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SHORT COMMUNICATION

Urinary bladder worm (*Pearsonema* sp.) infection in domestic dogs and cats in Mexico at a high altitude

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Abstract
Urinary bladder worm infection is relatively uncommon in pet dogs and cats in the Americas. This report describes the diagnosis of lower urinary tract infection by *Pearsonema plica* in two asymptomatic dogs and *P. feliscati* in a cat with lower urinary tract clinical signs diagnosed between 2002 and 2015, and the first report of this type of parasitism in domestic small animals in Mexico at an altitude above 2600 m above sea level. The studied cases demonstrate the need to consider a urinary bladder worm infection in domestic small animals, both stray animals and those with controlled access to the streets. Although a definitive host as foxes does not exist among the urban wildlife in cities of the Americas, stray dogs and cats should be considered as potential reservoir hosts of *Pearsonema*, which requires future epidemiological studies in these populations.

Keywords Urinary bladder worm · *Pearsonema plica* · *Pearsonema feliscati* · Dog · Cat · México

Introduction

Parasitic urinary tract infection is an infrequently reported disease in pet dogs and cats worldwide. *Pearsonema plica* and *P. feliscati* (syn. *Capillaria plica* or *C. feliscati*) are nematode parasites with a worldwide distribution and are universally known as the "urinary bladder worm." They can be found in the urinary bladders of different species of the *Canidae* and *Felidae* families, which are considered their definitive hosts (Basso et al. 2014; Bork-Mimm and Rinder 2011). In the companion animals, generally is considered that dogs can be parasitized by *P. plica*, and the cats by *P. feliscati*.

In Europe, red foxes (*Vulpes vulpes*) are the principal reported definitive host of *P. plica*, with a 23.5 to 93.3% prevalence infection (Basso et al. 2014). In the Americas, the prevalence of *P. plica* infection is 54% in wild foxes and 58 and 64% in raccoons in Canada and the USA, respectively (Butterworth and Berverly-Burton 1981; Cole and Shopp 1987). The high prevalence of *Pearsonema* observed in red foxes in Europe and the colonization of urban areas by them may enhance the infection risk for domestic dogs and cats. Therefore, *Pearsonema* infection should be considered in the differential diagnosis of urinary disorders in dogs and cats in European cities (Knaus et al. 2014; Basso et al. 2014; Mariacher et al. 2016).

The prevalence data on these nematodes in domestic dogs and cats has been scarcely studied. A prevalence of 59 to 76% in dogs was reported by two kennels in the USA (Senior et al. 1980), and studies of cats in Germany found a 1 to 2.7% (Schuster et al. 1997), and in Brazil 3.42% (Ramos et al. 2013). Most of the information about *Pearsonema* urinary bladder infection refers to sporadic clinical cases in several countries of Europe (Callegari et al. 2010; Rossi et al. 2011; Basso et al. 2014; Knaus et al. 2014; Mariacher et al. 2016), and in the Americas, cases have been reported in Canada (Bédard et al. 2002), Brazil (Pagnoncelli et al. 2011), Uruguay (Castro et al. 2009), and Mexico; in the latter, there have been two clinical cases previously reported in a dog and a cat (Ramírez-Díaz et al. 1997; Ventura-Morales et al. 2012). However, we do not know if all countries should be considered as endemic areas due to the unknown prevalence of the parasite.

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Case descriptions and discussion

We studied three clinical cases of lower urinary tract infection by *Pearsonema* in dogs and cats diagnosed between 2002 and 2015 at the Hospital Veterinario para Pequeñas Especies, Veterinary Faculty-Universidad Autónoma del Estado de México, located in Toluca city at 2680 m above sea level (MALS). The local climate is subtropical, with two predominant seasons: cool and dry in autumn–winter and mild and wet in spring–summer.

