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HELMINTHOLOGY - SHORT COMMUNICATION

First report of cystic echinococcosis caused by *Echinococcus granulosus sensu stricto*/G1 in *Felis catus* from the Patagonian region of Argentina

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Abstract

Two domestic cats from the Patagonia rural area in Argentina were found to be naturally infected with *Echinococcus granulosus sensu stricto*/G1 genotype; so far, the only species/genotype of *E. granulosus sensu lato* complex described to infect domestic cats. The felines developed abdominal disseminated larval disease; the diagnosis was performed by ultrasound, exploratory laparotomy, and molecular techniques. These results indicate that cystic echinococcosis must be considered for differential diagnosis of felines with abdominal distension and/or observation of vesicles through ultrasound, from endemic areas. Even though cats and dogs are carnivores, differences in digestive physiology and immunological characteristics between them could allow the development of larval or adult worm parasites. Domestic cats with cystic echinococcosis show to be environmentally infected with *E. granulosus* s. s./G1 eggs.

Keywords *Felis catus* · *Echinococcus granulosus sensu stricto*/G1 · Argentina · Cystic echinococcosis

Introduction

Cystic echinococcosis (CE) is a chronic parasitic zoonosis caused by *Echinococcus granulosus sensu lato* (s. l.), which affects humans and domestic and wild mammals. *E. granulosus* s. l. requires two mammalian hosts to complete its life cycle: a definitive host (usually dogs or other canids) and an intermediate host (wild or livestock mammals), with humans acting as accidental intermediate hosts. This disease is endemic in Argentina, southern Brazil, Uruguay, Chile, and mountainous regions of Peru and Bolivia. In South America, 5687 human cases were reported between January and December 2018; 486 (8.5%) cases were reported in children less than 15 years of age (PANAFTOSA 2020). *E. granulosus* s. l. is a complex composed of *Echinococcus granulosus sensu stricto* (s. s.) (G1 and G3 genotypes), *E. equinus* (G4 genotype), *Echinococcus ortleppi* (G5 genotype), *Echinococcus canadensis* (G6, G7, G8, G10 genotypes), and *Echinococcus felidis*. In Argentina, circulation of a total of five genotypes, corresponding to the three species *E. granulosus* s. s. (G1/G3), *E. ortleppi* (G5), and *E. canadensis* (G6/G7), has been described (Cucher et al. 2016; Avila et al. 2017; Debiaggi et al. 2017). The most frequent species/genotype found in all continents is *E. granulosus* s. s. (G1),

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which causes a significant burden of disease in humans and animals. Consequently, it is considered the species/genotype of greatest sanitary importance (Cucher et al. 2016; Ito et al. 2017). Although, *E. granulosus* s. l. intestinal infections is usually found in canids, it has previously been reported in cats from Germany (von der Ahe 1967), New Zeeland (McDonald and Campbell 1963), Turkey (Burgu et al. 2004), Russia (Konyaev et al. 2012), Uruguay (Armua-Fernandez et al. 2014), and Italy (Bonelli et al. 2018). This report describes for the first time two felines naturally infected by *E. granulosus* s. s./G1 in Argentina, concretely from the Patagonian region.

Abdominal infection presentation and evolution

Two female cats, from Chubut (case 1) and Rio Negro (case 2) provinces, were referred to different veterinary clinics due to fluctuating and distended soft abdomen and general discomfort (Fig. 1a and Table 1). Case 1 cohabited with ten dogs and was reportedly kept indoors of owner's house; case 2 was a stray cat. In both cases, abdominal ultrasound revealed multiple vesicles compatible with abdominal cysts, which were extracted by exploratory laparotomy (Fig. 1b and Table 1). The liver was the only organ affected, with superficial and intraparenchymal cysts. Numerous vesicles from the abdominal cavity and cysts attached to the peritoneum have been found. After being diagnosed, euthanasia was decided by case 1 owners. Case 2 was treated one month after surgery with praziquantel 15 mg/kg/day, and a liver cell protector/regenerator (DL-methionine 160 mg/choline bitartrate 160 mg/silymarin 12 mg), for a period of six months. Unfortunately, case 2 died a year later. During necropsy, visceral cysts were not observed; however, ten free vesicles (1 cm diameter) containing viable protoscoleces were collected from the abdominal cavity. In both cases, the immunological and FIV/FeLV status was not determined.

