Role of Wildlife in Parasitic Zoonosis

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ABSTRACT

Zoonotic diseases are a group of communicable disorders caused by variety of pathogens of which 95% are helminthes. Zoonotic agents can spread by contaminated food and drink, direct contact with the animal, feces samples, animal excretions and secretions. The development of zoonotic spillover from the wildlife reservoir has been linked to a sharp increase in global human activity, human population growth, habitat encroachment, expanding deforestation and land use change, globalization of travel and trade, and rising need for an animal-based food system. Some of the zoonotic species are Echinococcosis spp, Trichinella spp, Trypanosoma cruzi, Dirofilaria spp, Cryptosporidium spp, Toxoplasma spp, Toxocara spp, Taenia multiceps, Strongyloides stercoralis, Fasciola hepatica, Fasciola gigantica, Toxoplasma gondii, Leishmania infantum, Baylisascaris procyonis, Giardia spp, Ancylostoma spp etc. Wild and domestic animals are host of zoonotic diseases. Gastrointestinal disorders, fever, weight loss, skin lesions, dysfunction of organs, white fluid filled cysts in infected tissues, and paralysis are the major clinical symptoms. People often use wildlife as a source of food and as a home for parasites that can spread disease to people. Certain zoonotic parasites that originate from wildlife are emerging and resurfacing, but they have either been disregarded or are not believed to pose a serious threat to human health at this time. The perspective has to change by informing the public about possible sources and possible countermeasures to lessen the risk of human infection. Workers with wildlife should be mindful of the possibility of disease transmission. It is possible to develop and implement detection, prevention, and control programs that work.

Keywords: Wildlife, Parasites, Zoonosis, Transmission, Zoonotic spillover

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1. INTRODUCTION

Zoonotic diseases are a class of contagious illnesses that affect the animals and humans and can propagate from humans to vertebrate animals and from vertebrate animals to humans (Franjić 2022). Zoonoses, pose a risk to public health. According to estimates, 71% of new zoonotic human infections originated from wildlife. Public health is at risk from zoonoses, infectious disorders spread from animals to people (Mafuyai et al. 2013). Wildlife has historically played a significant role in the dissemination of infectious agents to humans. Zoonoses with a reservoir in wildlife afflicting all continents, posing a prominent public health issue recently. These zoonoses are becoming more and more important, and there is a need for additional focus in this field. Although there are 1415 recognized human infections, 62% of them are zoonotic; hence, the actual number of zoonoses is unfamiliar (González-Barrio 2022). Wildlife serves as a significant zoonotic pathogen reservoir and wild animals can spread disease to domestic animals and humans directly or indirectly (Cilia et al. 2021).

Numerous pathogens, such as parasites, viruses, bacteria, and fungi can be the source of zoonoses. Approximately 95% of helminthes, 40% of fungi, 50% of bacteria, and 80% of viruses that infect people are zoonotic (Morse et al. 2012; Recht et al. 2020). Cryptosporidiosis, balantidiosis, and taeniasis are some examples of parasitic zoonoses (Atawodi et al. 2013). Emerging zoonoses like leishmaniasis, *Bordetella bronchiseptica* infections, arthropod-transmitted rickettsioses, brucellosis and bartonellosis and re-emerging zoonoses like onchocercosis, leptospirosis, sporotrichosis, influenza, rabies, salmonellosis, and echinococcosis have been announced universally (Gado et al. 2023). The study of parasites in wild animals is crucial because they may have significant zoonotic indications (Liatis et al. 2017; Hewavithana et al. 2022). Animal excretions and secretions, fecal samples, contaminated food and water, and direct contact with the animal are all possible ways that zoonotic agents can circulate (Jannat et al. 2020). The proportion of wild species that are carriers for zoonotic disease is rising, raising concerns about human safety and management. Wildlife is frequently utilized by humans and serves as both a source of food and a host for parasites that can infect humans with diseases (Okoye et al. 2015).

The prevalence of zoonoses with a wildlife source may also be influenced by demographic factors and human behavior. Activities like hunting, camping, and hiking may increase the risk of contracting some zoonotic agents that have wildlife origin, like tularemia and tick-borne zoonoses. Eating patterns may also be important. For instance, consuming meat from unusual animals like bears raises the risk of contracting trichinellosis (Schellenberg et al. 2003; Kruse et al. 2004). However, certain other human-specific infections were first discovered in wildlife earlier. For instance, the parasite that causes malaria, *Plasmodium falciparum*, is most likely a descendant of *Plasmodium* of western gorillas (*Gorilla gorilla*) (Sharp et al. 2020; Wegner et al. 2022). Indirectly, through detrimental effects on host fitness, parasitic infection can harm wild animal populations irreparably, further threatening species that are already threatened with extinction. High parasitic infection would decrease fitness and renders animals more susceptible to predators and random environmental events (Hewavithana et al. 2022). The purpose of this chapter is to evaluate studies on the function of wild animals as reservoirs and dispersers of etiological agents of human infectious diseases in order to assemble information on the primary wild animals and etiological agents engaged in zoonotic outbreaks (Cupertino et al. 2023).

