Journal of Parasitology 2021 107(2) 358–363

Published 28 April 2021

Contents and archives available through www.bioone.org or www.jstor.org

Journal of Parasitology

journal homepage: www.journalofparasitology.org

DOI: 10.1645/20-127

GIANT RED KIDNEY WORM (*DIOCTOPHYMA RENALE*) SCREENING AND TREATMENT PROTOCOL AND ABERRANT WORM MIGRATION IN DOGS FROM ONTARIO AND MANITOBA, CANADA

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KEY WORDS

Giant red kidney worm
Dogs
Dioctophyma renale
Northern Ontario
Northern Manitoba

ABSTRACT

The life cycle of *Dioctophyma renale* involves an intermediate host (oligochaete), a paratenic hosts (fish and frogs), and a definitive host (mustelids and canids). Dogs are at risk of infection with *D. renale* when they consume paratenic hosts infected with the larval form of *D. renale*. Water containing the oligochaete intermediate host cannot be disregarded as another source of infection. Infections occur mainly in the right kidney, but worms have also been found in the abdominal cavity as well as other organs. Most dogs appear asymptomatic and infections are usually noted as incidental findings on necropsy. Recently, the Ontario Society for the Prevention of Cruelty to Animals (SPCA) and Humane Society conducted transports of dogs located in northern remote communities. In 2016, some female dogs were found to be infected with *D. renale* upon ovariohysterectomy. In response to this discovery, we developed a screening protocol to screen for *D. renale* infections. In 2018, a total of 130 intact dogs were transferred from 2 northern communities in the provinces of Ontario and Manitoba. A prevalence of 7.94% (95% confidence interval 3.87–14.11%) was found from dogs from the northern communities. The screening protocol we developed provides a method of screening for dogs that are transported from communities that could be at risk of infection with *D. renale*.

Dioctophyma renale is one of the longest nematodes to infect mammals. Both males and females have a blood-red appearance and grow up to lengths of 35 and 100 cm, respectively (Woodhead, 1950; Paras et al., 2018). In North America, mustelids have been considered the definitive host and shed eggs in their urine intermittently (Woodhead, 1950). The eggs contaminate water sources, where they infect aquatic oligochaetes, the intermediate host (Woodhead, 1950). The eggs hatch and the larvae develop to the third stage (Woodhead, 1950). The third-stage larvae also can survive in the muscles of paratenic hosts such as fish and frogs, and the life cycle is completed once the larvae are ingested by the definitive host (Measures and Anderson, 1985; Centers for Disease Control and Prevention [CDC], 2020).

Dogs have also been shown to be a definitive host for *D. renale* (Paras et al., 2018). Infections of *D. renale* mainly occur in the right kidney of these hosts, but they can be asymptomatic depending on the size of *D. renale* impacting the function of the kidney (Kommers et al., 1999; Nakagawa et al., 2007). However, ectopic migrations (outside of the kidney) have been identified in dogs with the majority located in the abdominal cavity and rarely in the scrotum and testicles (Camargo et al., 2013; Paras et al., 2018). Ectopic migrations can cause pain, swelling, and distension (Paras et al., 2018). Historically, limited canine cases of *D. renale* infections have been recorded in northern Canada (McLeod, 1966; Unruh et al., 1973; Whelen et al., 2011; Schurer et al., 2014).

In many northern communities of Canada, veterinary services are restricted or not present and disease surveillance is rare (Salb et al., 2008; Schurer et al., 2015). Thus, decreased veterinary services in northern communities can limit animal welfare resources and information on the presence and distribution of parasites, specifically *D. renale* in northern Ontario and Manitoba. Animal transport is used to accommodate communities where veterinary services are limited and to support the communities, at their request, with rehoming dogs.

In 2016, The Ontario SPCA and Humane Society conducted transport operations to bring dogs from northern communities into southern Ontario for adoption. Before adoption, dogs were examined and ovariohysterectomy or orchidectomy would be performed. Unexpectedly, during several ovariohysterectomies, *D. renale* was found to be free floating in the abdomen and removed.

