



Infection Rate of *Sarcocystis* Spp. of the Intermediate Hosts in Iraq from 1999-2020

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Received: 13-4-2022, Accepted: 16-10-2022, Published online: 10-11-2022

Abstract. *Sarcocystis* spp. are protozoal parasites that are widely spread in mammals, reptiles, and birds. The disease they cause is called Sarcocystosis. The aim of this review is to gain knowledge of the infection rate and species of *Sarcocystis* in intermediate hosts in the provinces of Iraq and the areas that haven't been notified till now. Thirty relevant published research were collected about *Sarcocystis* spp. that infected the intermediate hosts in Iraq. Ten species determined in some intermediate hosts in Iraq are only: *S. tenella*, *S. arieticanis*, *S. gigantean*, *S. ovicanis*, *S. capricanis*, *S. caprifelis*, *S. moulei*, *S. cruzi*, *S. cameli* and *S. fusiformis*. There have been no population studies on *Sarcocystis* in the following Iraqi provinces: Kurkuk, Saladin, Diyala, Wasit, Al-Qadisiya, Al-Najef Al-Ashraf, Dhi Qar and Al-Muthanna. The infection rate ranged from 0.1% in Missan in water buffalo to 100% in several animals in Nineveh, Baghdad and Duhok of Iraqi provinces. The *Sarcocystis* spp. can be diagnosed by several methods.

Keywords: *Sarcocystis*, intermediate hosts, Iraq.

Note: The present study is a review literature study.

Introduction

Sarcocystis spp. are worldwide distributed parasites in human beings and several species of animals. They infect different muscles of the body. The *Sarcocystis* protozoan parasite (Phylum: Apicomplexa, Family Sarcocystidae) (Fayer, 2004). A sexual stage and cyst formation take place in the intermediate host (human beings and several species of animals). Sexual stage and formation oocysts take place in the definitive host (human beings and predators such as dogs or cats). The definitive host gets infected when it eats meat containing encysted parasites. Each encysted contains hundreds to thousands of *Sarcocystis* bradyzoites. In the intestinal wall of the definitive host, each bradyzoite directly develops into a microgamete or macrogamete, which fertilizes to form oocysts. Mature oocysts which have two sporocysts are eliminated with the feces. Intermediate hosts will be infected when they eat vegetables or drink water contaminated with oocysts (or sporocysts). The ingested oocysts or sporocysts cross into the blood stream. They can multiply in the small blood vessels before invading the different muscles where they eventually develop into bradyzoites, and mature into

sarcocyst usually taking about 2 months or more (Saeed *et al.*, 2018) (See Fig. 1).

Sarcocystis species may cause several symptoms such as diarrhea, vomiting and abdominal pain (Koneman *et al.*, 2005; Juckett, 1996). Death occurs in severe cases due to electrolytes and water loss (Koneman *et al.*, 2005). The muscular infections are possible causes of some cardiac diseases (viz. myocarditis, cardiomyopathy or valvular lesions) and rheumatic (viz. myositis and musculoskeletal complaints) (Habeeb *et al.*, 1996). *Sarcocystis* spp. infection in the intermediate mammals may cause abortion, but we don't know if this can happen in human cases (Greve, 1985).

Treatment of intestinal sarcocystosis are usually self-limiting (Bunyaratvej *et al.*, 1982). Prevention of infections in intermediate hosts depends on reducing exposure to oocysts or sporocysts. And in the definitive host, it is based on preventing eating of raw or not well cooked animal tissues. Freezing raw meat, to -20°C for about 48 hours or -4°C for about 48 hours, can be effective on parasites and can prevent infection because it will destroy the parasites (Leek *et al.*, 1978; Aiello and Moses, 2016).

The aims of the present study are to record the infection rate of *Sarcocystis* spp. in intermediate

hosts in different regions of Iraq and the areas that have not been registered till now, as well as, to urge other researchers to study this disease in all Iraqi areas to form an imagination about this epidemic and the species of *Sarcocystis* in Iraq. In

addition, the study aims to increase studies on sarcocystosis specially in Kurkuk, Saladin, Diyala, Wasit, Al-Qadisiya, Al-Najef Al-Ashraf, Dhi-Qar and Al-Muthanna to diagnose many other types of *Sarcocystis*.