Case 1 October (autumn) 2002. A female domestic dog approximately 7 years old and weighing 33 kg was referred to the hospital because of a vulvar secretion detected by the new owners, who had adopted it as a stray 2 weeks earlier. During the physical examination, physiological parameters were normal, and only a vulvar secretion of the sanguineous type was observed, without any clinical evidence of lower urinary tract disease. The results of a complete blood count and biochemical profile were within normal parameters. Urine was obtained by cystocentesis, showing a slightly turbid yellow color, specific gravity (SG) 1.028, albumin 2+, blood 1+, and pH 6.5. The urinary sediment showed erythrocytes 20/hpf, 400×; transitional cells 10–11/hpf, 400×; leukocytes 4–5/hpf, 400× and was negative for bacteria and positive for multiple mature *P. plica* eggs (Fig. 1a). Vaginal cytology showed 70 and 30% superficial and parabasal cells, respectively, abundant erythrocytes, and few neutrophils, suggestive of a proestrus phase. The patient was treated with fenbendazole 50 mg/kg BW SID PO for 7 days, and the response was favorable. The patient had access to the street under the control of the owner and in the follow-up, with three serial urinalyses in 6 months, no evidence of reinfection was observed.

Case 2 October (autumn) 2010. A female shorthair domestic cat, approximately 4 months old and weighing 1.1 kg was referred to the hospital because of periuria, pollakiuria, and inability to move the tail, 3 days after being adopted as a stray. Upon physical examination, the patient showed evidence of urine stains in the perineal region, a urinary bladder that was distended but emptied easily with manual compression, localized inflammation and pain on palpation in the dorsal region of the pelvis, and loss of sensitivity and mobility of the tail, without evident lesions of the pelvic limbs and anal sphincter. Laboratory studies showed no changes in the blood count or biochemical profile. Urine obtained by cystocentesis was a yellow color with an SG 1.036, albumin 1+, pH 6, and blood 2+. The urinary sediment contained erythrocytes 2–3/hpf, 400× and leukocytes 0–1/hpf, 400×, without evidence of bacteria, and a UPC 0.4. In the Rx simple study, a fracture of the sacral body was observed with a caudal-dorsal displacement of the caudal fragment of the sacrum and the coccygeal vertebras. A diagnosis of fracture of the sacrum and idiopathic cystitis related to pain was established. Analgesic therapy with meloxicam and buprenorphine was initiated, and caudectomy was performed, starting antibiotic therapy with amoxicillin and continuing analgesic therapy. Three days later, the patient showed no progress and persistent pollakiuria. The urine exhibited the same characteristics as in the initial samples, and a urine culture was negative for the growth of bacteria at 72 h. Serial urinalysis was performed every 3 days. On the 15th day, mature eggs of *P. feliscati* were found (Fig. 1b), and therapy with ivermectin 0.2 mg/kg BW SD SC was administered, resolving the pollakiuria in 24 h. The patient was discharged 2 days later, the owners kept it inside, and on follow-up with three serial urinalyses in 6 months, there was no evidence of reinfection.

