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Microscopic Examination of *Sarcocystis* in Meat Camels from Slaughterhouses in Al-Furat Al-Awsat, Iraq

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Abstract: A total of 150 esophageal samples were collected from slaughtered camels and examined for *Sarcocystis* spp. Macroscopic examination detected no positive samples. Direct microscopic examination of tissue preparations also revealed no positive samples. However, using the acid-pepsin digestion technique, the overall microscopic infection rate was 3/150 (2%), with bradyzoites appearing as characteristic banana- or crescent-shaped organisms under light microscopy. According to age, the infection rate was 1/70 (1.43%) in camels aged ≤1 year and 2/80 (2.50%) in those aged 1-3 years, with no statistically significant difference (X^2 = 0.214; P = 0.64). According to sex, infection was detected in 1/100 (1%) of males and 2/50 (4%) of females, with no statistically significant difference (P = 0.23). Conclusion: Microscopic examination revealed a low prevalence of *Sarcocystis* spp. infection in camel esophageal samples. The acid-pepsin digestion method was more effective than direct microscopic examination for detecting *Sarcocystis* bradyzoites.

Keywords: Camels, Sarcocystis, Microscopic, Oocyst, Iraq.

Research Paper

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INTRODUCTION

Sarcocystosis is a cosmopolitan protozoan disease caused by parasites of the genus *Sarcocystis* (phylum *Apicomplexa*), which are capable of forming tissue cysts in the striated and cardiac muscles of their intermediate hosts. The parasite was first described by Miescher in 1843, who observed whitish, thread-like cysts in the skeletal muscle of a house mouse, and since then more than 200 species have been identified, infecting a wide range of domestic and wild animals and causing substantial health and productivity losses in farmed animals worldwide (Abbas *et al.,* 2023; Dubey *et al.,* 2015a). A defining biological feature of *Sarcocystis* is its obligatory two-host life cycle, which requires both an intermediate (herbivore) host and a definitive (carnivore) host for completion (Dubey *et al.,* 2016). The intermediate host becomes infected through the ingestion of food or water contaminated with sporulated oocysts or sporocysts shed in the faeces of the definitive host, whereas the definitive host acquires infection by consuming raw or undercooked meat containing mature tissue cysts, which are disrupted in the stomach and intestine, thereby liberating bradyzoites (Kirillova *et al.,* 2018). Meat sarcocystosis significantly reduces both the grade and quality of meat, rendering meat and offal unsalable, and as a food-borne parasite affecting both humans and animals, it results in considerable financial losses due to the condemnation of carcasses and/or offal at abattoirs (Ahmed *et al.,* 2016). Mason (1910) first reported Sarcocystis in camels, describing its presence in the oesophagus and heart of Egyptian camels. Since that initial report, the parasite has been documented in virtually every region of the world where camels are raised. Sarcocystis species, including S. cameli and S. ippeni, utilise camels as intermediate hosts (Valinezhad *et al.,* 2008; Dubey *et al.,* 2015a); additionally, S. *miescheri* (Abd-Elmalek *et al.,* 2015) and S. *camelicanis* (Abdel-Ghaffar *et al.,* 2009) have been described. Camels acquire infection through the ingestion of food or water contaminated with sporulated oocysts or sporocysts shed by a definitive host, and current evidence suggests that the dog serves as the potential definitive host for *Sarcocystis* spp. in camels (Valinezhad *et al.,* 2008; Kirillova *et al.,* 2018). In Iraq, *Sarcocystis* was first reported in sheep (Daoud, 1976; Al-Dulaimi, 1992), followed by reports in goats (Barham, 1992), cattle (Al-Bayati, 1993), buffaloes (Al-Amery, 1995), camels (Al-Hamed, 1999), humans and farm animals (Al-Taie, 2002), and wild birds (Faraj, 2012).