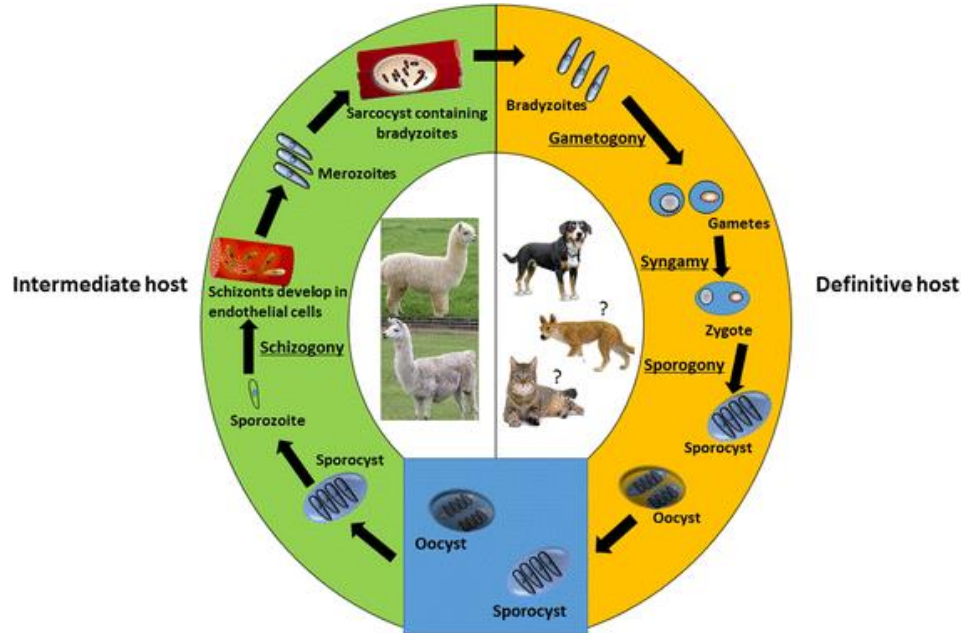


Fig 1. Life cycle of *Sarcocystis* spp (Saeed *et al.*, 2018).

Method

A total of thirty relevant research (English and Arabic) from PubMed, Google Scholar and articles dealing with *Sarcocystis* spp. published in Iraqi Academic Scientific Journals from 1999-2020 were used to provide the present study the rates of infections of this disease in several intermediate hosts in 10 Iraqi provinces including: Nineveh, Sulaimania, Duhuk, Erbil, Baghdad, Karbala, Babylon, Anbar, Missan and Basra. Data from these references were collected to show the *Sarcocystis* spp. study areas, hosts, species of

Sarcocystis, methods of diagnosis and infection rates. The arrangement of the Table (1) depends on the publication years of these research starting from the oldest down to the newest.

Literature Review

As mentioned before, thirty relevant research on *Sarcocystis* spp. was collected and shown in Table (1), as well as, all the species infectioning the intermediate hosts in several Iraqi provinces shown in Table (2) to facilitate the review studies.

Table 1. The record *Sarcocystis* spp. in Iraqi provinces.

Provinces	Infections animals	Species of <i>Sarcosystis</i>	Examination Methods	Infection rate %	References
Baghdad	Sheep	<i>Sarcosystis</i> spp. (Macroscopic and microscopic)	Peptic digestion method	93.3	(Latif <i>et al.</i> , 1999)
	Goats		Indirect fluorescent antibody test (IFAT)	88.6	
	Cattle		Squeezing	81.3	
	Water buffloes		Muscle squash	81.2	
Sulaimania	Goats	<i>S. caprifelis</i> <i>S. capracanis</i>	1-Macroscopical examination	33.6	(Barham <i>et al.</i> , 2005)
			2-Microscopical examination (Muscle squash, Pepsin digest of muscles, Histology)	97.4	
Northern Iraq	Goats	<i>S. capracanis</i>	Macroscopic examination	34	(Barham <i>et al.</i> , 2005)
Nineveh	Sheep	<i>S. gigantea</i>	Macroscopic examination Histopathological	94.83	(Al-Tae and Al-Hyali, 2007) (in Arabic)

