

Treatment of *E. boehmi* Infection in a Mixed-Breed Dog Using Milbemycin Oxime

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ABSTRACT

Numerous bipolar plugged capillarid eggs were detected on a routine centrifugal fecal flotation examination of a 2 yr old castrated male boxer-Chinese shar pei mixed-breed. The eggs were identified as *Eucoleus boehmi* (*E. boehmi*), the nasal capillarid, based on size and shell wall surface morphology. The dog had a history of chronic sneezing (> 5 times/day) and intermittent postexercise nasal discharge. Currently, there are no anthelmintics approved for use in dogs for the treatment of *E. boehmi*. Treatment of the dog with 0.5–1 mg/kg milbemycin oxime was ineffective, but treatment with 2 mg/kg milbemycin oxime resulted in negative fecal examinations 7–28 days and 5 mo posttreatment. The dog's postexercise nasal discharge greatly lessened, and the sneezing behavior improved (it was only noted 2–3 times/wk), but neither the discharge nor sneezing completely resolved following the anthelmintic treatments. Use of milbemycin oxime at an increased dose (2 mg/kg) appeared to be an effective treatment against *E. boehmi* infection in this dog based on clinical response and the cessation of fecal egg shedding. (*J Am Anim Hosp Assoc* 2013; 49:204–209. DOI 10.5326/JAAHA-MS-5832)

Introduction

Eucoleus boehmi (*E. boehmi*), formerly *Capillaria boehmi* is a capillarid found in the nasal passages and sinuses of dogs, red foxes (*Vulpes vulpes*), and wolves (*Canis lupus*).¹ Morphologically, it closely resembles the lungworm *Eucoleus aerophilus* (*E. aerophilus*), formerly *Capillaria aerophila* and has often been misidentified as such, especially in the older literature. Adult worms are long and thin (22–43 mm × 0.08–0.15 mm) and occur embedded in the mucosa of the nasal turbinates, frontal sinuses, and paranasal sinuses.² Diagnoses have been reported in Europe, North America, and South America.¹ Infections are nonfatal, and clinical signs (when present) consist of a chronic nasal discharge and sneezing.³ Gagging and epistaxis have also been reported.^{4,5} Diagnosis can be achieved by detecting the bipolar plugged eggs of *E. boehmi* (54–60 μ × 30–35 μ) by fecal flotation. Specific identification of *E. boehmi* eggs is based on size and subtle morphologic characteristics of the plugs and shell wall surface, the evaluation of which present a significant challenge to the

diagnostician. No anthelmintics have been approved for use in the treatment of dogs infected with *E. boehmi*.⁶ The following report details the diagnosis and treatment of a dog infected with the nasal capillarid, *E. boehmi*.

Case Report

In January 2007, a routine centrifugal fecal flotation examination using saturated sugar (specific gravity = 1.24) as the flotation media was performed on a fecal sample collected from a 2 yr old castrated male boxer-Chinese shar pei mixed-breed. The dog had originally been obtained from a humane society in Amherst, VA 8 mo previously (May 2006). The owner and dog lived in Brookfield, OH from May 2006 to August 2006 then moved to Charlottetown, PEI, Canada. The dog had been administered a monthly heartworm preventative^a containing ivermectin (0.006 mg/kg) and pyrantel pamoate (5 mg/kg) from May 2006 to October 2006. Numerous bipolar plugged eggs, measuring 53.7–58.6 μ × 29.3–31.7 μ (mean, 56.1 μ × 30.7 μ), were detected

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E. aerophilus *Eucoleus aerophilus*; *E. boehmi* *Eucoleus boehmi*; *C. hepaticum* *Calodium hepaticum*; *PO per os*; *T. vulpis* *Trichuris vulpis*

on the fecal examination (**Figure 1**). The eggs had a clear shell wall with a delicately pitted outer surface and contained a multicelled embryo that did not completely occupy the space within the egg. The eggs detected in the fecal sample from this dog were identified as *E. boehmi* based on size and the observed shell wall surface pattern (**Figures 2, 3**).

