primates</td>
</tr>
<tr>
<td>28</td>
<td>Ticks (mainly <em>Haemaphysalis</em> spp.)</td>
<td>Tick infestation</td>
<td>Bite injuries, blood loss</td>
<td>Cervids, wild canids, wild boar, non-human primates</td>
</tr>
<tr>
<td>29</td>
<td><em>Linguatula serrata</em></td>
<td>Linguatuliasis</td>
<td>Ocular or nasopharyngeal affections</td>
<td>Sambar deer (<em>Cervus unicolor</em>)</td>
</tr>
</tbody>
</table>

7. Conclusion

There are many emerging and re-emerging zoonotic parasites acquired from wildlife sources which have been neglected or not been considered of major significance for human health so far. The outlook needs to change by creating public awareness of possible sources and the measures that can lessen the risk of human infection. Persons working with wildlife should be alert to the potential of disease transmission. Effective campaigns for the recognition, prevention and control can be designed and implemented (Polley, 2005). As the various interfaces between wildlife, domestic animals and humans increase and become

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monitor lizard (*Varanus bengalensis*) which was likely paratenic host, was reported from Central Kerala (Panackel *et al*., 2006; Parmeswaran, 2006) and the adult worms were detected in cardiopulmonary system of bandicoot rats (*Bandicota indica*) from agricultural areas of the region (Thomas *et al*., 2015). Trichinoses (*T. spiralis*) clusters from undercooked meat of wild boar in Uttarakhand (Sethi *et al*., 2010; Pebam *et al*., 2012). *Baylisascaris transfuga* recorded from a Himalayan black bear (Islam and Nashiruddullah, 2000) is considered a potential source of larva migrans in mammals including humans (Bauer, 2013).
more complex, there is obvious need for strategic disease surveillance in wildlife. Host parasite interaction in changing landscapes and ecosystems, transmission pathways and risk factors require continuous updating. Alongside, the management practices including disease prevention, for conservation of biodiversity should be adopted in line with the “one health” philosophy. The “one health” approach also lays emphasis that successful veterinary public health interventions are holistic and integrate current knowledge on human medicine, veterinary medicine and environmental sciences.

References


Chhabra and Muraleedharan…Parasitic Zoonoses and Role of Wildlife: An Overview


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