In this article we present a screening protocol we developed, in response to these incidental observations, to screen dogs for *D. renale* from communities located in northern Ontario and Manitoba. We also present the prevalence of *D. renale* infections based on the screening results.

MATERIALS AND METHODS

Dogs were transported in 2018 from 2 northern regions consisting of several communities located in Manitoba and Ontario (Fig. 1). Region 1 is located in northwestern Ontario just east of Manitoba, surrounded by inland lakes. Region 2 is located on the eastern shore of Lake Winnipeg in Manitoba. The climate of both regions is cold and temperate, with large rainfall throughout the year with the maximum and minimum temperature reaching 17.8 and –20.0 C, respectively (Government of Canada, 2020).

Figure 2 illustrates the screening protocol developed and utilized. Urine samples were submitted to Antech Diagnostic Labs, Canada and IDEXX Laboratories of Canada for sediment analysis of *D. renale* eggs (Fig. 3). A blood sample was collected from potential nephrectomy candidates and submitted for blood cell counts and a biochemical profile to help determine whether the dog could survive with 1 functioning kidney. If screening results did not indicate *D. renale* presence or related damage, the dog would receive moxidectin (Advantage Multi®; 2.5 mg/kg monthly; Bayer Animal Health, Mississauga, Ontario, Canada), prophylactically to treat ascarid infections based on its known efficacy against ascarids.

Prevalence and exact 95% confidence interval calculations were completed using STATA/SE 15.1 (Stata Corp, College Station, Texas).

RESULTS

A total of 130 dogs were transported from the 2 northern communities described. All the dogs were intact.

Urine samples from 126 dogs were collected and examined for *D. renale* eggs. Four urine samples were not collected because the dogs were adopted before the screening process was conducted. Of the 126 urine samples, 6 samples demonstrated the presence of *D. renale* eggs. Two of these urine samples originated from dogs located in Region 1 and 4 originated from dogs in Region 2. Upon negative urinalysis results, 56 ultrasound examinations were performed on individual dogs and 2 ultrasound examinations showed evidence of *D. renale* in the right kidney (Fig. 4). These 2 ultrasound examinations represent 1 dog from each of Regions 1 and 2. Blood samples were submitted for all 8 dogs to evaluate renal function. All 8 samples demonstrated adequate function, and a nephrectomy procedure was performed on all 8 dogs. During surgery, observations ranged from inflamed omenta to extensive adhesions between the renal capsule, the vena cave, and the body wall. All nephrectomies were successful.

Finally, 2 additional positive cases were found: 1 dog had no evidence of either an egg on urinalysis or giant kidney worm on ultrasound, but *D. renale* was discovered during a routine orchidectomy. *Dioctophyma renale* were noted in the abdomen of another dog during necropsy. A urine sample was drawn from the bladder and submitted; no kidney worm eggs were found.

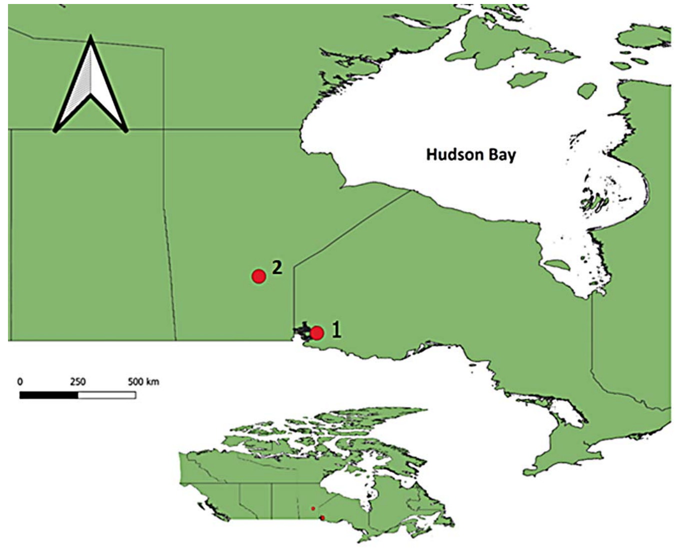

Figure 1. The 2 locations of 126 dogs that were screened using the screening protocol for *Dioctophyma renale* infections. Created in QGIS 2020. Color version available online.