In view of the diagnosis of nasal capillarid infection, the owner (one of the authors, S.B.) related that the dog had a history of a transient nasal discharge brought on by exercise, and that the dog would sneeze > 5 times/day. The owner had attributed that behavior to breed predisposition due to the brachycephalic conformation. The dog was administered a single dose of milbemycin oxime^b (0.5 mg/kg *per os* [PO]), which was approved for use in dogs at a dose of 0.5 mg/kg for the prevention of heartworm (*Dirofilaria immitis*) and the treatment of various intestinal nematode infections (e.g., *Toxocara canis*, *Ancylostoma* spp., *Trichuris vulpis* [*T. vulpis*]). Posttreatment sugar centrifugal fecal flotation results were negative 7 days later, but egg shedding was detected again at 14 days. The dog was treated with milbemycin oxime at a higher dosage (1 mg/kg PO) with similar results (negative at 7 days and positive at 14 days posttreatment). Subjectively, the number of eggs shed in the feces appeared to be decreasing. The dog was re-treated once again with milbemycin oxime (1 mg/kg PO) with posttreatment sugar centrifugal fecal flotation examinations negative at 7 days and 14 days, but positive again at 21 days. The dog was subsequently treated with 2 mg/kg



FIGURE 1 *Eucoleus boehmi* (*E. boehmi*) egg detected on sugar centrifugal fecal flotation examination (400× magnification). The egg has bipolar plugs and contains a multicelled embryo that does not completely fill the space within the egg shell wall. The bipolar plugs appear clear with no evidence of striations (i.e., “threading”).



FIGURE 2 *E. boehmi* egg showing the finely pitted shell wall surface (high-dry magnification). The various capillarid eggs can be identified based on their unique shell wall surface patterns.

milbemycin oxime PO, and sugar centrifugal fecal flotation examinations were negative at 7 days, 14 days, 21 days, and 28 days posttreatment.

The dog was then relocated to OH from May 2007 to August 2007 before returning to PEI. The dog was again administered a monthly heartworm prevention (as described above) from May 2007 to October 2007. A sugar centrifugal fecal flotation examination performed 5 mo after milbemycin oxime treatment was negative. An evaluation of the dog at that time indicated that the postexertion nasal discharge had lessened significantly and the sneezing behavior had improved (from > 5 times/day to only 2–3 times/wk), but neither condition had completely resolved with the anthelmintic treatments.

Discussion

Nasal eucoleosis in dogs has been reported in various states, including FL, IN, KS, LA, OH, NC, and WI.^{1,4,5,7–10} Information concerning *E. boehmi* infection prevalence in dogs in North America is incomplete, but infection appears to be relatively uncommon. Fecal surveys usually do not differentiate between the various capillarid eggs detected due to the difficulty in making specific identifications. In a large, national fecal examination survey involving 6,458 samples from humane society dogs in the United States, 0.4% of the samples contained capillarid eggs, and *E. boehmi* was cited as the most common capillarid detected.¹¹ Samples positive for *E. boehmi* were detected in all of the geographic regions of the study. A retrospective study of fecal results from 12,515 canine samples submitted to the veterinary

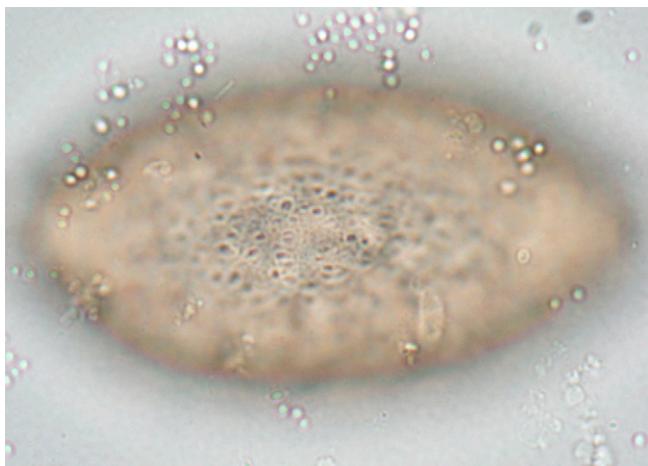


FIGURE 3 *E. boehmi* egg showing the finely pitted shell wall surface (oil-immersion, 1000× magnification). Visualizing the shell wall surface pattern can be facilitated by use of the oil immersion objective in some cases.

