

Review articles

Epizootiology of zoonotic parasites in Middle East: a comprehensive review

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ABSTRACT. Parasitic zoonosis (PZs) have a cosmopolitan significant impact on public health but they are often omitted in discussions, especially in developing countries. Zoonotic parasites include protozoa, cestodes, nematodes, trematodes and arthropods, and notably in African and Arabian countries have a high prevalence among livestock and man. Through this comprehensive review, we summarize the extant published research of the most significant zoonotic parasites present in some countries of Arabic world and we identify the epidemiology and risk factors for significant infections and suggest some effective control measures. This review might help the researches, governments about the zoonotic impact of these neglected infections for future considerations and application for real control programs.

Keywords: epizootiology, zoonotic, Arabic, *Leishmania*, *Echinococcus*

Introduction

Zoonotic parasites may be classified into four main categories: direct-zoonotic, meta-zoonotic, cyclo-zoonotic, and sapro-zoonotic. Direct-zoonotic parasites infect humans directly from animals, and include, *Cryptosporidium parvum* and *Toxoplasma gondii*. Meta-zoonotic parasites that require invertebrate host, as *Fasciola hepatica* can infect humans via invertebrate intermediate hosts (snail intermediate host). Cyclo-zoonotic parasites have vertebrate intermediate hosts and include *Multiceps multiceps* (*Coenurus cerebralis*), *Echinococcus granulosus* (hydatid cyst), *Taenia saginata* (*Cysticercus bovis*). Sapro-zoonotic parasites (a zoonosis the agent of which requires both a vertebrate host and a non-animal – food, soil, plant – reservoir or developmental site for completion of its cycle) can infect humans through soil or water and include *Strongyloides stercoralis* and hookworm, through skin penetration of larvae presented in soil [1].

Many parasites that infect humans depend on

vertebrate animals to continue their life cycle. Humans are most commonly infected with zoonotic parasites through contaminated food, water, through the consumption of the infected host or through the fecal-oral route [2]. The results of these infections may vary from asymptomatic carriers to long-term morbidity and eventually death. Although data for zoonotic parasites are still scarce in the Middle East, it is clear that these parasitic zoonosis (PZs) present a significant danger for public health, particularly in developing and marginalized communities [3]. Populations have been exposed to tremendous numbers of zoonotic foodborne parasites, due to the close relationship between humans and domestic animals, the encroachment of people into landscapes previously reserved for wildlife, climate change, which results in modified flora and fauna, to revolutions in cooking methods, diet and food availability, and to in-vogue culinary items expanding throughout societies [4,5]

Little data is now available regarding the current status of zoonotic parasites among Middle East

populations. The aim of this systematic review is to determine the prevalence of zoonotic parasites in some Middle East countries, so that we give assistance to the authorities in their efforts to apply suitable control programs and to enhance public health awareness [5].

Methodology

Systematic review guidelines were used, research papers were collected from internet websites, English databases (PubMed, Scopus, Science Direct, Springer, Web of Science, Google Scholar, Saudi Digital Library and Egyptian Knowledge Bank) were used. Using systematic review guidelines set forth by PRISMA, research articles were identified, screened and summarized based on exclusion criteria for the documented presence of zoonotic parasites in Arabian countries. Articles were reviewed, collated and summarized, based on exclusion criteria for the documented presence of zoonotic parasites within the Middle East region population.

Criteria for inclusion

This review included journal papers with methods and results for the prevalence and epidemiology of zoonotic parasites among Arabian countries populations. The list of the most prevalent zoonotic pathogens used in this search was adapted from previous research and expanded by the authors (Table 1). Animal-only results were excluded as were studies with human sampling for non-enteric or non-zoonotic parasites and broad descriptions of the current health status of these groups. Meeting notes, conference proceedings, abstracts, book chapters, and editorial letters were also excluded.

Journal articles were included for analysis if they were written in English language only. The search was done for all published literature up until our final search date of October 2019.