However, the species most commonly detected in Iraq include *S. cameli* in camels (Al-Hamed, 1999), *S. tenella* and *S. arieticanis* in sheep, *S. cruzi* and *S. bovifelis* or *S. hominis* in cattle (Abdullah, 2021), and *S. gigantea, S. moulei*, and *S. medusiformis* in sheep and goats (Swar and Shnawa, 2020). The prevalence of *Sarcocystis* depends on the parasite species, as some hosts exhibit genetic resistance to particular parasite species, particularly in felines, thereby impeding parasite growth (Ng, 2016). In camels, the prevalence of sarcocystosis has been reported from various regions worldwide, including the Middle East, Africa, and Asia (Valinezhad *et al.,* 2008). Furthermore, infection rates may vary considerably among different organs examined, and in general, the probability of detecting a tissue cyst increases when more than one organ is examined (Asma *et al.,* 2017; Zeng *et al.,* 2021). Virtually all camels, regardless of clinical involvement, have been reported to harbour some macroscopic and microscopic *sarcocysts* in their muscles during meat inspection (Gareh *et al.,* 2020). A variety of conventional and advanced methods have been employed for the diagnosis of sarcocystosis in camels, including direct scotch cellophane adhesive tape, trichinoscopy, squeezing, acid pepsin digestion test, histopathology, and molecular techniques (Zangana and Hussein, 2017; El-Kady *et al.,* 2018; Oliveira *et al.,* 2020). Given that studies on *Sarcocystis* taxonomy in camels are scarce and there is a lack of comprehensive information regarding the species infecting this animal as an intermediate host, conducting investigations on species characterisation of the parasite is essential in our country. Moreover, little is known about various aspects of sarcocystosis in camels, including its molecular biology, pathology, molecular epidemiology, life cycle, economic impact, and public health significance. In recent years, molecular techniques have been applied for the characterisation of *Sarcocystis* isolated from different animals (Shekarforoush *et al.,* 2006). In Iraq, several *Sarcocystis* species have been detected in many animal species such as cattle, buffalo, sheep, and goats (Dakhil *et al.,* 2017; Al-Saadi *et al.,* 2020; Swar and Shnawa, 2020; Abdullah, 2021). However, in camels, no available molecular studies regarding *Sarcocystis* species have been found. Therefore, the present study was designed to diagnose *Sarcocystis* species in camels in Al-Furat Al-Awsat Province using morphological to determine the prevalence of the parasite in relation to sex, age, and geographical area.

Materials and Methods

All equipment and instruments used in the present study, together with their countries of origin. After handling contaminated samples, hands were thoroughly washed with soap, water, and a disinfectant solution as a safety measure. All laboratory safety equipment, cutting tools, and containers—including Petri dishes, beakers, and other glassware—were rinsed with detergent before sterilization following contact with tissue or sediment. Plastic materials were carefully disposed of by autoclaving and incineration.

Sample Collection

A total of 150 esophageal samples were collected from slaughtered camels (100 males and 50 females) of varying ages (ranging from less than one year to one to three years). The samples were obtained from different areas of Al-Furat Al-Awsat between October 2025 and the end of July 2026. Small pieces of the esophagus, approximately 9–12 cm in length, were selected from each slaughtered animal. The specimens were placed in labeled clean plastic containers, transferred in a box from the slaughter sites, and then transported to the laboratory. The samples were stored in a refrigerator at 9 °C until examination (Omatá et al., 1994; Huong and Uggla, 1995; Abdullah, 2021).

Sample Preparation

Each sample was prepared for traditional macroscopic and microscopic evaluation. The tissue was minced and processed according to the following techniques.

Squeezing (Compression) Technique

In this method, 3–4 g of each sample were placed into a tissue presser (garlic press). A drop of the expressed fluid was immediately transferred onto a glass slide, covered with a coverslip, and examined under a light microscope at 10× and 40× magnification (Al-Bayati, 1993; Mohammed *et al.,* 2022).

Acid-Pepsin Digestion Technique

Muscle samples were minced and subjected to individual peptic digestion following the protocol described by Dubey *et al.* (1989). Approximately 25 g of each minced sample was processed with 50 mL of digestion solution, consisting of 1.3 g pepsin, 2.5 g NaCl, and 3.5 mL concentrated HCl, made up to a total volume of 500 mL with distilled water. The suspensions were kept at room temperature for 30 minutes, then filtered through a strainer lined with gauze. The filtrates were collected in sterile test tubes and centrifuged at 3000 rpm for 5 minutes. The resulting sediment was examined under a light microscope at ×40 magnification for the presence of *Sarcocystis* bradyzoites, which appear as banana-shaped bodies.