Dohuk	Goats	<i>Sarcosystis</i> spp.	1-gross exam 2-trichinoscopy 3-squeezing method 4- post trichinoscopy 5-drop exam	93%	(Al-Bayati, 2008)
Dohuk	Cattle	<i>Sarcosystis</i> spp. (microscopic cysts)	1-gross examination 2-trichinoscopy 3-squeezing method 4-post trichinoscopy drop examination	81-96	(Al-Nakshabandi, 2008)
Nineveh	Sheep Goats Cattle Human	<i>Sarcosystis</i> spp.	ELISA IFAT IHAT Agar Gel Immunodiffusion Test	82 60 45 26	(Al-Tae et al., 2009) (in Arabic)
Dohuk	Sheep	<i>Sarcosystis</i> spp.	1-Trichinoscopy 2-Post trichinoscopy drop 3-Peptic digestion 4-histopathological	63.63 81.81 100 100	(Barwary et al., 2009)
Babylon	Goats	<i>S. caprifelis</i> <i>S. capracanis</i>	Trichenoscopy Squeezing Histopathological	0.39 93.22	(Mohammed and Kadihm, 2010) (in Arabic)
Nineveh	Sheep	<i>Microscopic Sarcosystis</i> spp	Histopathological	100	(Al-Sadi& younis, 2010)
Nineveh	Sheep	<i>S. gigantea</i>	Macroscopic examination Histological test		(Hyali et al., 2011)
Anbar	Camels	<i>S. cameli</i>	1-Macroscopic examination 2-muscle ingestion with pepsin and fluid testing	1.78 80.3	(Shahatha, 2011) (in Arabic)
Duhok	Sheep Goats	<i>S. gigantea</i> <i>S. caprifelis</i>	Macroscopic examination	7 8	(Al-Bayati, 2012)
Babylon	Slaughtered Cattle	<i>S. cruzi</i>	Trichenoscopy histological techniques	66.5 70	(Mohammad, 2012)
Babylon	Sheep	<i>S. gigantea</i> <i>S. tenella</i>	Macroscopic examination muscle ingestion with pepsin and fluid testing Trichenoscopy Histological test	7.69 97.93	(Mohammed and Kadihm, 2013)
Nineveh	Pigeons	<i>Sarcocystis</i> spp.	Trichenoscopy	3.08%	(Hasan et al., 2014) (in Arabic)
Nineveh	Sheep	<i>Sarcocystis</i> spp.	Histological techniques to brain	1%	(kako and Alhbiti, 2014)
Basra	Buffalo		Trichenoscopy Squeezing	77.5 72.2	(Maktoofa and abeeekh, 2015)
Baghdad	Sheep	<i>S. tenella</i>	Digestion method PCR	100	Whaeeb et al., 2016)
Nineveh	Sheep	<i>S. gigantea</i>	Macroscopic examination	94.8	(Al-Tae& Al-Hayali, 2017) (in Arabic)
Duhok	Sheep Goats	<i>S. ovis</i> <i>S. capricanis</i>	1-Direct Scotch Cellophane Adhesive Tape 2-Muscle Mincing and Squash Method 3-Acid pepsin Digestion Test 4-Histopathological Examination	97.5 100	(Zangana and Hussein, 2017)
Missan	Water buffloes	<i>S. fusiformis</i> <i>S. moulei</i>	Macroscopic examination PCR	2.8 0.1	(Dakhil et al., 2017)
Missan	Human : 1-Rheumatoid arthritis patients 2-non-heumatoid arthritis patients	<i>Sarcocystis</i> spp.	ELISA	33.33 23.8	(Dakhil et al., 2017)
Nineveh	Pigeon	<i>Sarcocystis</i> spp.	Trichinoscopy	3.08	(Hasan et al., 2018)
Baghdad	Sheep	<i>S. tenella</i> and <i>S. arieticanis</i>	Transmission Electron Microscopic		(Whaeeb, 2018)