2. ZOONOTIC PARASITES

The four types of zoonotic parasites are sapro-zoonotic, cyclo-zoonotic, meta-zoonotic, and direct zoonotic. *Strongyloides stercoralis* and *Ancylostoma caninum* are two sapro-zoonotic parasites that can infect people through water or soil. The vertebrate intermediate hosts of cyclo-zoonotic parasites involve *Taenia saginata*, *Taenia solium*, and *Echinococcus granulosus*. *Schistosoma* spp. and *Fasciola* spp. are examples of meta-zoonotic parasites that can infect people from invertebrate intermediate hosts. *Cryptosporidium parvum*, *Toxoplasma gondii*, *Sarcoptes scabiei*, and *Entamoeba histolytica* are examples of direct zoonotic parasites that transmit infection directly from animals to humans (Youssef and Uga 2014).

3. ROLE OF WILDLIFE IN TRANSMISSION OF PARASITIC INFECTION

All the animals including helminths to mammals are included in wildlife (Kruse et al. 2004). A sharp and growing rise in global human activity including habitat encroachment and human population growth, globalization of travel and trade, expanding deforestation and land use change, rising need for animal consumption based food system, has been associated with development of zoonotic spillover from the wildlife reservoir (Hilderink and de Winter 2021). Dietary, vector borne and environmental factors can all contribute to parasite transmission. Toxoplasma, a soil and foodborne parasite, and *Plasmodium*, *Leishmania* (both spread by blood-sucking arthropods), are some of the most common human protozoan parasites on a globe scale. The helminthes (parasitic worms) *Dirofilaria* (spread by mosquitoes), *Toxocara*, *Echinococcus*, and hookworms, which are all soil borne, are important for human health. Because of their behavior of feeding on blood, varieties of arthropods are implicated in the spread of infection. They play a key role in zoonotic infections, which are cycles of animal to human transmission (Franjić 2022). Whether it is legal or unlawful, using wildlife for commercial purposes brings a variety of wild species into proximity with people (Watsa 2020). Because of the frequent or extended contact required for husbandry, wildlife farms—also known as establishments that raise non-domesticated species for commercial purposes—can increase the risk of disease transmission between wild animals and the people who care for them (Kimman et al. 2013). Additionally, the conditions found frequently found in wildlife farms, such as a dense population of wild animals housed in the same territory, stress brought on by captivity, and poor sanitation can lower the risk for pathogen resistance and raise the likelihood of disease transmission (Mukarati et al. 2013; Whitehouse-Tedd et al. 2015; Green et al. 2020).

3.1. ECHINOCOCCOSIS SPP

One of the most ignored zoonotic illnesses identified by the World Health Organization (WHO) is echinococcosis, often named as hydatid disorder (Guo et al. 2022). In Asia, echinococcosis is endemic (Ito and Budke 2017). Cystic echinococcosis (CE) and Alveolar echinococcosis (AE) are both caused by *Echinococcus granulosus* sensu lato and *Echinococcus multilocularis*, respectively (Guo et al. 2022). Alveolar echinococcosis involves rodents (primarily arvicolids) as intermediate hosts in its life cycle. Wild carnivores like raccoon dogs (*Nyctereutes procyonoides*), golden jackals (*Canis aureus*), arctic fox (*Vulpes lagopus*), red fox (*Vulpes vulpes*), wolves (*Canis lupus lupus* and *Canis latrans*), and domestic dog (*Canis lupus familiaris*) serves as definitive hosts (Khan et al. 2021).

Canids are the definitive hosts of the larval stage metacestodes of *Echinococcus granulosus* (sensu lato), while a large variety of domestic, ungulates primarily serve as intermediate hosts in the development of Cystic echinococcosis (CE) (Ohiolei et al. 2019). About hundreds to thousands of adult *Echinococcus* spp. worms, which range in length from three to seven (mm), grow in the intestines of their chosen hosts. As

each worm reaches sexual maturity, its proglottid releases eggs into the environment through the excretion of the carnivore. Then, after being consumed by humans or intermediate hosts, the eggs hatch in the intestine to release oncospheres that travel through the lymphatic and portal vessels and eventually reach the liver, where they usually develop as larvae (hydatid cysts or metacestodes). Less frequently, however, they may also travel to the bones, brain, lungs, and any other organ of intermediate host or humans (Wen et al. 2019).

3.2. TRICHINELLA SPP

Nematode worms of the genus Trichinella are one of the most widespread zoonotic pathogens worldwide (Pozio 2007). The primary factor favoring human infection is cultural eating practices that involve eating undercooked or raw meat from diseased animals (Pozio 2013). Universally, 66 countries have records of Trichinella infections in wildlife, compared to 43 countries for domestic animals. Trichinella may be carried by a diverse range of animal species birds, reptiles, and mammals. One of the most significant foodborne zoonoses, *Trichinella* spp. larvae have been found in weasels, wild boars, raccoon dogs, foxes, bears and a variety of rodents in China (Wang et al. 2007) where it is one of the most common causes of outbreaks and fatalities each year. As a result, human infections from animal hunting pose a continuing threat to domestic foci and are increasing (Thompson 2013; Chhabra and Muraleedharan 2016).