Data screening

The authors read through the titles and abstracts of the full list of retrieved papers and kept those that either a) demonstrated zoonotic parasites in human populations in Arabic countries; or b) the purpose and results of the article could not be determined based on title or abstract alone. When the adequacy of an article could not be determined by the abstract alone, full text versions were obtained. Complete articles were read by three reviewers and included in the final analysis based on the initial criteria and a majority decision [6].

Prevalence of significant zoonotic parasites in some Middle East countries

Echinococcosis

Echinococcosis is one of the most significant zoonotic parasitic diseases in the Middle East and in Arabic North Africa, from Morocco to Egypt. Both cystic and alveolar echinococcosis has been reported. Cystic echinococcosis is the more prevalent and has been reported from all Arabic countries. Alveolar echinococcosis has been reported only from Iran, Turkey, Iraq and Tunisia [7].

In Egypt, the overall prevalence of cystic echinococcosis was 1.9%, with the highest prevalence of 14%, reported in sheep. This species of parasite is widely prevalent throughout the country [8].

Another study in Egypt showed an infection rate

Table 1. The mean prevalence of zoonotic parasites in some Arabic countries

Zoonoses	Country				
	Egypt	Syria	Iraq	Libya	Saudi
Hydatidosis	9.5%	41%	4.2%	21%	8.12%
Coenurosis	3%	8.5%	12%	2.1%	0.1%
Leishmaniosis	133 cases in 2018	41.000 cases in 2018	7.112 cases in 2014	5.000 cases in 2016	1.400 cases in 2014
Cysticercosis	4.5%	3,75%	2.9%	3.4%	1.3%
Fasciolosis	12%	6.3%	4.5%	9%	4.6%
Amoebosis	21%	29%	25%	4.6%	30%
Cryptosporidiosis	7%	9%	17%	5%	1%

of 4.8% in sheep, 1.2% in goats, 0.9% in cattle, 0.4% in buffalo, and 18% in camels. The prevalence rate is slightly different in Upper and Lower Egypt. The seropositive rate for antibodies against hydatidosis in human sera was (6.1%). It is apparent that echinococcosis is a major public health problem in Egypt, due to high infection rates in humans and in animals. Apparent too is that sheep play an important role in echinococcosis dissemination, since their cysts are highly fertile to dogs, the risk cycle is sheep-dog-man [9].

In Kuwait, cystic hydatid disease is endemic. An estimated incidence rate of 3.6/100,000 has been reported [10]. In Oman, the prevalence was low, (one out of 306 humans and 5 out of 390 camels) were seropositive, as reported by ELISA [11].

In Saudi Arabia, the prevalence was 6% in camels in Al-Qassim; however, 14.9% of sheep, 29.5% of goats and 3.1% of cattle were infected with metacestodes. The overall infection rate was 11.3%. The incidence of hydatid disease in Saudi Arabia appears to be high and increasing [12]. Currently the infection rate in Saudi Arabia has fallen sharply, with an overall prevalence of 2.33%, which reflects better diagnostic facilities and improved medical care for this zoonotic infection [13]. In Iraq, the infection rate in sheep, goat and cattle was 15.0%, 6.2%, and 20.6%, respectively [14].

In Turkey, the seropositivity rate was 2.7% in humans, as found by ELISA and IFA [15]. In Tunisia, 21% of the dogs examined were found to be infected with *E. granulosus* [16], while the annual incidence of infection in humans was found to be 15 cases/100,000 [17]. These statistics of echinococcosis infection in dogs and in other definitive hosts, in animal intermediate hosts and in humans in the Middle East shows high prevalence and high endemicity of the infection. From the above mention data, we find out high prevalence of echinococcosis in countries like Egypt, Sudan, and Syria and this is due to widespread of stray dogs. Low prevalence is noticed in gulf countries due to application of strict control programs.

Coenurosis

Coenurosis is a zoonotic disease caused by the metacestode of *Taenia multiceps* that is prevalent in a wide variety of ruminants, especially sheep.