The prevalence and 95% confidence interval (CI) of *D. renale* in this dog population was found to be 7.94% (95% CI 3.87–14.11%).

DISCUSSION

We developed the screening protocol for detecting *D. renale* because we encountered several dogs in prior transfers that were infected with *D. renale* but were asymptomatic. In this screening protocol, only dogs 6 mo of age or older are included in the screening process because of the long prepatent period of 4–5 mo (Companion Animal Parasite Council [CAPC], 2020). Urine samples are collected and submitted for urine sediment analysis for the presence of *D. renale* eggs. Ultrasound examination is performed on dogs whose urinalyses do not reveal the presence of *D. renale* eggs to diagnose any infection that might be missed because of intermittent shedding, presence of 1 sex or 1 worm only, or the absence of worms in the kidney but located elsewhere due to aberrant migration. Upon completion of screening these populations, we found that the ultrasound examination can detect evidence of prior infections where the renal parenchyma has been obliterated and the worms are long dead and fragmented or absent. Moxidectin (Advantage Multi®; 2.5 mg/kg monthly) was used in the treatment protocol based on its known efficacy against ascarids, including *Toxocara canis*; however, future research on its efficacy against *D. renale* is warranted. All dogs were asymptomatic except for a single dog that exhibited hematuria. Migration to the urinary system can result in no clinical signs if the unaffected kidney can compensate (Paras et al., 2018).

Of the 126 urine samples submitted, 6 samples demonstrated the presence of *D. renale* eggs. Two of these samples were collected from dogs that originated from Region 1, near Kenora. A previous report also documented that *D. renale* was found in a young mixed breed dog from a local community near Kenora, Ontario. This dog had a history of eating raw fish and frogs (Whelen et al., 2011). Dogs who have inadequate food have been