3.3. TRYPANOSOMA CRUZI

The parasite *Trypanosoma cruzi* (*T. cruzi*) causes the zoonotic infectious disorder known as Chagas disease (CD) (Ibarra-Cerdeña et al. 2020). *T. cruzi* is a vectorborne stercorarian trypanosome with considerable genetic variability that affects changes in host specificity in both the vector and a wide variety of wildlife hosts, causes the disease (Zingales et al. 2012). Triatomine bugs, which contract the disease through blood-feeding on an infected mammal, spread *T. cruzi*. The parasite's infectious stage is transmitted through the bug's feces, contaminating successive hosts' bite wounds or surrounding mucosal membranes. In addition, oral transmission in animals occurs when they consume infected insects (Barr 2009; Dorn et al. 2012; Rocha et al. 2013; Desquesnes 2017; Hodo et al. 2018).

Congenital transmission, blood transfusions, and organ transplants are additional methods of transmission. Raccoons, wood rats, opossums, skunks, armadillos, packrats are just a few of the mammalian species that have been discovered to be *T. cruzi*-infected and acting as disease reservoirs in the US (Paniz Mondolfi et al. 2020). The acute phase of disease typically lasts 8 to 10 weeks and manifests as either asymptomatic or mild flu-like symptoms (CDC 2007; Montgomery et al. 2016). The chronic indeterminate phase, which affects people with chronic CD, is marked by prolonged periods without symptoms that might last years or decades. Only 30% of those with CD are thought to progress to the determining phase and experience intriguing gastrointestinal and cardiac symptoms (Kruse et al. 2019). The condition is challenging to treat, and the few available medications are frequently hazardous (Keenan et al. 2013).

3.4. DIROFILARIA SPP

One of the new zoonotic parasite diseases, dirofilariasis is brought on by filarial worms of the genera Dirofilaria and Nochtiella, which unintentionally infect humans (the dead-end host). Canines are the primary reservoir hosts, and it naturally infects a variety of domestic and wild animals. They have a history of accidentally infecting people. The most common species found in India is *Dirofilaria repens* (*D. repens*).

In order to obtain a blood meal, mosquitoes of the genera Mansonia, Armigeres, Anopheles, Culex, Aedes deposit hemolymph on the wound, which contains infectious "larvae 3" stage that enters the host's skin on their own. Coughing, an intolerance to strenuous activity, dyspnea, hemoptysis, cyanosis, ascites, epistaxis, and syncope are among the clinical symptoms (Vivekanandhan et al. 2019).
The zoonotic parasite *Dirofilaria repens*, which affects dogs and other animals, is spreading through vectors (Alsarraf et al. 2023). The zoonotic parasite *D. repens*, which affects dogs and other animals, is spreading through vectors. The prevalence of *Diroflaria immitis* has been extensively studied in wildlife and reported frequently in a wide range of carnivorous species, including grey wolves, red foxes, raccoon dogs, golden jackals, wild cats, and domestic ferrets, in contrast to the relatively few studies on reservoir hosts of *D. repens* (Kido et al. 2011; Penezić et al. 2014; Hiedari et al. 2015; Moroni et al. 2020; Gomes-de-Sá et al. 2022; Villanueva-Saz et al. 2022).

3.5. CRYPTOSPORIDIUM SPP

One of the most intestinal protozoa known as Cryptosporidium spp. causes diarrhea in wild animals, domestic animals, and people (Khan et al. 2019). Wild mammals particularly rodents can accompany in human made habitats and poses a threat to the public's health because they serve as reservoirs for several zoonotic parasites, bacteria, viruses (Meerburg et al. 2009), including some species of Cryptosporidium (Zhao et al. 2010; García-Livia et al. 2020). Due to the parasite's wide range of hosts, it is less common in poultry and more prevalent in wild birds (Li et al. 2021). The three most common species of Cryptosporidium found in birds are *C. galli*, *C. meleagridis*, and *C. bailey* (Javed and Alkheraije 2023). Cryptosporidium is one of the numerous zoonotic infections that wild rats (*Rattus* spp.) carry (Zhao et al. 2019).