Coenurosis is an economically significant disease as it causes serious problems in the sheep and goat industry. *T. multiceps* inhabit the small

intestine of the definitive hosts, which include dogs and wild carnivores.

The commonest intermediate host for the metacestode is the sheep, and the resulting disease is known as gid because the location of the lesions changes the sheep's equilibrium and leads the animal to rotate in circles around its position. It must be differentiated from other nervous manifestations. The presence of the disease is rare in humans, and is mainly reported in the subcutaneous tissues. There are about 60 cases of human intracranial coenurosis described in the literature. Its histological appearance is remarkably similar to that of *T. solium* cysticercosis. It can be differentiated through multiple scolex found in each larva [18,19]. In Egypt, the overall infection rate with intracranial coenurosis was found to be 3.03% of the sheep population in Menofia province [20]. A single case of intraocular cyst was reported in a sheep in Qena province [19]. In Iraq, a study conducted in Thi-Qar province reported 13% of the examined sheep were infected with coenurosis [21].

In spite of its zoonotic importance, there are few or no studies on the prevalence of the cyst in humans, and the reported cases were only accidentally. We recommend that more attention be paid to this infection in carnivores, the final host, and in ruminants, the intermediate hosts.

Leishmaniosis

Leishmaniosis is a zoonotic disease which caused by a protozoan parasites called *Leishmania*; there are some 20 species that are pathogenic for humans. *Leishmania* is a protozoan transmitted by the bite of a small insect vector, the Phlebotomine sand fly (2–3 mm in length). Leishmaniosis is prevalent in large parts of Central and South America (New world leishmaniosis), and in Africa, Asia and the Mediterranean (Old world leishmaniosis). According to World Health Organization (WHO) reports, leishmaniosis is now endemic in 90 countries, with a total of 350 million people at risk, and the number of new cases of cutaneous leishmaniosis each year in the world is thought to be about 1.5 million. The number of new cases of visceral leishmaniosis is thought to be approximately 500,000. An estimated 12 million people worldwide are presently infected [22]. Leishmaniosis is a vector-borne zoonotic disease caused by obligate intracellular parasitic protozoa of the genus *Leishmania*. The disease gets into the human population when humans, flies and the

reservoir hosts share the same environment [23]. The most prevalent *Leishmania* in the Arabic world is *L. tropica*, which causes cutaneous leishmaniasis and is transmitted through the bite of the sand fly, *L. donovani*, which causes visceral leishmaniasis, and *L. major*, which causes localized cutaneous leishmaniasis and is prevalent in some areas [24,25]. In Iraq WHO reports 1.250 cases with cutaneous leishmaniasis in 2008 and 1.041 cases with visceral leishmaniasis. In Jordan, 244 cases with cutaneous leishmaniasis were found.

In Saudi, WHO reports only 32 cases of visceral leishmaniasis, and 2.321 cases of cutaneous leishmaniasis. In Syria, the prevalence of cutaneous leishmaniasis was high, with WHO reporting 29.140 cases in 2008, while the incidence of visceral leishmaniasis was low, with only 17 cases in that report. In Egypt, infection with visceral leishmaniasis is sporadic, as there were few cases reported. Cutaneous leishmaniasis is more prevalent in Egypt, with 471 cases reported in 2008. The reported number of cases is estimated to be 4–5 times lower than the actual number of cases. In 2010, only 133 cases were reported [26,27]. In Yemen, the prevalence of leishmaniasis is not well investigated. A recent survey conducted in 2018 by [28] reported the prevalence rate of cutaneous leishmaniasis was 18% with higher prevalence among kids under 16 years' old which accounted for 75% of the reported cases. In Libya, a study conducted in 2017 showed that only 420 cases were found to be positive for *Leishmania*. Zoonotic cutaneous leishmaniasis in Libya is caused by *L. major*, which is the main type of leishmaniasis in the country. The number of cases has progressively decreased since the implementation of control activities at the end of 2006, and probably the decline is also due to protective immunity in the populations affected [29].