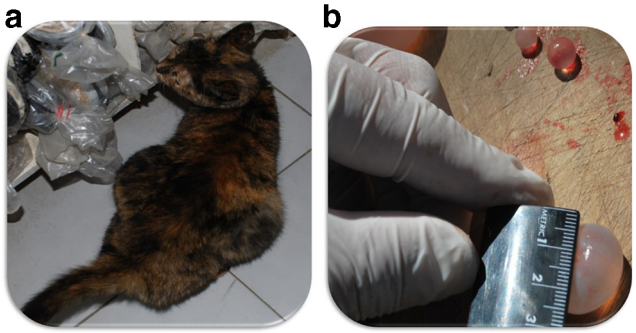

Fig. 1 Cystic echinococcosis in *Felis catus*. a Female cat with distended abdomen caused by cystic echinococcosis. b Approximately 1000 vesicles, between 0.5 and 5 cm, were removed from the abdominal cavity

Arecoline purgation

The arecoline purgation test was performed to ten dogs that co-inhabited with case 1. Three dogs were positive for *Taenia hydatigena*, but *Echinococcus* sp. adult worms were not recovered from any of the dogs. Unfortunately, stray dogs associated with case 2 could not be studied.

Optic microscopy

Extracted vesicles were examined under optical microscopy at × 100 and × 400 magnification. *Echinococcus* sp. determination was performed by morphological characteristics, evaginated and invaginated protoscoleces, with and without rostellar hooks, and calcareous corpuscles were observed. Viability was evaluated using methylene blue; 10% viability was observed (Fig. 2a).

Genotype determination

The extracted vesicles were conserved in 70% ethanol; DNA was obtained by alkaline hydrolyses of protoscoleces from vesicles (Nakao et al. 2003). The *E. granulosus* s. l. genotype/species determination was performed by amplification and sequencing of mitochondrial *cox*1 gene fragment (Avila et al. 2017). Sequences were aligned with reference genotype sequences using the BioEdit® software. Genotype/species determination was performed by the method of maximum likelihood using MEGA6® software. Distance matrices were constructed and the obtained tree was evaluated by the bootstrap on 500 replicates. The values of the nodes correspond to data obtained in over 50% of the replicates. All samples were identified as *E. granulosus* s. s./G1 genotype (Fig. 2b). Additionally, amplification and sequencing of genes involved in immunological response and metabolic pathways, AgB2 gene (Maglioco et al. 2019), AgB4 gene and HSP90 gene, involved in adaptive response and morphogenesis (Taipale et al. 2010), were performed. In all cases, identity greater than 95% was demonstrated with sequences from GenBank databases (sequence ID: AY569341.1, ID AY357114.1, ID: XM_024499809.1) and the positive control performed with cyst-parasite G1 from Patagonian-ovine.

Discussion

Two cats from the Patagonian region of Argentina were diagnosed with CE, this area is endemic for CE, and active cycle infection has been reported (PANAFTOSA 2020).

Domestic cats are not considered relevant for the transmission cycle; some studies show low susceptibility of felines to be infected (Lizardo-Daudt et al. 1993). However, naturally occurring infections have been documented previously in cats

Table 1 General case description

Case	Age (years)	Weight (g)	Corporal temperature (°C)	Sterilized	Habitat	Extracted vesicles	
						Number	Size (cm)
1	7	4.200	38.4	Yes	Domestic, co-habitat with dogs and cats.	~ 1000	0.5–5
2	4	4.800	38.6	No	Stray	> 1000	0.5–5

(Konyaev et al. 2012; Armua-Fernandez et al. 2014; Bonelli et al. 2018) and *E. granulosus* s. s./G1 has been; so far, the only species/genotype of the *E. granulosus* s. l. was detected as the causative agent. Additionally, we consider that the haplotype variations should be analyzed in future studies. Protoscoleces presented low viability (10%), as was observed by Burgu et al. (2004).

E. granulosus s. s./G1 has been found in sheep, cattle, and humans in the Argentina Patagonian region; this species is the most adaptable to different hosts and it is found worldwide (Cucher et al. 2016; Avila et al. 2017; Debiaggi et al. 2017). However, AgB belongs to a highly polymorphic multigene family (AgB1–AgB5), its genetic variability has been previously described, and the genotype is frequently associated with an intermediate host species. AgB is associated with the Th2 host immune response, and the polymorphism is hypothesized to modify the host-parasite interaction (Haag et al. 2006). In this report, the results showed that AgB2 and AgB4 conserved high genetic identity with *E. granulosus* s. l. G1; and similar identity results were obtained with the HSP90 sequence, another protein thought to be involved in the host-parasite relationship. Despite the fact that dogs related to case 1 were negative for *Echinococcus* sp. adult worm parasite detection by arecoline purgation, we cannot affirm that dogs were really *Echinococcus granulosus* s. l. free, due to low sensitivity of this technique (Craig et al. 2015). Both carnivore domestic mammals, cats and dogs, have differences in their digestive physiology, including bile acid composition (Harper 1998), microbiome, and immunological response (Day 2016). These factors could influence the parasite stage presentation and behavior in felines and, could explain why domestic felines can act as rare intermediary accidental hosts for *E. granulosus* s. l. complex, and rare definitive hosts for *E. multilocularis*. In fact, *Echinococcus* species are differentiated by genetic and biochemistry patterns, pathognomonic among them (Thompson 2017).

