Epidemiological profile and distribution pattern of *Sarcocystis* spp. infection in goats slaughtered for human consumption in Aswan, Egypt

Original Article

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ABSTRACT

Background: *Sarcocystis* spp. are one of the most common food-borne tissue cyst-forming coccidia with public health and veterinary concern.
Objective: The presented study aimed to assess the epidemiological profile of *Sarcocystis* spp. infection in goats slaughtered for human consumption in Aswan, Egypt.
Material and Methods: A total of 180 goats were included in the study. Specimens from the cardiac and skeletal muscles collected from slaughtered goats, were subjected to histological examination of sections stained with hematoxylin and eosin (H&E).
Results: The results showed that 35% of goats contained tissue cysts histologically compatible with *Sarcocystis* spp. Microscopic sarcocysts were more prevalent in female goats (43.3%) than in males (30.8%). The detection rate of *Sarcocystis* spp. was 47.3% and 21.8% in adult and young, respectively. The results demonstrated 26.7% and 8.3% affection in skeletal and cardiac muscles, respectively.
Conclusion: The obtained results confirmed the high detection rate and tissue distribution pattern of sarcocystosis in the examined goats. Therefore, efficient cooking of goat meat is highly recommended before serving for human consumption.

Keywords: goats; human consumption; *Sarcocystis* spp.; Upper Egypt.

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INTRODUCTION

Goats play an important role in the livelihood of Egyptian farmers through provision of meat and milk, and as a source of income[1]. Goats' infection and associated mortality caused by apicomplexan protozoa of terrestrial origin such as *Sarcocystis* spp. have been reported worldwide. *Sarcocystis* spp. have a heteroxenous life cycle that includes a carnivorous definitive host and herbivorous intermediate host. From the former host infectious sporocysts are released into the environment via the feces. The definitive hosts include a variety of animals according to the *Sarcocystis* spp.[2,3].

These obligate two-host parasites may cause intestinal and muscular sarcocystosis in immunosuppressed individuals[4]. Meat heavily infected with *Sarcocystis* spp. is condemned as unsuitable for human consumption[5].

Among livestock, the different *Sarcocystis* spp. present as macroscopic or microscopic intramuscular cysts. The microscopic cysts are spindle-shaped with well-formed walls, and are filled with crescent-shaped bradyzoites of variable dimensions[6]. The gross appearance of sarcocysts can vary with their location, e.g., while macroscopic sheep sarcocysts of *S. gigantea* are elongate in the diaphragm, those in the esophagus are globular. Some species of *Sarcocystis* avoid certain muscle-organ types, e.g., mouse *S. muris*, sheep *S. gigantea*, and cattle *S. hirsuta* do not develop in the heart[7]. The size of all 141 macroscopic sarcocysts in 32 infected sheep carcasses were measured, and the results revealed the presence of three cyst types: a narrow filiform type (2–10 x ≤ 1 mm) in the diaphragm, abdominal muscles and hind legs, and two wider types (2–20 X 2-6 mm), including short and wide cysts in the esophagus, and more elongated cysts in other muscles. *Sarcocystis fusiformis* form grossly broad, white cysts that are not embedded deeply between the muscle fibers. The cysts measure 3.0-15.0 mm long (mean 9.0 mm) and 1-4 mm wide (mean 2.5 mm)[8].

Goats were reported intermediate hosts for three *Sarcocystis* spp., *S. capracanis, S. hircicanis, S. caprafelis* (syn. *S. moulei*), harboring sarcocysts in their striated muscles. Later, *S. tenella* (syn. *S. ovicanis*) of sheep was also recorded in goats[2]. While *S. capracanis, S. hircicanis* and *S. tenella* sarcocysts are microscopic and transmitted by canine final hosts; *S. caprafelis*

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produces macroscopic cysts and is transmitted by cats. Besides, *S. capracanis* was reportedly the most pathogenic species in goats, causing anorexia, weight loss, fever, tremors, abortion, and death[3].

On the other hand, sheep are intermediate hosts and harbor sarcocysts of at least six species, including *S. tenella, S. arieticanis, S. gigantea, S. medusiformis, S. mihoensis,* and *S. microps*. While *S. tenella* and *S. arieticanis* that produce microscopic sarcocysts are transmitted by canids, *S. gigantea* and *S. medusiformis* that produce macroscopic cysts are transmitted by felids[8]. Heating and freezing have a substantial impact on *Sarcocystis* spp.; a temperature of -20°C for 24 h was utilized to inactivate the bradyzoites in contaminated meat. Temperatures above 90°C for 10 min and above 60°C for 20 min were also suitable for their deactivation[9]. Marination in 6% NaCl and 3% acetic acid for 48 h was found to be effective in inactivating all bradyzoites[10].

Available information regarding the status of *Sarcocystis* spp. infection in goats in Aswan Governorate, Egypt is deficient. Therefore, the current research was conducted to determine the detection rate and tissue distribution patterns of *Sarcocystis* spp. infection as well as the histopathological changes caused by the sarcocysts in goats.