Taeniosis/cysticercosis

The two most important Taeniae for humans are *T. solium* and *T. saginata*. The zoonotic parasite *T. saginata* utilizes bovines (cattle and buffaloes) as an intermediate host (causing cysticercosis), and humans as the final host (causing taeniosis). Swine are the intermediate host for *T. solium*, and the human acts as intermediate and definitive host. In Arabic countries, taeniosis due to *T. saginata* is more prevalent, as religious causes prevent people from eating pork. The beef tapeworm *T. saginata* is an important zoonotic Cestoda, with a cosmopolitan

distribution. The hermaphrodite adult Cestoda develops in the human intestine and produces thousands of eggs that are either excreted free or within intact, motile, proglottids in the faeces [30]. The eggs are able to survive for several months in the environment [31]. Domestic bovines, cattle and buffaloes, which are of particular importance in the Arabian region, are the natural intermediate hosts of the parasite, and are infected by ingestion of eggs, and then developing cysticercosis at their muscles and tissues. Humans are infected with the adult worm through ingesting the undercooked beef meat that contains the infective stage (*Cysticercus bovis*). In Egypt, the prevalence of cysticercosis in cattle and buffaloes was 7.5% and 1.5%, respectively. Taeniosis was detected in (0.4%) of patients with gastroenteritis. The results confirmed that cysticercosis is highly endemic among cattle in Upper Egypt [32]. The prevalence of cysticercosis in humans was found to be due to *T. solium*. The seroprevalence of *T. solium*/cysticercosis in humans in Assiut and Sohag Governorates was 6.5%, the ELISA test has found [33].

Fasciolosis

Fasciolosis, a cyclo-zoonotic disease caused by a liver fluke (*Fasciola* spp., mainly *Fasciola hepatica*), is one of the neglected zoonotic diseases in global public health, especially in Middle East. In Africa, infection with fasciolosis is a major animal and human health problem, with economic losses in animals in Egypt estimated to be \$800 million USD [34,35]. Fasciolosis is a parasitic disease caused by the *Fasciola* species, and is a disease of herbivorous animals. It has a cosmopolitan distribution in such grass-grazing animals as sheep, deer, goats, cattle, buffaloes, horses and rabbits. In the Middle East, donkeys and camels also are hosts for *F. gigantica*. Fasciolosis is a zoonotic trematode which occasionally infects man. Human infection causes serious hepatic pathological sequences that add to the already known threats to the liver in the Arabic population. Human fasciolosis in the Middle East was very sporadic until the last three decades, where clinical cases and outbreaks were reported, but more studies are required. In Egypt, animal as well as human fasciolosis is a growing problem. It has been recorded in many cities there, especially in those of the Nile Delta in Lower Egypt [36]. The two most important species are *F. hepatica* and *F. gigantica*. Both species are present among humans and animals in Egypt [37]. In Egypt, human infection

with *Fasciola* was reported found in 4.8% of people in Dakahlia Governorate [38]. Another study reported a prevalence rate of 12%, which is the highest infection rate found of *Fasciola* in Egypt [39]. The overall prevalence of *Fasciola* sp. in animals was 30.3%, including 28.6% in cows, 33.7% in buffaloes, and 17.2% in sheep [40]. A study conducted in Taif, Saudi Arabia, revealed a prevalence of *Fasciola* sp. of 8.6% in slaughtered cattle; two human cases also were reported [41]. In Iraq, the prevalence of *Fasciola* in ruminant animals was 3.6% in cows and 5.77% in sheep [42]. Another study in Basrah, revealed infection rates of 4.8, 3.3, 0.72, and 0.13% in buffaloes, cattle, sheep and goats, respectively [43]. Human infection with *Fasciola* in Iraq is sporadic; 18 patients were diagnosed *Fasciola* positive some years ago in Sulaimaniyah governorate [44].