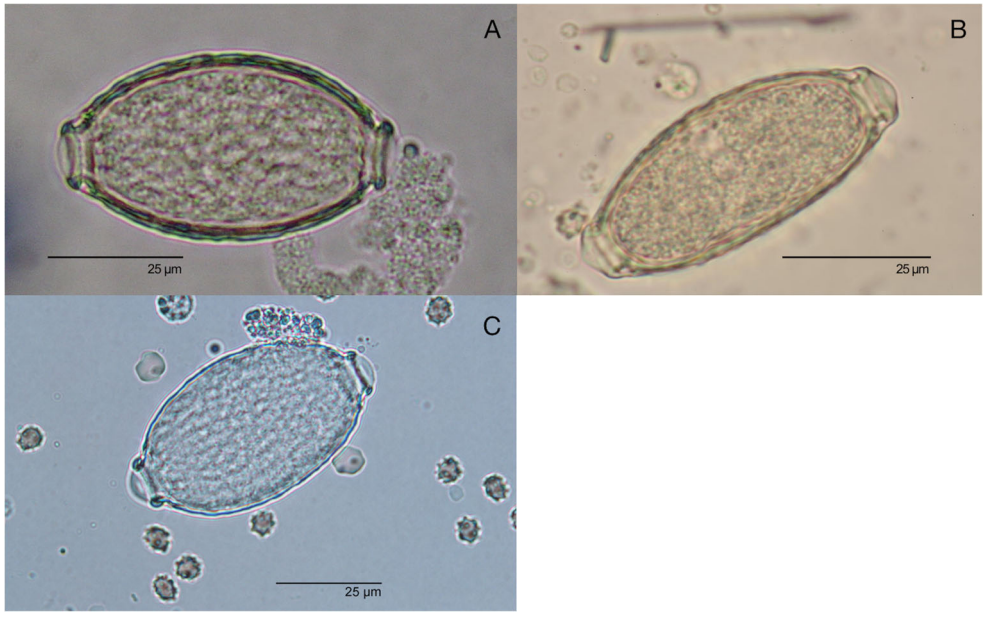

Fig. 1 *Pearsonema* eggs. **a** Characteristic mature *P. plica* egg from clinical case 1. **b** Mature *P. feliscati* egg from clinical case 2. **c** Immature *P. plica* egg clinical case 3, note the very thin shell and rudimentary bipolar plugs

Case 3 July (summer) 2015. A female crossbreed domestic dog, 8 years old and with a weight of 3.5 kg, was referred to the hospital due to small nodules of the mammary gland. On physical examination, nodules on different nipples of both mammary glands were detected, without evidence of other clinical problems. In the cytology by fine-needle aspiration, a diagnosis of mammary adenocarcinoma was obtained. The patient was scheduled for mastectomy and elective ovariohysterectomy by conventional laparotomy. Pre-surgical studies showed no changes in the blood count and biochemical profile, with coagulation times in the normal ranges. Urine obtained by cystocentesis was light yellow, SG 1.020, blood 1+, pH 6, and negative for albumin; the urinary sediment contained erythrocytes 8–10 /hpf, 400×, a single *P. plica* egg that showed a very thin shell and rudimentary bipolar plugs, suggesting that it was in the process of maturation (Fig. 1c), and a UPC 0.2. With these findings and only for the opportunity to gain experience with this pathology, with the owners' authorization, we performed a cystoscopy to observe the parasites in the urinary bladder using the opportunity of anesthetic management for the surgical procedures that were performed. Due to the size of the patient, an antegrade cystoscopy was performed, allowing us to observe multiple worms with different levels of activity: in an extended position or contracted in a spiral, some loose floating in the urine, and others with a part of the body inserts below to the mucosa of the urinary bladder. We obtained endoscopically some parasite specimens for evaluation, but it was not possible to see the parasite eggs (Fig. 2 and Video attached). The wall wound of the urinary bladder was closed by two simple stitches of monofilament absorbable material, and the procedures of ovariohysterectomy and mastectomy were performed in a conventional manner. Post-surgical management was performed with antibiotic and analgesic therapy, in addition to fenbendazole 50 mg/kg BW PO SID for 7 days. The patient was discharged 3 days later and at its follow-up at 30 days' post-surgery had recovered well, with no evidence of a medical problem remaining. The histopathological diagnosis of mammary tumors was of a mammary adenocarcinoma. At follow-up with four serial urinalyses in 6 months, there was no evidence of reinfection.