3.6. TOXOPLASMA SPP

The parasite *Toxoplasma gondii* (*T. gondii*) is one of the most common in the world. Wildlife is acknowledged as a significant *T. gondii* reservoir and source of infection (Trisciuoglio et al. 2015). Because they are the only source of oocysts, the parasite life stage that allows overall *T. gondii* transmission, wild felid animals and domestic animals are crucial to the epidemiology and ecology of *T. gondii* (Zhu et al. 2023). Because of their strong dispersal ability, wild birds are particularly significant intermediate hosts for *T. gondii* (Wilson et al. 2020). Migratory birds can transport infectious disease pathogens across oceans while flying (Sandström et al. 2013). Additionally, because herbivores consume intermediate hosts of *T. gondii* and wild birds' forage on the ground, both domestic and wild birds provide good sentinels for environmental contamination with *T. gondii* oocysts (Dubey et al. 2020; Iemmi et al. 2020). As a result, a wide range of wild bird species with various habitats and diets are susceptible to contracting this parasite (Wilson et al. 2020; Dubey et al. 2020). *T. gondii* prevalence rises with trophic level in the terrestrial environment, consistent with transmission of main cyst tissue, but it decreases with trophic level in the aquatic environment, reflecting a significant amount of watery exposure to oocysts (Wilson et al. 2020).

3.7. TOXOCARA SPP

Toxocara spp. nematodes are the primary cause of the global anthropozoonotic disease toxocariasis. The disease is reported to be highly prevalent in underdeveloped nations, particularly in areas with low hygienic conditions. (López-Osorio et al. 2020). The source of zoonotic parasitic nematodes is wild animals. More than 66% of samples of feces from boars, hares, deer, and fallow deer living in the territories of the

Pozna Province had developmental forms of parasites from the genera *Trichostongylus* spp., *Capillaria* spp., *Toxocara* spp., *Eimeria* spp., and *Trichuris* spp. (Gałęcki et al. 2015).

Table 1: Parasitic species involving wildlife.

Parasitic species	Disease	Pathogen class	Animal host	Major clinical symptoms	References
Trichinella spp.	Trichinellosis	Helminthes	Cats, pigs, dogs and other wild species	Gastrointestinal disorder (Vomiting, nausea, abdominal pain, diarrhea)	(Rahman et al. 2020)
Echinococcus granulosus and *Echinococcu smultilocularis*	Echinococcosis	Helminthes (Cestode)	Domestic and wild animals (Foxes, sheep, dogs)	Dysfunction of organs (lungs, liver, brain, kidney, spleen)	(Rees et al. 2021; Wen et al. 2019)
Taenia multiceps	Coenurosis	Cestode	Wild and domestic animals (foxes, jackals, dogs)	White fluid filled cyst in infected tissues	(Sikandar et al. 2018; Varcasia et al. 2022)
Strongyloides stercoralis	Strongyloidiasis	Nematode	Non human primates, cats, dogs, wild canids, rodents	Respiratory and gastrointestinal issues	(Eslahi et al. 2022; Unterköfer et al. 2022; Kusumarini et al. 2022)
Fasciola hepatica Fasciola gigantica	Fasciolosis	Trematode	Wild and domestic animals (camelids, monkeys, horses, donkeys)	Fever, hypereosinophilia, Obstructive symptoms (acute pancreatitis and cholecystitis)	(Rayulu and Sivajothi 2022; Levy et al. 2022; Webb and Cabada, 2018)
Toxoplasma gondii	Toxoplasmosis	Apicomplexan Protozoan	Domestic and Wild felines (lions, cheetahs, and leopards)	Asymptomatic infection in the immune competent host, Abortions in goats and sheeps	(Bokaba et al. 2022)
Leishmania infantum	Leishmaniosis	Intracellular protozoan	Rodents, lagomorphs, carnivores	Progressive weight loss, skin lesions, muscular atrophy, generalized lymphadenomegaly, Epistaxis, ocular lesions, onychogryphosis, diarrhea and vomiting	(Abbate et al. 2019; Edo et al. 2021)

Baylisascaris procyonis	Baylisascariasis	Roundworms	Wild and domesticated animals (rodents, foxes, dogs, woodchucks and primates)	Paralysis, death, blindness in intermediate hosts	(Pope et al. 2021; Sorvillo et al. 2002)

Toxocara canis (*T. canis*) is a worldwide nematode parasite that uses domestic and wild canids as its primary hosts (Richards and Lewis 2001). Large number of unembryonated, non-invasive, *T. canis* eggs are excreted in canine feces (Glickman and Schantz 1981), and after a number of weeks, in the right environmental settings, these eggs can mature into an embryonated level that can infect paratenic and definitive hosts (Keegan and Holland 2013; Overgaauw and Nederland 1997). Avian species, pigs, rodents, humans and many other hosts can serve as paratenic hosts (Strube et al. 2013). Although infective larvae can survive in host tissue for a long time and serve as a *T. canis* reservoir for canids, eggs ingested by paratenic hosts cannot mature into the adult stage (Parsons 1987). When a defensive host consumes prey that has been infected with stalled tissue larvae, the life cycle is complete (Brunaská et al. 1995; Krupińska et al. 2023).