In Tunisia, the prevalence of *F. hepatica* in humans was found to be 6.6%. It was found in that study in 4.3% of cattle, 35% of sheep and 68.4% of goats [45]. Unfortunately, there were no enough studies or available data to determine how extensive human fasciolosis is in Arabic countries. Only sporadic or accidental cases have been reported, in spite of the high prevalence of *Fasciola* infection in ruminants. We recommend that greater attention be paid to the problem of human fasciolosis in Arabic countries. In Turkey, the seroprevalence of *F. hepatica* was 7.5% in sheep and 14% in hair goat [46]. Human infection with *Fasciola* in Turkey [47] was reported in 0.79% of the participants in Mersin province, who were seropositive for *F. hepatica*.

Amoebosis

Amoebosis is an infection caused by the protozoa *Entamoeba histolytica*, which is considered the 3rd leading parasitic cause of human mortality, after malaria and schistosomosis, causing 40.000–100.000 deaths annually [48]. Amoebosis is caused by the *Entamoeba* complex which comprises pathogenic *E. histolytica* and non-pathogenic *E. dispar*. *E. moshkovskii* has further added to the complexity of the amoebosis diagnosis and epidemiology. The most pathogenic species is *E. histolytica*, which is responsible for human morbidity and mortality [49]. Amoebosis is defined as an intestinal or extra-intestinal disease that is caused by the parasite *E. histolytica*. *E. histolytica* is transmitted mainly through the fecal–oral route [50]. The infection causes a variety of clinical pictures, from asymptomatic carriers to carriers with

dysentery to carriers with invasive amoebic dysentery and extra-intestinal amoebosis (liver and brain infection) [51]. *Entamoeba* is highly endemic in poor countries (Africa and Latin America) due to their poor socio-economic and sanitary conditions, and there the populations play an important role in amoeba prevalence. Naous et al. [52] have reported that *Entamoeba histolytica* may be an emerging serious infection in Lebanon, where a prevalence rate of 3.1% was found, especially when it finds suitable environmental conditions and host factors. In Egypt, the prevalence of *E. histolytica* in diarrheic patients varies from 6.4% to 57% with mean prevalence of 21% [53,54]. In comparison to other Arabic countries, *E. histolytica* infection in Egypt tends to be asymptomatic at high rates (> 21%). While amoebosis caused by *E. histolytica* is rare in Saudi Arabia, it is sometimes observed in migrants from South Asia. Hence, it should always be included as one of the differential diagnoses of acute abdominal pain and a colonic mass [55]. On the other hand, the prevalence of *E. histolytica* is surprisingly high among infants in Jeddah. There, *E. histolytica* was the most common prevalent enteropathogen associated with gastroenteritis in infants (120 cases; 20%) [56].

In Sudan, in Khartoum, microscopically examination was made of 196 stool samples and these were reported as positive for *E. histolytica*. By using PCR it was found that 54% of the infection was caused by *E. histolytica* (106 of 196), and 51% was caused by *E. dispar* (100 of 196). Both species are highly prevalent in Sudan and control measures are urgently needed [14].

In Iraq, the prevalence of *E. histolytica/dispar* infection was found to be 20.61%, and somewhat higher in Basrah region 29.2% [57]. In Libya, recent testing found the prevalence of the infection is comparatively low, in comparison with countries like Egypt and Sudan. Among 150 stool samples taken from children, only 6 samples were positive (4%) for *E. histolytica* [58]. From the above-mentioned data, it is clear the prevalence of *E. histolytica* is a serious problem in poor developing countries. Other species of non-significant intestinal protozoa have been documented in Arabic countries, with a mean prevalence of Microsporidia spores (3.2%), *Enteromonas hominis* (1.9%), *Embadomonas intestinalis* (1.3%), *E. hartmani* (5.9%), *Dientamoeba fragilis* (5.1%), *Iodamoeba butschlii* (16%), *Isospora hominis* (7.7%), *Endolimax nana* (6.9%), *Chilomastix mesnili* (5.1%), and *Trichomonas hominis* (4.2%) [38].