Pearsonema plica and *P. feliscati* are nematodes (*Trichurida*, *Capillaridae*), fine whitish filamentous worms, the adult's males measure 13–30 mm and the females 30–60 mm in length in case of *P. plica* (Basso et al. 2014; Studzinska et al. 2015), and 13–32 mm the *P. feliscati* (Bowman et al. 2002). The characteristic mature eggs of *P. plica* are barrel-shaped, with slightly pitted shells and two opercules with bipolar plugs, 63–68 × 24–27 μm in length. The almost colorless contents are granular and unsegmented and typically contain one cell. *P. feliscati* eggs are 51–65 × 24–32 μm in length and similar, but their surface does not appear to have pits as large as those of *P. plica* (Bowman et al. 2002)

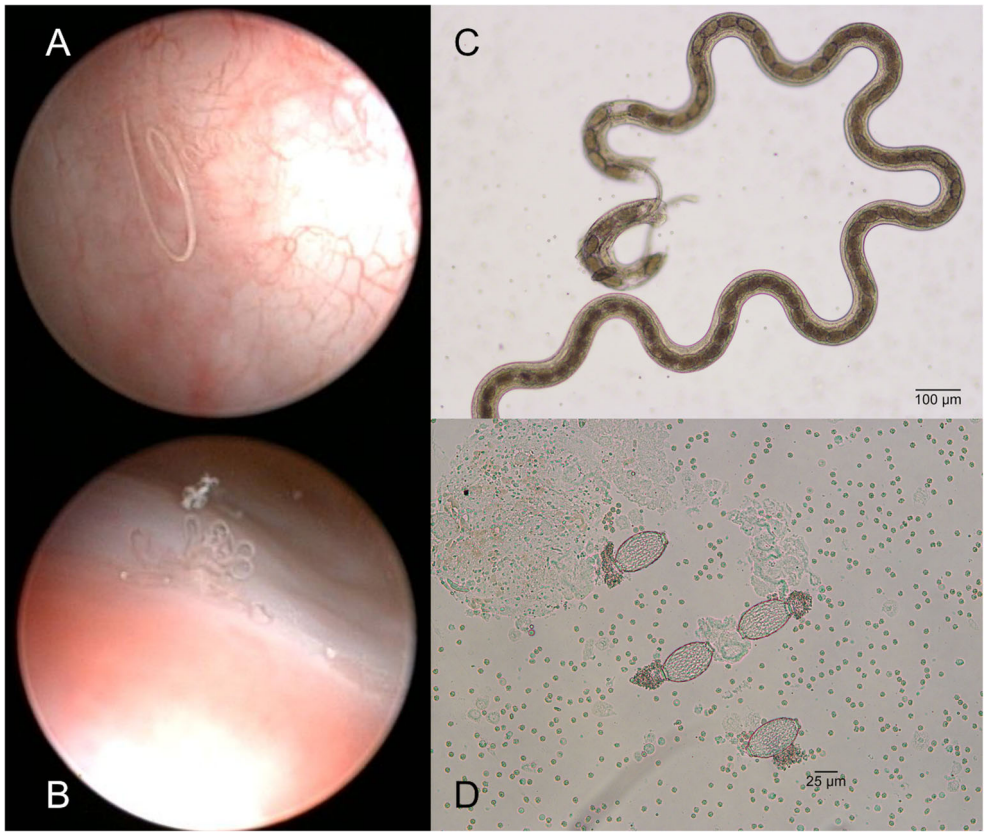

Fig. 2 *Pearsonema plica* worms and eggs found in a dog. **a** Endoscopic image of an adult worm with a part of the body inserted below the mucosa of the urinary bladder. Note the increased vascularization of the urinary bladder wall due to the inflammatory process. **b** Endoscopic image of an adult worm contracted in a spiral, this specimen was not inserted in the mucosa. (Images **a** and **b**, and video attached obtained with HOPKINS® telescope 30°, diameter 2.7 mm with protection sheath of 3.5 mm, and Telecam SL II, Karl Storz-Endoscopy, Germany.) **c** Stereoscopic microscope image, detail of a segment of a gravid female. Notice the presence of eggs along the body. **d** *P. plica* eggs with immature characteristics. (The specimens in images **c** and **d** were obtained by aspiration during an antegrade cystoscopy procedure, and images obtained with Eclipse 80i light microscope with DS-Ri2 digital camera, Nikon, Japan)

(Fig. 1a, b). In both species, immature eggs are smaller, lack a shell, and show rudimentary bipolar plugs (Basso et al. 2014; Mariacher et al. 2016), like that found in case 3 (Fig. 1c). The presence of immature *Pearsonema* eggs may be due to a low parasite load or may be more likely when the number of eggs in the urinary sediment is low (Mariacher et al. 2016).