3.8. GIARDIA SPP

There are eight recognized species of *Giardia*. These include *Giardia duodenalis* (*G. duodenalis*), which affects both animals and humans. *G. ardeae*, *G. agilis*, *G. muris*, *G. psittaci*, *G. microti*, *G. cricetidarum*, and *G. peramelis* which affect non-human hosts like rodents, marsupials, birds and amphibians. Eight assemblages (A-H) make up the species complex *G. duodenalis*, with assemblages A and B predominating in people (Ryan and Zahedi 2019). Giardiasis is a significant protozoan illness that affects both adult and children and causes diarrhea. It is widely spread around the world and is frequently transmitted by the fecal-oral route. *Giardia* spp. also infects wild and domestic birds, which can serve as asymptomatic mechanical carriers of Giardia cysts. There are six different species of Giardia. A complex species with several assemblages, *G. lamblia* (syn. *G. intestinalis*) is linked to human disorders via the assemblages A and B (Malik et al. 2021). Throughout the world, giardia infects a wide variety of animal hosts, including birds, reptiles, fish, amphibians and mammals, and causes asymptomatic or moderate to severe gastrointestinal sickness in its host species (Caccio` et al. 2018; Feng and Xiao 2011; Ryan and Caccio` 2013).

3.9. ANCYLOSTOMA SPP

Ancylostoma hookworm infections in wild species, cats, and dogs result in the zoonotic illness of Ancylostomiasis, frequently seen in tropical areas and Asia (Kladkempetch et al. 2020). One of the most significant soil-transmitted helminth parasites that affect a number of animal species, including humans, is the Ancylostoma species. The family Ancylostomatidae includes several species of Ancylostoma. The third-stage larvae of Ancylostoma species may penetrate the host's skin or infect them through the fecal-oral pathway (Palmer et al. 2007). Intestinal hypersensitivity and eosinophilic enteritis are symptoms of *Ancylostoma caninum* (*A. caninum*) infection. *Ancylostoma caninum* mostly affects dogs, with very little exposure to cats or people. Humans frequently get cutaneous larva migrans or enteric infections when they have eosinophilic enteritis (Daba et al. 2021).

In humans, follicular dermatitis is also typical (Colon and Patton 2012). In Asia, the small intestine is frequently inhabited by the parasitic worm *A. ceylanicum*, which may cause iron-deficient anemia in affected individuals. This is the first record of *A. ceylanicum* in wild canids; it was previously seen in domestic dogs in Australia. *A. ceylanicum* has been found in wild felids such as the civet (*Felis temminchii*), the leopard cat (*Felis bengalensis*), and the Asian golden cat (*Viverricula malaccensis*) (Smout et al. 2013). Table 1 highlights the parasites that may infect wildlife.

4. CONCLUSION

There are zoonotic parasites that are developing and reemerging that are acquired from wildlife sources but have thus far been ignored or are not thought to be of major consequence for human health. By educating the public about potential sources and the steps that may be taken to reduce the danger of human infection, the viewpoint has to shift. People who work with wildlife need to be aware of the risk of illness transmission. Effective programs for identification, prevention, and control may be created and put into practice.

REFERENCES

Abbate JM et al., 2019. Leishmania infantum in wild animals in endemic areas of southern Italy. Comparative Immunology, Microbiology and Infectious Diseases 67: 101374.

Alsarraf M et al., 2023. Occurrence of Dirofilaria repens in wild carnivores in Poland. Parasitology Research 122(5): 1229-1237.

Atawodi JC et al., 2013. Animals as reservoir of some human diseases. Electronic Journal of Biology 9: 24-28.

Barr SC, 2009. Canine Chagas' disease (American trypanosomiasis) in North America. Veterinary Clinics: Small Animal Practice 39(6): 1055-1064.

Bokaba RP et al., 2022. Toxoplasma gondii in African Wildlife: A Systematic Review. Pathogens 11(8): 868.

Brunaska M et al., 1995. Toxocara canis: ultrastructural aspects of larval moulting in the maturing eggs. International Journal for Parasitology 25(6): 683-690.

Cacciò SM et al., 2018. Host specificity in the Giardia duodenalis species complex. Infection, Genetics and Evolution 66: 335-345.

Centers for Disease Control and Prevention CDC, 2007. Blood donor screening for Chagas disease--United States, 2006-2007. MMWR. Morbidity and Mortality Weekly Report 56(7): 141-143.

Chhabra MB and Muraleedharan K, 2016. Parasitic zoonoses and role of wildlife: An overview. Veterinary Research International 4(1): 1-11.

Cilia G et al., 2021. Presence and characterization of zoonotic bacterial pathogens in wild boar hunting dogs (Canis lupus familiaris) in Tuscany (Italy). Animals 11(4): 1139.

Colon CP and Patton S, 2012. Parasites of civets (Mammalia, Viverridae) in Sabah, Borneo: A coprological survey. Malayan Nature Journal 64(2): 87-94.

Cupertino MC et al., 2020. Emerging and re-emerging human infectious diseases: A systematic review of the role of wild animals with a focus on public health impact. Asian Pacific Journal of Tropical Medicine 13(3): 99-106.

Daba M et al., 2021. Current status of Ancylostoma species in domestic and wild animals and their zoonotic implication. Animal and Veterinary Sciences 9(4): 107-114.