Cryptosporidiosis

Cryptosporidium is a gregarine protozoan parasite of the intestinal tract that causes mild, severe and sometimes fatal watery diarrhoea mainly in immunocompromised patients, and self-limiting but prolonged diarrheal disease in immunocompetent individuals. It exists naturally in animals and can be of significant zoonotic impact. Cryptosporidiosis is an important causative agent of diarrhoeal diseases in human populations worldwide. Cryptosporidiosis is usually waterborne or food-borne. To date, this neglected protozoan disease has a cosmopolitan distribution, except in Australia and Oceania. Children and adults are liable to this infection, more often when immunocompromised by the HIV infection (83%). To date, seven *Cryptosporidium* species (*C. felis*, *C. canis*, *C. muris*, *C. hominis*, *C. parvum*, *C. meleagridis*, and *C. suis*) have been shown to be responsible for the infection in humans. Much attention on zoonotic cryptosporidiosis is focused on *C. parvum* [22]. The prevalence of *Cryptosporidium* infection varies widely among countries and regions [59]. Furthermore, there is insufficient epidemiological data on the prevalence of *Cryptosporidium* infections in most North African and Middle Eastern countries, including Egypt, the KSA and UAE. The prevalence of *Cryptosporidium* in Egypt varies according to region. A total of 61 published studies between 1985 and 2006 were reviewed. Nineteen studies examined immunocompetent individuals with diarrhoea presenting to inpatient or outpatient clinics with a *C. parvum* prevalence ranging from 0%–47% [60]. A more recent study conducted in Egypt in 2015 revealed that the prevalence of cryptosporidiosis there at that time was 13.5%. The infection rate was higher among low socioeconomic peoples and at young ages, ranging from 5–15 years old [61].

It may be said that the prevalence of *Cryptosporidium* in Arabic and North African countries is low. In KSA, a study conducted in Dammam found the prevalence of *Cryptosporidium* was just 1% [62]. We examined the epidemiology and the prevalence of *Cryptosporidium* in the Gulf countries and in the neighbouring Arabic and North African countries by reviewing 32 published studies of *Cryptosporidium* and of the aetiology of diarrhoea there between 1986 and 2018. The prevalence of *Cryptosporidium* infection in humans ranged from 1% to 47%, with a median prevalence of 4%. The highest prevalence was in countries like

Egypt, Sudan, Syria and Iraq, with a mean prevalence of 14% and this was due to waterborne and food borne infection and the transmission of the infection from animals to humans. In the Gulf and North African countries, the prevalence is much lower, ranging from 0–3% while in animals it varied by species of animals and by geographic location of the studies. Most cases of cryptosporidiosis occur among children from 5–12 years of age, and children in the first two years of life are also particularly vulnerable.

In conclusion, parasitic zoonotic diseases are common and they cause serious illnesses and have significant economic repercussions in the Middle East. Many parasitic zoonoses caused by helminths and protozoa are endemic in Middle East countries. Intestinal infections of parasitic zoonoses are exceedingly common and widespread and are a leading cause of diarrhoea, particularly among children and in rural areas. Some parasitic zoonoses such as cutaneous leishmaniasis are confined to specific geographic areas in the Sahara Desert. One of the most significant parasites studied was hydatidosis, which is a significant threat to health in the region. Middle Eastern populations are at risk of infection from different zoonotic parasites, due to the way of living, their cultural and dietary traditions, and their proximity to and interaction with the animal economy. Global health efforts aimed at decreasing the transmission of these zoonotic parasites to humans must incorporate a broad public health education program that supports water, food, sanitation, animal care, and hygiene development, and that provides education on safe food handling and preparation. Then it is recommended that public programs be implemented, educating people about zoonotic parasites and about how humans become infected. Public education should address how to care for and improve the health of peoples' domestic animals, particularly pets. This suggests need for interdisciplinary collaboration among agricultural, health and environmental ministries of all the Middle Eastern countries, to deter the emergence and/or re-emergence of these pernicious zoonotic diseases in their countries, a modern day plague that causes great human suffering.

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