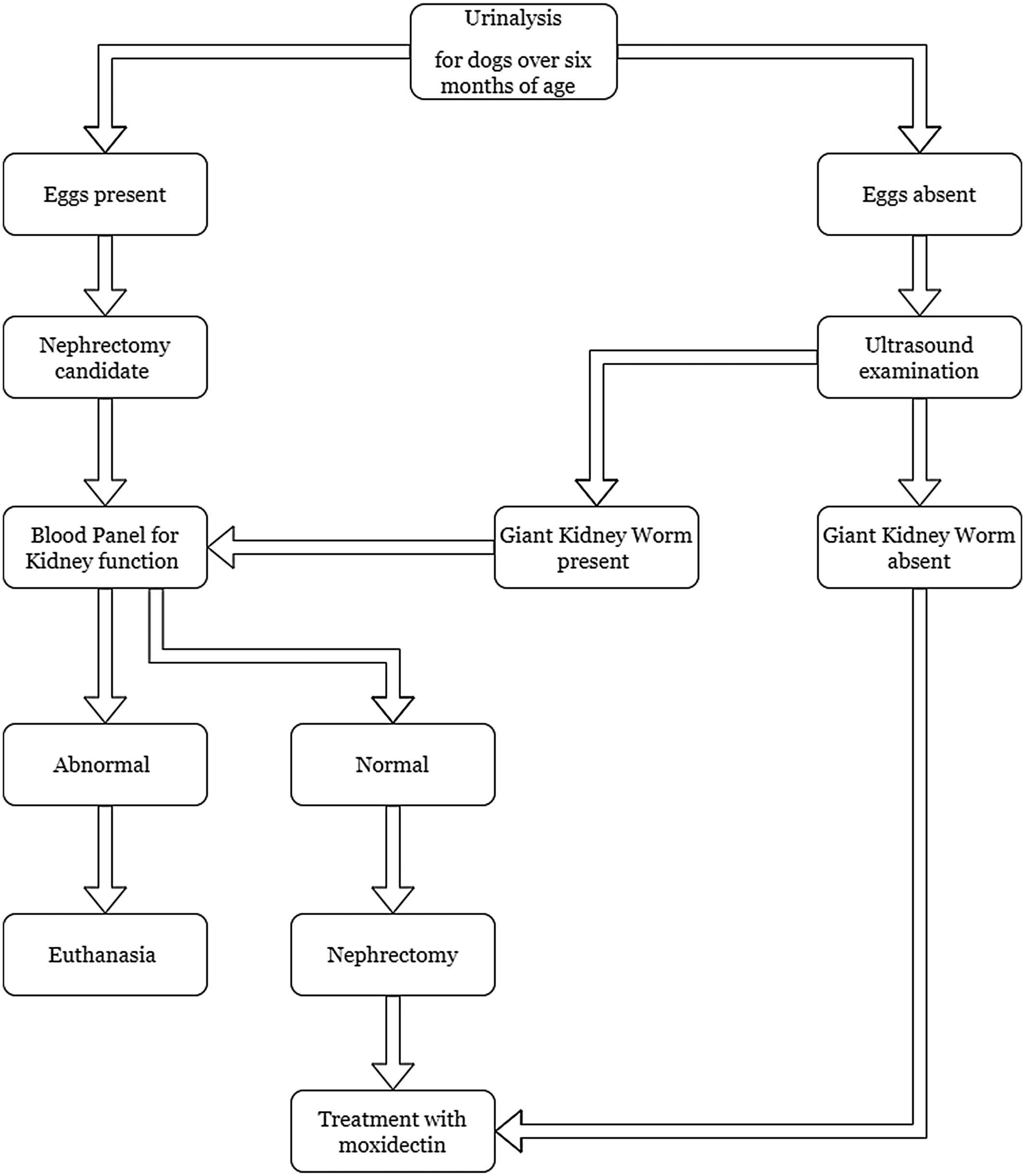

Figure 2. A screening protocol for the screening, diagnosing, and treating of dogs over 6 mo of age infected with *Dioctophyma renale* that originated in communities located in northern Canada in 2018.

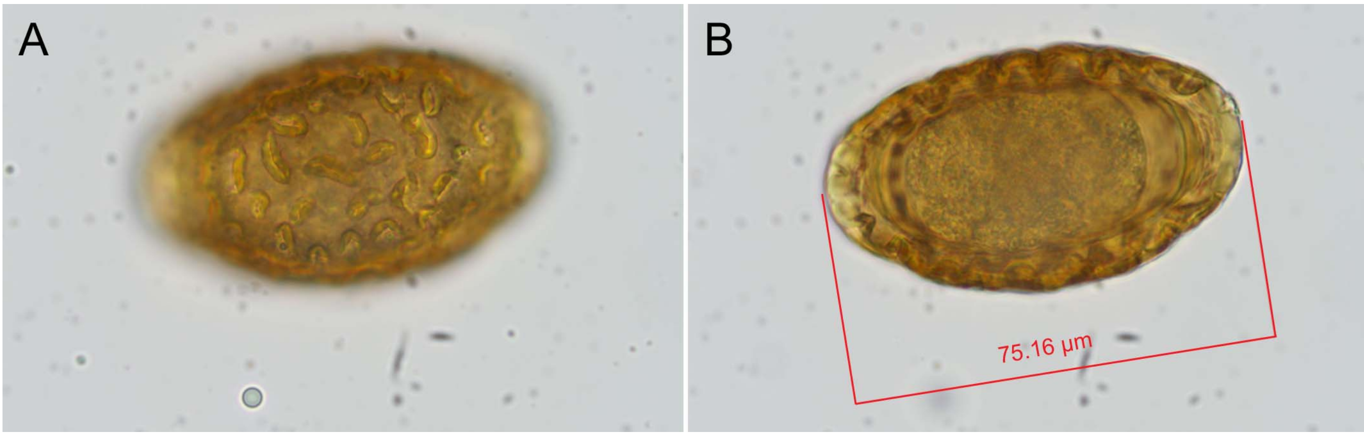

Figure 3. *Dioctophyma renale* egg under a light microscope. Color version available online.

shown to hunt small mammals or scavenge for resources (Butler and Toit, 2002; Krauze-Gryz and Gryz, 2014). However, the food consumption histories of the 2 dogs from Region 1 and the dogs from Region 2 were not recorded.