MATERIAL AND METHODS

This descriptive analytical study was conducted in the laboratory of Parasitology Department, Faculty of Veterinary Medicine, Aswan University during the period from February to July 2022.

Study design: Fresh meat specimens were collected from slaughtered goats to examine for presence of tissue cysts of *Sarcocystis* spp. macroscopically and histopathologically.

Study area and sample collection: This study was conducted in the local abattoir of Aswan Governorate, Upper Egypt (24° 5′N latitude, 32° 53′E longitude). A total of 180 randomly selected goats were included in the study, 60 females and 120 males. Their age was determined based on the eruption of permanent incisor teeth. Each animal was assigned a unique ID number, and samples were marked accordingly. Specimens from the cardiac and skeletal muscles were collected from slaughtered goats and transported to the laboratory of Parasitology Department, Faculty of Veterinary Medicine, Aswan University. Muscle specimens, ~15 x 10 mm, with or without macroscopically visible sarcocysts, were cut from the heart and *Longissimus dorsi* skeletal muscles. Samples were fixed in 10% neutral buffered formalin.

Histopathological examination: Muscle specimens were processed for histological examination, sectioned at 5 mm, stained by H&E and examined by light microscopy[11].

Ethical considerations: The study was approved by the ethical committee of the faculty of Veterinary Medicine, Assiut University, Assiut, Egypt, according to the OIE standards for use of animals in research under the No. 06/2023/0086.

Table 1. Detection rate of *Sarcocystis* spp. infection in slaughtered goats in relation to age and sex risk factors.

	No. examined	*Sarcocystis* spp. No. infected (%)
Detection rate	180	63 (35)
Age		
Adult (>2 years)	93	44 (47.3)
Young (<2 years)	87	19 (21.8)
Sex		
Male	120	37 (30.8)
Female	60	26 (43.3)

RESULTS

The naked eye examination did not reveal any macroscopic sarcocysts in the carcass muscles. Microscopic tissue cysts in goats' muscles were histologically compatible with *Sarcocystis* spp. (Fig. 1). Accordingly, the detection rate of sarcocystosis in slaughtered goats at the local abattoir of Aswan governorate was estimated at 63/180 (35%) (Table 1). The sarcocysts were recorded in 43.3% and 30.8% of females and males respectively, 47.3% and 21.8% in adult and young, respectively (Table 1). The examination revealed that the skeletal muscles were the most affected (26.7%), followed by the heart (8.3%) (Table 2).

Histopathologic examination revealed muscular lesions consisting of perivascular necrosis with mononuclear and neutrophilic cell infiltration, accompanied by edema, degeneration, and focal necrosis of muscle (Fig. 2).

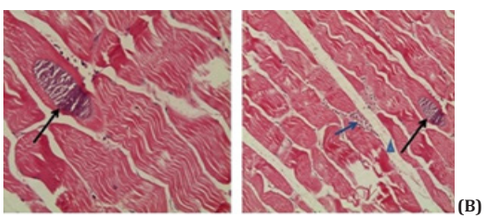

Fig. 1. Longitudinal histological section revealed: **(A)** a microscopic sarcocyst within *Longissimus dorsi* skeletal muscle isolated from an infected goat (black arrow). Cysts contained several basophilic crescent-like bradyzoites enclosed by a thin cyst wall ×100; **(B)** sarcocyst initiated tissue reaction of mylosis (triangle), infiltration of inflammatory cells (blue arrow) and starting necrosis ×40.

Table 2. Organ distribution of microscopic *Sarcocystis* spp. tissue cysts in slaughtered goats.

Muscles	No. infected/ total examined Detection rate (%)
Cardiac	15/180 (8.3)
Skeletal	48/180 (26.7)

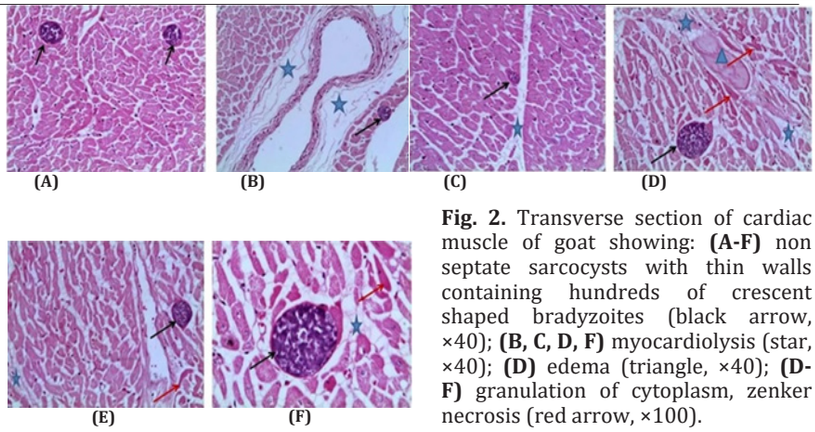

Fig. 2. Transverse section of cardiac muscle of goat showing: **(A-F)** non septate sarcocysts with thin walls containing hundreds of crescent shaped bradyzoites (black arrow, ×40); **(B, C, D, F)** myocardiolysis (star, ×40); **(D)** edema (triangle, ×40); **(D-F)** granulation of cytoplasm, zenker necrosis (red arrow, ×100).

