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ORIGINAL ARTICLE

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Prevalence and distribution patterns of *Sarcocystis* in camels (*Camelus dromedarius*) in Yazd province, Iran

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Abstract *Sarcocystis* spp., are zoonotic cyst-forming coccidian parasites that cause sarcocystosis. This study was conducted to investigate the prevalence as well as distribution patterns of *Sarcocystis* spp. infection in slaughtered one-humped camels of Yazd province, Iran. Muscles of 130 camels were investigated for either macroscopic or microscopic sarcocysts during summer 2009. No macroscopic cyst was observed in the animals at naked eye inspection. Of examined camels, 67 (51.5 %) were positive for bradyzoites of the parasite by pepsin-digestion method. The infection rates of infected animals were 55.22, 50.75, 38.81, 34.33, and 28.36 %, in esophagus, heart, masseter muscle, intercostal muscle and limb muscle, respectively. Esophagus was the most commonly infected organ. No significant difference in the rate of infection between male (52.08 %) and female (51.22 %) camels was observed. Logistic regression analyses showed that infection rates' risk increased with increment in age of camels. This considerable prevalence of microscopic *Sarcocystis* spp. in Yazd province camels reflects a significant role played by wild and domestic carnivores in the transmission of these parasites.

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Introduction

Sarcocystosis is caused by *Sarcocystis* spp. These apicomplexan intracellular protozoan parasites have worldwide distribution and significant economic impact on production of domestic animals as well as public health importance. More than 150 species of *Sarcocystis* parasitize humans and animals (Motamedi et al. 2011). These parasites' indirect life, cycles between two hosts. Generally, intestinal infection occurs in carnivorous definite host; while in intermediate host parasites invade tissues. However, birds, reptiles and wild mammals can be definite host for different species of *Sarcocystis* (OIE/CFSPH 2005). The parasite produces tissue cysts in cardiac, striated and smooth muscles of intermediate host. Some *Sarcocystis* species induce weight loss, general weakness, fever, anorexia, abortion and death in domestic animals (Dubey et al. 1989). Humans can serve as both definite host of *Sarcocystis hominis* and *Sarcocystis suihominis*, and as intermediate host of some other species. Muscular sarcocystosis manifestations in humans include musculoskeletal pain, fever and cardiopathy. Intestinal infections with estimated worldwide incidence of 6–10 % cause nausea, stomach pain, diarrhea, inappetence, vomiting and dyspnea (Fayer 2004; OIE/CFSPH 2005).

Sarcocystis cameli, the only known species in camels with two different thin-walled and thick-walled cysts, was described for the first time by Mason (1910) in myocardium and esophagus of Egyptian camels. Since then it has been reported from almost all of the camel-rearing areas of

the world (Abdel-Ghaffar et al. 2009). Camels, as intermediate host, become infected by ingestion of sporulated oocysts passed in feces of carnivores, but so far there is no report on human infection by *S. cameli.* Two morphologically distinct sarcocysts have been reported in camels; the thin-walled cysts are generally found in diaphragm, heart and esophagus, while the thick-walled cysts are present only in esophagus. Both types are microscopic (Wernery and Kaaden 2002). Dogs can be infected with *S. cameli* after ingestion of camel meat, so are important in spreading the infection (Hilali et al. 1995). Several authors from Iran have detected sarcocystosis in camels from different parts of the country by various diagnostic methods, and reported its prevalence to be up to 86.3 % (Rahbari et al. 1981; Shekarforoush et al. 2006; Valinezhad et al. 2008; Motamedi et al. 2011). Therefore, the aim of this study was to determine distribution patterns of camel *Sarcocystis* in different organs, as well as the influence of age on infection rate in Yazd province.