Because the oligochaete intermediate host is found in water, consumption of water containing infected oligochaetes could be another source of infection for dogs in these communities (Radman et al., 2017).

Of the 2 dogs that had evidence of *D. renale* presence on ultrasound examination, 1 dog had extensive damage to the right renal parenchyma with what was described in the ultrasound report as sludge and worm segments. The other dog had only 1 worm present in the right kidney. Both ultrasound results explain why the urinalyses were negative for *D. renale* eggs and justify the inclusion of the ultrasound step in our screening protocol.

Two additional dogs infected with *D. renale* were negative for kidney worm eggs on urinalysis. The first dog had a subsequent ultrasound examination that did not demonstrate evidence of *D. renale*. The presence of *D. renale* was discovered during a routine orchidectomy, where an adult female worm was found wrapped around the right testicle (Fig. 5).

The second dog did not have an ultrasound examination as she was still nursing puppies and demonstrating aggressive behavior. She was noted to have marked hematuria. She was euthanized because of behavioral decline. The necropsy revealed an inflamed omentum and a single male worm that was found in the abdomen, which is a common location for aberrant migration; the aberrant migration of these very large worms can cause peritonitis and perihepatitis (Uzal et al., 2016) as well as other pathologies previously described.

In South America, incidental findings of *D. renale* have occurred through routine surgical procedures such as ovariohysterectomy and orchidectomy (Pereira et al., 2006; Hernández-Russo et al., 2014). The dogs in this study were all intact. Theoretically, if ultrasound was not available, a diagnostic step to replace the ultrasound examination could be to create a larger ovariohysterectomy incision to visualize the abdominal cavity and both kidneys and bladder in the female, or to perform a laparotomy during orchidectomy in the males.

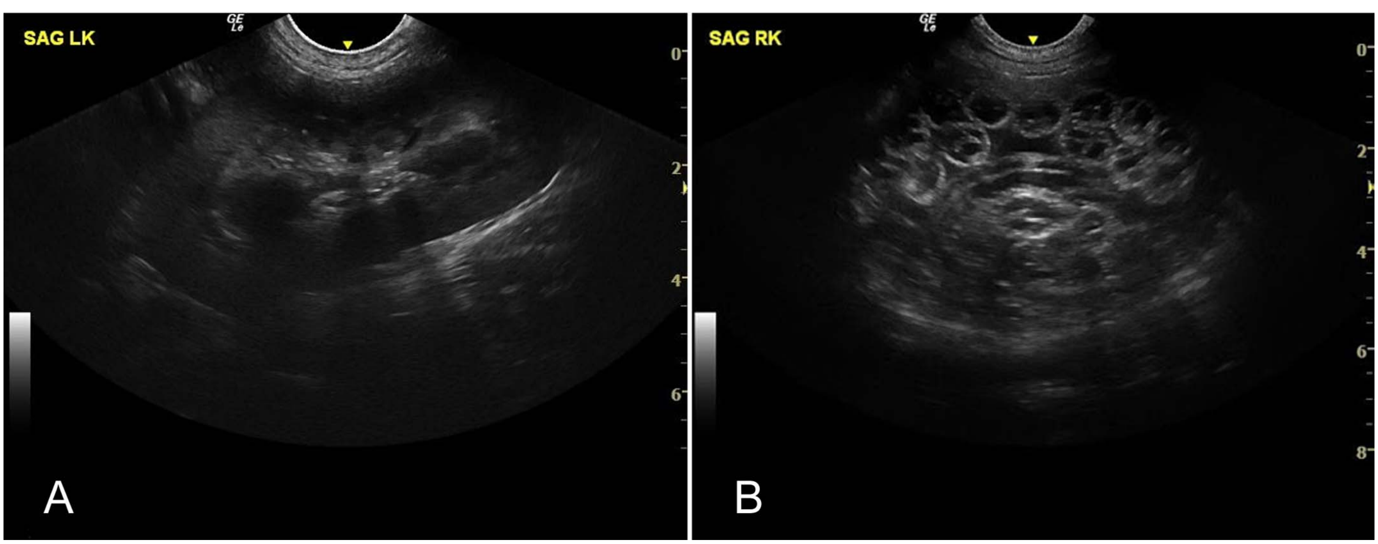

Figure 4. (**A**) Sagittal image of the normal left canine kidney and (**B**) sagittal image of the right canine kidney with multiple circular structures within the kidney are cross sections of giant kidney worms. Color version available online.