Macroscopic Examination

Collected samples were examined immediately for parasitic cysts, which appeared as rice-grain-like structures visible to the unaided eye (Musa'ata, 2021). This macroscopic examination was used to detect the cysts (Faraj, 2012; Salam and Salih, 2021).

Results and Discussion

Microscopic examination revealed a 2.0% (3/150) overall prevalence of Sarcocystis infection. The prevalence was 2.50% (2/80) in the 1 to 3 years age

group, compared to 1.43% (1/70) in camels under 1 year. Despite this difference, no statistically significant association was established between age groups and infection occurrence ($p = 0.64$, $X^2 = 0.214$), as presented in Table 1.

Table 1: Age-specific infection rate of sarcocystosis by microscopic examination

Age (year)	No. of examined samples	Positive sample	
		NO.	(%)
<1years	70	1	1.43%0
1 to 3 years	80	2	2.50%
total	150	3	
calculated X2	0.214		
calculated p value	0.64		

No significant difference at P>0.05

The present study showed that age was not a significant factor in determining infection rates. The infection rate did not differ significantly between camels aged one to three years (2.50%) and those younger than one year (1.43%); rather, the rate in the older group (1-3 years) was slightly higher than in the younger group. Similar findings have been reported in Iraq (Aggar and Al-Zubaidi, 2023), Egypt (El-Bahy *et al*., 2019), Saudi Arabia (Omer *et al.,* 2017), and Iran (Hamidinejat *et al.,* 2013). This age-related pattern may be explained by the fact that younger camels have a lower incidence of Sarcocystis infection due to slower cyst development and potentially less exposure to contaminated environments. Older camels are also more frequently infected because of their longer lifespan and higher slaughter rates. Furthermore, younger camels may be less susceptible to infection because some owners keep them indoors for breeding purposes, which reduces their exposure to contaminated pastures.

Increased exposure with advancing age is likely a contributing factor to the higher infection rates observed in older animals.

Overall, microscopic analysis revealed a 2.0% (3/150) prevalence of sarcocystosis. The infection rate was higher in females (4.0%, 2/50) compared to males (1.0%, 1/100). However, this gender-based difference was not statistically significant, as indicated by the recorded p-value ($p = 0.23$) see in table 2.

Table 2: Sex-specific infection rate of sarcocystosis by microscopic examination

Sex	No. of examined samples	Positive sample percentage(%)
Male	100	1%
Female	50	4%
Total	150	2%
calculated X2	1.44	
calculated p value	0.23	

No significant difference at P>0.05

In the present study, microscopic examination revealed a higher infection rate among female camels (4%, 2/50) compared to males (1%, 1/100). However, statistical analysis indicated that this difference was not significant ($P = 0.23$; $X^2 = 1.44$). The absence of a significant sex-related difference is consistent with previous reports by Shekarforoush *et al*., (2005) and Hamidinejat *et al*., (2013). Furthermore, the trend of a higher prevalence in females aligns with recent findings by Omer *et al*., (2017) and studies on other camelids, such as alpacas and llamas, which suggest that females are more susceptible to Sarcocystis infections, possibly due to reduced immunity during gestation and around parturition (Carletti *et al.,* 2013; Romero *et al*., 2017; Lucas *et al*., 2019). In contrast, these results differ from earlier studies conducted in Southern Ethiopia (Woldemeske and Gumi, 2001), Iran (Valinezhad *et al*., 2008), and Egypt (Rabie *et al*., 2021), which reported that male camels were at a greater risk of infection.

Figure 1 the bradyzoite resembles a banana in shape. According to the description in Dubey *et al.* (2017), the bradyzoites inside the sarcocysts appear elongated or crescent-shaped, and are often likened to a small banana due to their overall curvature.



Figure 1: The bradyzoite of *Sarcocystis* spp. by pepsin digestion method at (40X)

CONCLUSION

Microscopic examination revealed a low prevalence of *Sarcocystis* spp. infection in camel esophageal samples. The acid-pepsin digestion method was more effective than direct microscopic examination for detecting *Sarcocystis* bradyzoites.

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