Materials and methods

Camels are mostly raised for meat consumption in Iran. The present study was conducted in Yazd province, a semi-arid area in center of the country. Totally 130 slaughtered camels, 82 females and 48 males, aged 2–30 years were examined for *Sarcocystis* spp. during summer 2009. Carcasses were carefully inspected for macroscopic sarcocysts. The obtained tissue samples for microscopic investigation included esophagus, heart, diaphragm, limb muscles, masseter muscle and intercostal muscles. Our chosen organs are already shown to be the most common sites of the disease (Dubey et al. 1989). Collected specimens were cut and preserved in plastic containers, and moved to −20 °C freezer within hours.

Pepsin-digestion method is a gold standard procedure for diagnosis of sarcocysts, and its higher sensitivity compared with muscle squash method was concluded in cattle (Hamidinejat et al. 2010). We used this method described by Dubey et al. (1989) with some modifications for microscopic investigation. Approximately 10 g of each tissue organ of the examined animals were crushed and digested for 30 min at 40 °C in 50 mL of digestion medium containing 1.3 g pepsin, 3.5 mL HCl, and 2.5 g NaCl in 500 mL of distilled water. The digested solution was then centrifuged for 5 min at 1,500 g. The sediment was smeared on slides, stained by Giemsa, and examined at 400× magnification under the light microscope for detection of bradyzoites.

Statistical evaluation was performed by SPSS ver. 16, using the χ^2 test with 95 % confidence interval, and logistic regression test. A p value less than 0.05 was considered as significant difference.

Results and discussion

No macroscopic sarcocysts were found during carcass examination, but *Sarcocystis* bradyzoites were found by digestion method in 67 out of 130 investigated camels (51.5 %). Among different organs esophagus had the highest infection rate, although it was not significantly higher than other organs ($p > 0.05$). The infection rate was higher in males (52.08 vs 51.22 %) but it was not statistically significant. Logistic regression analyses showed that the risk of sarcocystosis increased with increment in animals' age.

No macroscopic sarcocysts were found in samples, whereas prevalence of *Sarcocystis* was 51.5 % at tissue digestion level. Similarly high prevalence rates were reported in neighboring countries; Iraq (91.6 %; Latif et al. 1999), Afghanistan (47.3–66.3 %; Kirmse and Mohanbabu 1986), United Arab Emirates (50 %; El-Afifi et al. 1963) and Saudi Arabia (88.4 %; Fatani et al. 1996). Former studies on *Sarcocystis* prevalence in other regions of Iran revealed 52.6, 52.3 and 83.6 % in Tehran, Esfahan and Mashhad, respectively (Rahbari et al. 1981; Shekarforoush et al. 2006; Valinezhad et al. 2008). Differences between the previously reported infection rates may be due to different husbandry management systems in northern and eastern parts of Iran, as well as diagnostic methods.

Analysis of results on distribution of *Sarcocystis* in different organs showed higher infection rate in esophagus. Different researches on camelids' sarcocystosis have reported dissimilar tissue patterns. Higher incidence in esophagus was reported previously by Woldemeskel and Gumi (2001) and Valinezhad et al. (2008), while Shekarforoush et al. (2006) found heart as the most infected organ. Fatani et al. (1996) reported diaphragm of camels to be the most common site. This predilection differences may be due to different *S. cameli* strains or definite host origin.

There was no significant difference in frequency of sarcocystosis between male and female camels in the present study. Lack of relationship between sex and infection rates has shown in similar studies on camels before (Woldemeskel and Gumi 2001; Shekarforoush et al. 2006; Valinezhad et al. 2008). In the present study, infection rates' risk in higher aged camels was observed. Our result is in accordance with Woldemeskel and Gumi (2001) on Ethiopian camels. Higher chance of acquiring infection in older animals has been reported by Shekarforoush et al. (2006) in camels.

Conclusion

Although human infection with camels' sarcocysts has not been reported yet, more investigations on ultrastructural and molecular definition of *S. cameli* is highly recommended regarding economic importance of this animal in arid and semi-arid regions of Iran. Since the most likely source of infection transmission is water and food contaminated with definite hosts' feces, controlling entrance of these animals (especially carnivores) to husbandries of Yazd province seems necessary.

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