Desquesnes M, 2017. Veterinary aspects. In: Telleria J, Tibayrenc M, editors. American Trypanosomiasis Chagas Disease (2nd Ed.): Cambridge, MA: Elsevier; pp: 283–298.

Dorn PL et al., 2012. Low prevalence of Chagas parasite infection in a nonhuman primate colony in Louisiana. Journal of the American Association for Laboratory Animal Science 51(4): 443-447.

Dubey JP et al., 2020. Epidemiologic significance of Toxoplasma gondii infections in chickens (Gallus domesticus): the past decade. Parasitology 147(12): 1263-1289.

Dubey JP et al., 2020. Epidemiologic significance of Toxoplasma gondii infections in turkeys, ducks, ratites and other wild birds: 2009–2020. Parasitology 148(1): 1-30.
Edo M et al., 2021. Is the prevalence of Leishmania infantum linked to breeds in dogs? Characterization of seropositive dogs in Ibiza. Animals 11(9): 2579.
Eslahi AV et al., 2022. Global prevalence and epidemiology of Strongyloides stercoralis in dogs: a systematic review and meta-analysis. Parasites & Vectors 15: 1-13.
Feng Y and Xiao L, 2011. Zoonotic potential and molecular epidemiology of Giardia species and giardiasis. Clinical Microbiology Reviews 24(1): 110-140.
Franjić S, 2022. Zoonoses are Dangerous Infectious Diseases. Journal of Internal Medicine and Cardiovascular Research 1: 17-21.
Gado DA et al., 2023. Review of Emerging and Re-Emerging Zoonotic Pathogens of Dogs in Nigeria: Missing Link in One Health Approach. Zoonotic Diseases 3(2): 134-161.
Galecki R et al., 2015. Parasites of wild animals as a potential source of hazard to humans. Annals of Parasitology 61(2).
García-Livia K et al., 2020. Diversity of Cryptosporidium spp. in wild rodents from the Canary Islands, Spain. Parasites & Vectors 13(1): 1-9.
Glickman LT and Schantz PM, 1981. Epidemiology and pathogenesis of zoonotic toxocariasis. Epidemiologic Reviews 3: 230-250.
Gomes-de-Sá S et al., 2022. Dirofilaria immitis antigenemia and microfilaremia in Iberian wolves and red foxes from Portugal. Parasites & Vectors 15(1): 119.
González-Barrio D, 2022. Zoonoses and wildlife: One Health Approach. Animals 12: 480.
Green J et al., 2020. African lions and zoonotic diseases: implications for commercial lion farms in South Africa. Animals 10(9): 1692.
Guo X et al., 2022. Proteomic profiling of serum extracellular vesicles identifies diagnostic markers for echinococcosis. PLOS Neglected Tropical Diseases 16(10): e0010814.
Heidari Z et al., 2015. Morphological and molecular identification of Dirofilaria immitis from Jackal (Canis aureus) in North Khorasan, northeast Iran. Journal of Vector Borne Diseases 52(4): 329.
Hewavithana DK et al., 2022. Gastrointestinal parasites of six large mammals in the Wasgomuwa National Park, Sri Lanka. International Journal for Parasitology: Parasites and Wildlife 17: 1-6.
Hilderink MH and de Winter II, 2021. No need to beat around the bushmeat–The role of wildlife trade and conservation initiatives in the emergence of zoonotic diseases. Heliyon 7(7).
Hodo CL et al., 2018. Trypanosoma cruzi transmission among captive nonhuman primates, wildlife, and vectors. EcoHealth 15: 426-436.
Ibarra-Cerdeña CN et al., 2020. Tackling exposure to Chagas disease in the Yucatán from a human ecology perspective. Culture, Environment and Health in the Yucatan Peninsula: A Human Ecology Perspective 293-309.
Iemmi T et al., 2020. Toxoplasma gondii in the Eurasian kestrel (Falco tinnunculus) in northern Italy. Parasites & Vectors 13(1): 1-7.
Ito A and Budke CM, 2017. The echinococcoses in Asia: the present situation. Acta Tropica 176: 11-21.
Jannat R et al., 2020. Enteric Parasites with Zoonotic Importance in Jackal (Canis aureus Linnaeus, 1758). National Journal of Life Sciences 17: 81-86.
Javed K and Alkheraije KA, 2023. Cryptosporidiosis: a foodborne zoonotic disease of farm animals and humans. Pakistan Veterinary Journal 43(2): 213-223.
Keegan JD and Holland CV, 2013. A comparison of Toxocara canis embryonation under controlled conditions in soil and hair. Journal of Helminthology 87(1): 78-84.
Khan A et al., 2019. Evaluation of prevalence and risk factors associated with Cryptosporidium infection in rural population of district Buner, Pakistan. PLoS One 14(1): e0209188.
Khan A et al., 2021. Investigation of Echinococcus multilocularis in foxes and dogs in Pakistan by detection of copro-DNA. Parasitology Research 120: 731-737.
Kido N et al., 2011. Prevalence of Dirofilaria immitis infection in living raccoon dogs assessed by hematological examination. Journal of Veterinary Medical Science 73(6): 845-847.