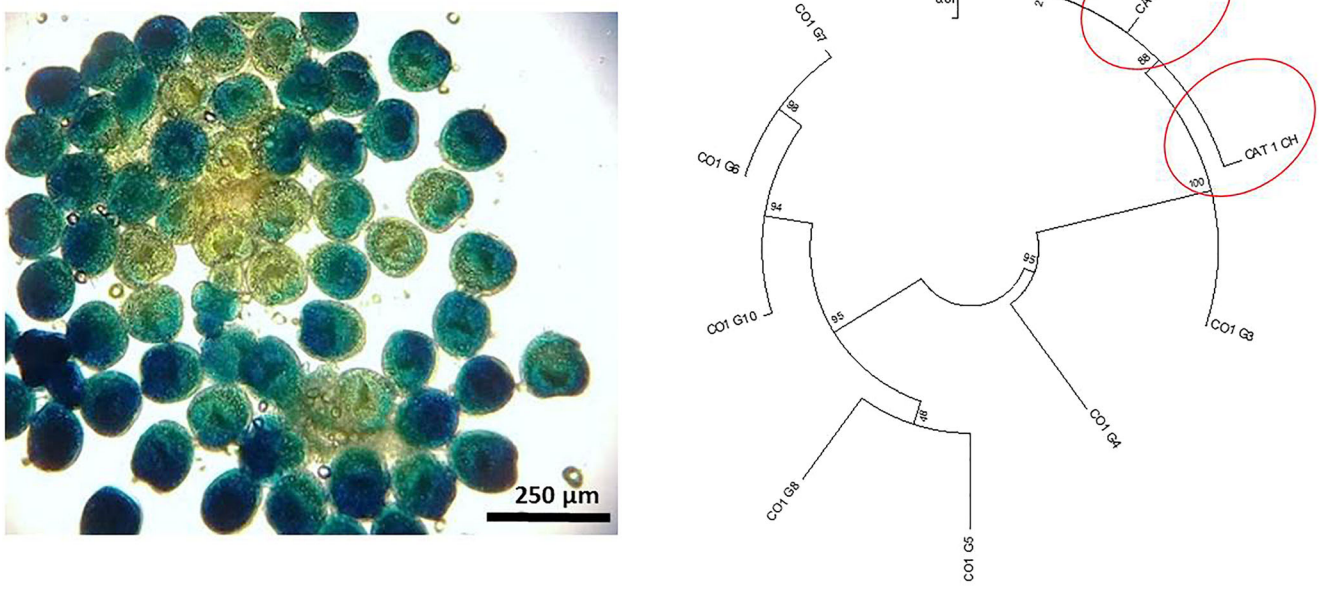

Fig. 2 Microscopic and molecular analysis of vesicles extracted. a Optical microscopy of vesicle contents; viable protoscoleces can be observed after staining with methylene blue. b Maximum likelihood tree of representative isolates (CAT 1, 2) and reference sequences of *Echinococcus granulosus sensu lato* species and genotypes, M84661 (G1), M84663 (G3), M84664 (G4), M84665 (G5), M84666 (G6), M84667 (G7), AB235848 (G8), and AF525457 (G10). Bootstrap values above 50% are shown at nodes

Given the findings from these two cats, we propose the relevance of CE in the differential diagnosis of felines with abdominal distension and/or observation of vesicles through ultrasound, from CE endemic areas. Domestic cats with CE show to be environmentally infected with *E. granulosus* s. s./G1 eggs.

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Authors' contributions HGA: molecular biology analysis, data collection, and writing; AM: molecular biology analysis and writing; MLG: morphologic analysis, arecoline purgations; MPF and FF: veterinary practices, case 1; EK: veterinary practices, case 2; MSBV and FAA: molecular biology analysis; AGF: co-direction, writing and revision of the manuscript; OJ: general direction of the work, revision of the manuscript

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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