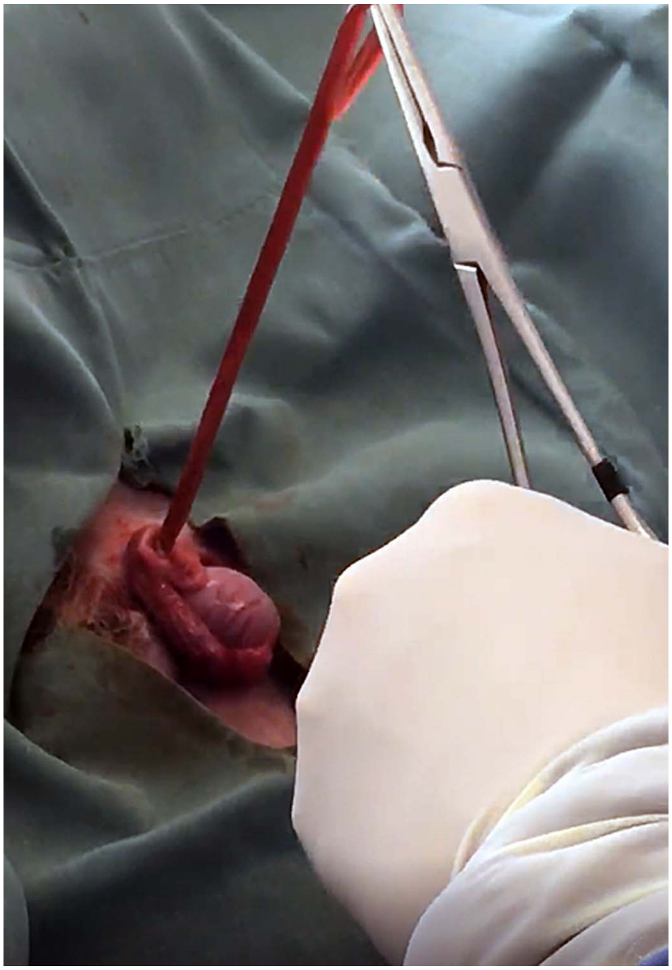

Figure 5. An incidental finding of *Dioctophyma renale* located around the testicle of a dog whose origin was from a northern community. Color version available online.

All dogs received moxidectin (Advantage Multi®; 2.5 mg/kg monthly). Dogs with no evidence of *D. renale* at the end of the diagnostic process were given moxidectin (Advantage Multi®; 2.5 mg/kg monthly) prophylactically. Dogs that underwent nephrectomies received moxidectin (Advantage Multi®; 2.5 mg/kg monthly) postoperatively.

The prevalence of *D. renale* was 7.94% (95% CI 3.87–14.11%) in this dog population. To date, most papers relating to *D. renale* have been case studies from South America and only 1 prevalence study and 2 retrospective necropsy studies at a population level have been published to our knowledge (Kommers et al., 1999; Pedrassani et al., 2017; Rapperti et al., 2017). A prevalence of 14.2% (95% CI 9.66–19.88%) was found in 197 healthy dogs in Brazil (Rapperti et al., 2017). The difference in infection for the dogs in Brazil could be attributed to access to a local river that contained the paratenic hosts (Rapperti et al., 2017).

Although the study presented here is based on a relatively small population of dogs, it nonetheless documents the presence of *D. renale* infections in dogs from Manitoba and Ontario and proposes a screening tool to assist in the diagnosis of *D. renale* infections.

ACKNOWLEDGMENTS

The authors would like to thank all of the communities of origin, Dr. Jennifer Budarick, Dr. Julia Hughes, Kate MacDonald, and Monica Seto for their invaluable contributions to the project. Finally thank you to Registered Diagnostic Medical Sonographer, Lisa Jones Bogie, for providing the ultrasound images. The authors assert all applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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