Nineveh	Sheep	<i>Sarcocystis</i> spp.	Histopathological	35.5	(Hamdany, 2019)
Erbil	Sheep	<i>S. gigantea</i>	Macroscopic examination	9.5	Swar and Shnawa, 2020)
	Goats	<i>S. moulei</i>	Histopathological Examination	8.8	
Baghdad	Slaughtered Cattle	<i>S. cruzi</i>	PCR	2.5 (depend on primar)	(Kamil and Faraj, 2020)
Karbala	Sheep	<i>Sarcocystis</i> spp.	Macroscopic examination	5.82 90.78	(Al-Saadi <i>et al.</i> , 2020)
			Microscopic examination: 1-Acid pepsin Digestion 2-Meat mincing by garlic presse 3-PCR		
Duhok	Cattle	<i>Sarcocystis</i> spp.	Macroscopic examination	76	(Mohammad <i>et al.</i> , 2020)
			Microscopic examination: 1-tissue squeezing		
			2-muscle squash		
			3-pepsin hydrochloric acid digestion 4-histopathological examination		

Table 1. The record *Sarcocystis* spp. in Iraqi provinces.

Infection intermidate hosts	<i>Sarcocystis</i> spp.
Human	<i>Sarcocystis</i> spp. <i>S. tenella</i> <i>S. arieticanis</i> <i>S. gigantean</i>
Sheep	<i>S. ovicanis</i> <i>S. capricanis</i> <i>S. caprifelis</i> <i>S. moulei</i>
Goats	<i>S. caprifelis</i> <i>S. capracanis</i> <i>S. ovicanis</i> <i>S. moulei</i> <i>S. gigantean</i>
Cattle	<i>S. cruzi</i>
Camels	<i>S. cameli</i>
Water buffloes	<i>S. fusiformis</i> <i>S. moulei</i>
Pigoen	<i>Sarcocystis</i> spp.

Discussion

The present study is the first literature review study dealing with the infection rate of *Sarcocystis* spp. of the intermediate hosts in Iraq. Latif *et al.* (1999) is the oldest research collected in this review. It recorded that *Sarcocystis* spp. in goats, sheep, water buffaloes, cattle and camels in Iraq use different methods to diagnose it. Besides, the study observed several methods for diagnosing *Sarcocystis* in Iraqi research including: macroscopical examination to see the cysts by eyes (Macrocystes in muscles), microscopical examination methods which are Pepttic digestion method, indirect fluorescent antibody test (IFAT), squeezing muscle squash, histology, trichinology

and PCR (Barham *et al.*, 2005; Al-Saadi *et al.*, 2020). These methods were the same methods used in several research in the world. Stojeci *et al.* (2012) used PCR, histological examination (Meistro *et al.*, 2015), and transmission electron microscope (Jehle, 2009).

Ten species were only determined in some intermediate hosts in Iraq which were as follows: *S. tenella*, *S. arieticanis*, *S. gigantean*, *S. ovicanis*, *S. capricanis*, *S. caprifelis*, *S. moulei*, *S. cruzi*, *S. cameli* and *S. fusiformis*. On the other hand, there were several species diagnosed in the world in addition to the species recorded in this review study: *S. hirsuta*, *S. hominis* in bovine (Meistro *et al.*, 2015), *S. tenella* (Dong *et al.*, 2018), *S.*

medusiformis in sheep (Obendorf and Munday 1987), *S.bertrami* and *S. fayeri* in horse (Chun-Li Ma *et al.*, 2020).

There are no studies on *Sarcocystis* in the following Iraqi provinces; viz. Kurkuk, Saladin, Diyala, Wasit, Al-Qadisiya, Al-Najef Al-Ashraf, Dhi-Qar and Al-Muthanna. There were no clear reasons preventing the researchers from studying this parasite in these provinces. The present study noticed the infection rate ranged from 0.1% in Missan to 100% in Bagdad, Nineveh, Dohuk provinces (See Table 1).

This different rate can be due to the differences that existed in definitive hosts, such as dogs, cats, etc. Or, it may be related to the weakness of sanitary control in the slaughter houses, as it requires to distrust infected meat. Eating undercooked infected meat is one of the most important factors for human being's infection. Thus, human can become a definitive host when eating undercooked meat (Beaver *et al.*, 1979).

Conclusion

Finally, the study concludes the following:

- 1-Several infections were recorded in many intermediate hosts in different Iraqi areas.
- 2- *Sarcocystis* spp. can be diagnosed by several methods including: peptic digestion, indirect fluorescent antibody test (IFAT), squeezing muscle squash, histology, trichinoscopy, PCR. and transmission electron microscope.
- 3- In 44% of Iraqi places and cities, there were no manuscript worked to diagnosing *Sarcocystis*.

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