Kimman T et al., 2013. Assessing and controlling health risks from animal husbandry. NJAS-Wageningen Journal of Life Sciences 66: 7-14.
Kladkempetch D et al., 2020. Ancylostoma ceylanicum: The neglected zoonotic parasite of community dogs in Thailand and its genetic diversity among Asian countries. Animals 10(11): 2154.
Krupińska M et al., 2023. Grassland versus forest dwelling rodents as indicators of environmental contamination with the zoonotic nematode Toxocara spp. Scientific Reports 13(1): 483.
Kruse CS et al., 2019. Leveraging technology to manage Chagas disease by tracking domestic and sylvatic animal hosts as sentinels: a systematic review. The American Journal of Tropical Medicine and Hygiene 101(5): 1126.
Kruse H et al., 2004. Wildlife as source of zoonotic infections. Emerging Infectious Diseases 10(12): 2067.
Kusumarini S et al., 2022. Screening Strongyloides spp. Infection from Wild Rodents Implications for Public Awareness and Attitudes on Zoonotic Diseases in Malang City, Indonesia. Jurnal Medik Veterinar 5(2).
Levy S et al., 2023. First molecular identification of Fasciola gigantica in slaughtered cattle in Cape Verde: Prevalence, gross pathological lesions, genetic identification and coprological analysis. Pathogens 12(1): 75.
Li J et al., 2021. Advances in molecular epidemiology of cryptosporidiosis in dogs and cats. International Journal for Parasitology 51(10): 787-795.
López-Osorio S et al., 2020. Prevalence of Toxocara spp. in dogs and cats in South America (excluding Brazil). Advances in Parasitology 109: 743-778.
Mafuyai HB et al., 2013. Baboons as potential reservoirs of zoonotic gastrointestinal parasite infections at Yankari National Park, Nigeria. African Health Sciences 13: 252-254.
Malik YS et al., 2021. Giardiasis. Role of Birds in Transmitting Zoonotic Pathogens 2021: 221-228.
Meerburg BG et al., 2009. Rodent-borne diseases and their risks for public health. Critical Reviews in Microbiology 35(3): 221-270.
Montgomery SP et al., 2016. What do we know about Chagas disease in the United States? The American Journal of Tropical Medicine and Hygiene 95(6): 1225.
Moroni B et al., 2020. Dirofilaria immitis in wolves recolonizing northern Italy: are wolves competent hosts? Parasites & Vectors 13(1): 1-7.
Morse SS et al., 2012. Prediction and prevention of the next pandemic zoonosis. The Lancet 380(9857): 1956-1965.
Mukarati NL et al., 2013. Occurrence, prevalence and intensity of internal parasite infections of African lions (Panthera leo) in enclosures at a recreation park in Zimbabwe. Journal of Zoo and Wildlife Medicine 44(3): 686-693.
Ohiolei JA et al., 2019. Cystic echinococcosis in Nigeria: first insight into the genotypes of Echinococcus granulosus in animals. Parasites & Vectors 12: 1-10.
Okoye IC et al., 2015 Intestinal parasitic fauna and zoonotic potentials of commonly consumed wildlife. Helminthologia 52(3): 195-204.
Overgaauw PA and Nederland V, 1997. Aspects of Toxocara epidemiology: toxocarosis in dogs and cats. Critical Reviews in Microbiology 23(3): 233-251.
Palmer CS et al., 2007. The veterinary and public health significance of hookworm in dogs and cats in Australia and the status of A. ceylanicum. Veterinary Parasitology 145(3-4): 304-313.
Paniz Mondolfi AE et al., 2020. Chagas disease endemism in the United States. Clinical Infectious Diseases 70(4): 717-718.
Parsons JC, 1987. Ascarid infections of cats and dogs. Veterinary Clinics of North America: Small Animal Practice 17(6): 1307-1339.
Penezić A et al., 2014. First findings and prevalence of adult heartworms (Dirofilaria immitis) in wild carnivores from Serbia. Parasitology Research 113: 3281-3285.
Pope T et al., 2021. Raccoon roundworm as an occupational hazard to caregivers of captive wildlife. Journal of Wildlife Rehabilitation 41(1).
Pozio E, 2007. World distribution of Trichinella spp. infections in animals and humans. Veterinary Parasitology 149(1-2): 3-21.
Pozio E, 2013. The opportunistic nature of Trichinella—exploitation of new geographies and habitats. Veterinary Parasitology 194(2-4): 128-132.
Rahman MT et al., 2020. Zoonotic diseases: etiology, impact, and control. Microorganisms 8(9): 1405.