Based on some descriptions, *P. plica* has an indirect life cycle (Senior et al. 1980; Fernández-Aguilar et al. 2010; Studzinska et al. 2015). The eggs are expelled out of the urinary bladder with the urine from the reservoir host and are ingested by earthworms (annelids) as intermediate hosts. In the intestine of the earthworm, the eggs hatch and the first-stage larvae (L1) that develop in approximately 1 month move through the intestinal wall to encyst in the adjacent connective tissue. Once the earthworm is eaten by the definitive host, the L1 molts to the second stage within the wall of the small intestine around 2 months. Third-stage larvae are found in the urinary bladder and rarely in the ureters and renal pelvis, and it is assumed that they migrate through the blood vessels or lymph bloodstream. Development to the fourth-stage larvae and adult worm takes place within the bladder, and the prepatent period is around 2 months.

For cats, the specific association of *P. feliscati* with an intermediary has not been completely accepted, because earthworms are only very rarely eaten by cats. It has been suggested that common prey species of cats that do feed on earthworms, such as birds, may play an important role as paratenic hosts in the epidemiology *P. feliscati* infection (Bowman et al. 2002; Bédard et al. 2002).

Clinical cases 1 and 2 were stray animals that were most likely exposed to contaminated settings; however, in our city, there are no wild animals considered as definitive hosts. Clinical case 3 lived exclusively indoors and was only walked outside on a lead by its owners. This finding suggests that contact with infected intermediate hosts can easily occur, even in urban environments. Therefore, *Pearsonema* sp. infection should always be included in the differential diagnosis of lower urinary tract disease, even when the dog does not live outdoors (Mariacher et al. 2016).

Regarding the season, two of the cases were attended in autumn and one in the summer, but due to the low number of cases, it is not possible to consider a higher incidence in the cold and dry season. In a series of six cases in dogs from Italy, five presented in autumn and winter (Mariacher et al. 2016).

In foxes, this parasitic infection has been reported at altitudes ranging between 300 and 1300 MASL (Wolf and Bucklar 1995). In Mexico, two clinical cases were reported, a dog in Mexico City (embedded in an oceanic subtropical highland climate) at 2250 MASL (Ramírez-Díaz et al. 1997) and a cat in Villahermosa-Tabasco city (a tropical monsoon climate) at 20 MASL (Ventura-Morales et al. 2012). Our study is the first report of this type of parasitism in dogs and cats at a high altitude above 2600 MASL.

Infection with *Pearsonema* usually remains asymptomatic, probably because of the superficial attachment of the worms to the epithelium of the urinary bladder. However, the parasites may occasionally invade the mucosa and the animals can also present inflammation of the urinary bladder as well as edema and hyperplasia of the mucosal membranes of the urinary tract leading to pollakiuria and hematuria (Basso et al. 2014; Callegari et al. 2010; Rossi et al. 2011). Subsequently, severe inflammation of the urinary bladder and pyelonephritis due to secondary bacterial urinary tract infection may occur (Bork-Mimm and Rinder 2011). Recently, *P. plica* infection has also been suggested to be a contributing factor to glomerular amyloidosis in a dog (Callegari et al. 2010).