DISCUSSION

Sarcocystosis is considered a common livestock parasitic disease, with potential public health importance, after consumption of raw or undercooked meat[7]. The results of the present study revealed a high detection rate of *Sarcocystis* spp. among goats slaughtered in the Aswan Governorate, Upper Egypt. Our overall detection rate of sarcocystosis recorded in 180 goats (35%), was closely related to the Iranian reports of 22.55% by Mandaalee and Rasouli[11], and the 35.83% by Valizadeh and Ebrahimi[12]. However our present record was lower as compared to that reported by Morsy *et al*.[13] in the year 2011 as 79.40% in Egyptian goats, and the 90% in Iraq goats reported by Mohammed *et al*.[14]. A high rate of infection by sarcocysts (72%) was also reported in Indian goats[15]. Since the *Sarcocystis* spp. infecting the local Aswan goats and hence their definitive hosts have not been identified, it may be assumed that infected dogs guarding herds of goats act as the definitive hosts[16]. They contaminate pastures with *Sarcocystis* spp. sporocysts which are in turn transmitted to the goats.

Infected dogs shed about 200 million sporocysts (about 4 million sporocysts/day) during the course of infection. The sporocysts are infective already when passed in the feces and this factor plays an important role in the epidemiology of sarcocystiosis[17]. The high detection rate of microscopic sarcocysts in goats reflects the high rate of dogs' sporocysts in the pasture. Contact of food animals with dogs must be avoided in the pasture to prevent them from ingesting the sporocyst stage from dogs' feces in contaminated feed, bedding, and water. These measures will prevent the development of intestinal stages in humans who according to the species may serve as definitive hosts.

The present results showed gender variation in the occurrence of goat sarcocystosis. Females seem to be more prone to protozoan diseases as compared to males, probably due to stress of gestation and lactation[18]. Additionally, sarcocystosis was apparently more prevalent in adults as compared to young goats. Similar observations were reported by Nasr *et al*.[19]. Increase in the detection rate of protozoan diseases in older animals is probably due to their prolonged exposure. Additionally, geoclimatic conditions in Aswan area, including high temperature and high relative humidity, may increase the survival and persistence of sporocysts shed from infected dogs. This would lead to an increased exposure to infection of adult goats specially with their continuous close contact with the final hosts.

In our study, microsarcocysts were detected more in skeletal muscles of the slaughtered goats rather than heart muscles which matches with the previous record in Egyptian goats (77%) obtained from Cairo abattoir[13]. The inability to detect macroscopic cysts compared with the high detection rate of microscopic sarcocysts in the present study may be due to the fact that dogs are the definitive hosts for *Sarcocystis* spp. affecting goats. On the other hand, macroscopic cysts are of feline origin[20] and contact between goats and dogs in pasture is more frequent than with cats in this area.

In spite of the high infection rate of *Sarcocystis* spp. in goats, little is known about the resulting pathological effects. However, our present examination indicated quite clearly that the *Sarcocystis* spp. can account for significant pathology. At first severe inflammatory, degenerative, and necrotic changes occur, leading to extensive damages of the musculoskeletal tissues. Later, the damaged parts undergo healing with fibrosis, scarring, and atrophy. These changes may occur concurrently in the same animal because of the prolonged irritation of the cysts. The microscopic species that are not detected during routine meat inspection and are not responsible for carcass condemnation are the infective species of these zoonotic protozoa. Nevertheless, the high detection rate of microscopic forms of *Sarcocystis* spp. has a definite economic impact on domestic animals production[21]. They can affect growth and weight gain, reduce the meat quality, and reduce milk yield, cause anorexia, fever, anemia, abortion, muscle weakness, and even death[22].

It was concluded that the detection rate and distribution intensity of *Sarcocystis* spp. infection in goats slaughtered for human consumption was relatively high in Aswan, Upper Egypt. The study highlighted that the risk of infection from goat to human is high as consumption of grilled meat is popular among Egyptians. Considering the fact that the infection can be massive, involving different muscles, and that the cysts may remain *in situ* for a long time, asserts the importance of further detailed investigations.

Author contribution: Abdelhamid M, Mohamed RS, Mohamed RH, El-Sayed AM, El-Kattan AM proposed the study topic and the study design. Abdelhamid M and Mohamed RS performed the histological and parasitological examination and analyzed the results. Abdelhamid M, Mohamed RS, Mohamed RH, El-Kattan AM, El-Sayed AM interpreted the results, and wrote the draft. Abdelhamid M supervised and finalized the article for publication. All authors agreed over the authorship and final version of publication.

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