Rayulu VC and Sivajothi S, 2022. Fasciolosis. In: Parija SC, editor. Textbook of Parasitic Zoonoses: Singapore, Springer Nature Singapore; pp: 223-233.
Recht J et al., 2020. Host diversity and origin of zoonoses: The ancient and the new. Animals 10(9): 1672.
Rees EM et al., 2021. Transmission modelling of environmentally persistent zoonotic diseases: a systematic review. The Lancet Planetary Health 5(7): e466-e478.
Richards DT and Lewis JW, 2001. Fecundity and egg output by Toxocara canis in the red fox, Vulpes vulpes. Journal of Helminthology 75(2): 157-164.
Rocha FL et al., 2013. Trypanosoma cruzi infection in neotropical wild carnivores (Mammalia: Carnivora): at the top of the T. cruzi transmission chain. Plos One 8(7): e67463.
Ryan U and Cacciò SM, 2013. Zoonotic potential of Giardia. International Journal for Parasitology 43(12-13): 943-956.
Ryan U and Zahedi A, 2019. Molecular epidemiology of giardiasis from a veterinary perspective. Advances in Parasitology 106: 209-254.
Sandström CA et al., 2013. Latitudinal variability in the seroprevalence of antibodies against Toxoplasma gondii in non-migrant and Arctic migratory geese. Veterinary Parasitology 194(1): 9-15.
Schellenberg RS et al., 2003. An outbreak of trichinellosis due to consumption of bear meat infected with Trichinella nativa in 2 northern Saskatchewan communities. The Journal of Infectious Diseases 188(6): 835-843.
Sharp PM et al., 2020. Ape origins of human malaria. Annual Review of Microbiology 74: 39-63.
Smout FA et al., 2013. First report of Ancylostoma ceylanicum in wild canids. International Journal for Parasitology: Parasites and Wildlife 2: 173-177.
Sorvillo F et al., 2002. Baylisascaris procyonis: an emerging helminthic zoonosis. Emerging Infectious Diseases 8(4): 355.
Strube C et al., 2013. Toxocara spp. infections in paratenic hosts. Veterinary Parasitology 193(4): 375-389.
Thompson RA, 2013. Parasite zoonoses and wildlife: one health, spillover and human activity. International Journal for Parasitology 43(12-13): 1079-1088.
Trisciuoglio A et al., 2015. The use of loop-mediated isothermal amplification improves Toxoplasma gondii detection in wildlife. Journal of Veterinary Diagnostic Investigation 27(6): 754-757.
Unterköfler MS et al., 2022. Strongyloides stercoralis infection in dogs in Austria: two case reports. Parasites & Vectors 15(1): 1-9.
Villanueva-Saz S et al., 2022. First serological study of Dirofilaria immitis antibodies in household domestic ferrets (Mustela putorius furo) in southern Spain–Short communication. Acta Veterinaria Hungarica 70(4): 282-286.
Vivekanandhan R et al., 2019. Dirofilariasis: An emerging zoonoses. Journal of Pharmacognosy and Phytochemistry 8(3): 3014-3018.
Wang Q et al., 2007. Impact of overgrazing on the transmission of Echinococcus multilocularis in Tibetan pastoral communities of Sichuan Province, China. Chinese Medical Journal 120(03): 237-242.
Watsa M and Wildlife Disease Surveillance Focus Group, 2020. Rigorous wildlife disease surveillance. Science 369(6500): 145-147.
Webb CM and Cabada MM, 2018. Recent developments in the epidemiology, diagnosis, and treatment of Fasciola infection. Current Opinion in Infectious Diseases 31(5): 409-414.
Wegner GI et al., 2022. Averting wildlife-borne infectious disease epidemics requires a focus on socio-ecological drivers and a redesign of the global food system. Clinical Medicine 47.
Wen H et al., 2019. Echinococcosis: advances in the 21st century. Clinical Microbiology Reviews 32(2): 10-1128.
Whitehouse-Tedd KM et al., 2015. Dietary factors associated with faecal consistency and other indicators of gastrointestinal health in the captive cheetah (Acinonyx jubatus). PLoS One 10(4): e0120903.
Wilson AG et al., 2020. Interaction of diet and habitat predicts Toxoplasma gondii infection rates in wild birds at a global scale. Global Ecology and Biogeography 29(7): 1189-1198.
Youssef AI and Uga S, 2014. Review of parasitic zoonoses in Egypt. Tropical Medicine and Health 42(1): 3-14.
Zhao W et al., 2019. Cryptosporidium spp. in wild rats (Rattus spp.) from the Hainan Province, China: Molecular detection, species/genotype identification and implications for public health. International Journal for Parasitology: Parasites and Wildlife 9: 317-321.
Zhao Y et al., 2010. Summary of mouse-spread diseases and measures to control them. Zhongguo Bingyuan Shengwuxue Zazhi/Journal of Pathogen Biology 5(5): 378-380.

Zhu S et al., 2023. More people, more cats, more parasites: Human population density and temperature variation predict prevalence of Toxoplasma gondii oocyst shedding in free-ranging domestic and wild felids. Plos One 18(6): e0286808.