The clinical manifestations of lower urinary tract disease are uncharacteristic of a specific disease; for this reason, it is necessary to rule out the most common lower urinary tract pathologies in dogs and cats. Once other possible pathologies have been discarded, one should suspect *P. plica* infection in those cases in which urinalysis reveals mild proteinuria, and the urinary sediment contains microscopic hematuria and numerous clumps of epithelial cells (Bédard et al. 2002). The definitive diagnosis is the finding of *Pearsonema* eggs in the urinary sediment. Nevertheless, not finding the parasite eggs is not definitive proof that the dog or cat is not infected. However, the sensitivity of this diagnostic test is low because the excretion of eggs by adult parasites varies considerably from day to day. Hence, serial studies should be performed to improve the probability of diagnosis (Bork-Mimm and Rinder 2011), as occurred in case 2, in which eight serial urinalyses were necessary to find the parasite eggs. In cases 1 and 3, the detection of eggs in the sediment was considered an incidental finding in the absence of clinical signs of lower urinary tract infection, which, in these cases, may be due to a low number of adult parasites in the urinary tract or to their only very superficial attachment to the bladder mucosa (Mariacher et al. 2016). It is important to consider the hair contamination with eggs of other intestinal or respiratory *Trichuroides*, which could be confused with *Pearsonema* eggs; so, it is advisable the use of antiseptic procedures for obtaining urine by cystocentesis again. In our experience with these three cases studied, new urine samples were obtained and it was possible to find the parasite's eggs repeatedly. Recently, FLOTAC and Mini-FLOTAC were found to be more sensitive than the classic sedimentation technique in detecting *Pearsonema* eggs in urine (Maurelli et al. 2014). Other types of minimally invasive diagnostic techniques, such as cystoscopy, can be considered to confirm the presence of parasites inside the urinary bladder (Basso et al. 2014), as was possible in clinical case 3 (Fig. 2a, b).

Although they are not treatments of choice, individual reports in dogs and cats have mentioned fenbendazole, albendazole, levamisole, and ivermectin (Senior et al. 1980; Bédard et al. 2002; Rossi et al. 2011; Ventura-Morales et al. 2012; Basso et al. 2014; Mariacher et al. 2016), and, specifically in cats, a topical treatment with a combination of fipronil, (S)-methoprene, eprinomectine, and praziquantel (Knaus et al. 2014). It has been suggested that urinary parasitosis can be

self-limiting, and the isolation of dogs and cats from earthworms should be enough to eliminate an infection in less than 90 days (Senior et al. 1980). The three clinical cases discussed here were treated and responded favorably to medical management with fenbendazole in asymptomatic dogs, and ivermectin in the cat with clinical signs; in all cases, the patients had no further contact with earthworms, and none presented reinfection during the follow-up period.

The low incidence of cystitis caused by *Pearsonema* in Mexico may be due to four different factors. First, the manifestation of clinical lower urinary tract disease by bladder worm infection is uncommon; second, as a characteristic of its biological cycle, the wild reservoir hosts of *Pearsonema* as foxes, coyotes, wolves, or raccoons do not exist in Mexican cities; on this basis, it is possible that dogs and cats from kennels or shelters are the reservoir hosts because they are in an indoor environment where infection by *Pearsonema* is possible to be easily maintained and spread; third, the common practice of prophylactic deworming for cestodes and trematodes in small animals pets may lower the rate of infection; and fourth, the absence of an exhaustive diagnostic process from serial urinalysis and the use of other minimally invasive techniques, such as cystoscopy, may decrease the diagnosis rate.

These three cases presented herein demonstrate the need to consider bladder worm infection in domestic small animals, both in stray animals and those with controlled access to the streets, and consider stray dogs and cats as potential reservoir hosts of *P. plica* or *P. feliscati*, which is required for future epidemiological studies in these populations.

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Compliance with ethical standards

The authors declare that the research complies with the current Mexican laws.

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

Author agreement/declaration All authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, has not received prior publication, and is not under consideration for publication elsewhere.

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