teaching hospital at Oklahoma State University from 1981 to 1990 reported a range in annual prevalence of capillarids of 0–5%, and again, *E. boehmi* was the most common capillarid detected.¹² In a fecal survey of greyhounds in KS, 4 (2%) of the 230 tested dogs were infected with *E. boehmi*.¹⁰

At present, the life cycle remains unknown. The capillarids, as a group, contain species with both a direct and indirect life cycle.¹³ Early studies on the life cycle of *E. aerophilus* predated the recognition that *E. boehmi* was a separate species and appeared to have involved mixed infections containing both species, making interpretation of the study results difficult.^{14,15} Further study is required to definitively determine the specifics of the life cycle for *E. boehmi*, but it likely involves earthworms as an intermediate host or possibly a paratenic host.

Diagnosis occurs by detecting eggs in either feces or nasal discharge or via rhinoscopy. Detection sensitivity data for any of the diagnostic tests for *E. boehmi* infection are lacking. Eggs may be detected in fecal samples by either centrifugal or simple flotation.⁶ Sensitivity of centrifugal fecal flotation for the detection of *T. vulpis* eggs is significantly higher than that of simple fecal flotation, and the same is likely the case for capillarid eggs.¹⁶ Egg shedding was reported to be cyclical in greyhounds infected with *E. boehmi*, indicating that collection and examination of multiple fecal samples may improve detection sensitivity.¹⁰ The accurate, specific identification of the various bipolar plugged eggs present in canine feces can be challenging for veterinarians and technicians due to the difficulties in visualizing and evaluating the morphologic characteristics. Other bipolar plugged eggs detected

in canine fecal samples that must be differentiated from those of *E. boehmi* include the whipworm (*T. vulpis*) and the lungworm (*E. aerophilus*) as shown in **Figures 4–6**.^{3,6} Eggs of *E. boehmi* detected in the fecal sample collected from the dog described in this case were differentiated from those of *T. vulpis* based on size and bipolar plug morphology. The eggs of *T. vulpis* are larger (72–90μ × 32–40μ), have a smooth shell wall surface, and striations on the plugs, giving the appearance of being “threaded” into the shell wall (Figure 4).⁶ Plug striations were lacking in the eggs detected in the dog’s fecal sample described herein, indicating that the eggs were capillarid (Figure 1). The eggs of *E. boehmi* detected in this case were differentiated from those of *E. aerophilus* based mainly on shell wall surface pattern. Eggs of each of the capillarids present in canine samples have a unique shell wall surface pattern. Visualization of the surface pattern is best achieved by microscopic examination under the 40× high-dry objective (i.e., 400×). It may also be helpful to use oil immersion (Figure 3); however, because a fecal flotation slide is a wet mount, it may not be possible, depending on the thickness of the fecal debris under the coverslip and the tendency for parasite eggs to roll out of the microscopic field of view due to the pressure of the oil and objective on the coverslip. Examination using the oil immersion objective should only be attempted as a final step in the evaluation of the slide. Application of immersion oil to the coverslip will prevent further examination using the 40× high-dry objective. To view under oil immersion, center the egg in the 40× high-dry microscopic field and lower the microscope stage well below the length of the oil immersion lens. Place a drop of immersion oil on the coverslip, and slowly lower the oil immersion lens until it just



FIGURE 4 *Trichuris vulpis* egg (400× magnification). Note the bipolar plugs have spiral striations giving the appearance that they are “threaded” into the shell wall of the egg.



FIGURE 5 *Eucoleus aerophilus* (*E. aerophilus*) egg (400× magnification). Note the embryo tends to fill the space within the egg.

makes contact with the oil. Then, continue to lower the lens using the fine focus until the egg shell wall surface comes into focus. The finely pitted shell wall surface of *E. boehmi* eggs are in marked contrast to the network of anastomosing ridges seen with *E. aerophilus* eggs (Figure 5). Rarely, eggs of other capillarids, such as either *Calodium hepaticum* (*C. hepaticum*) or *Pearsonema plica*, may also be present in fecal samples of dogs. *C. hepaticum* eggs have a very thick shell wall with a porous surface and are retained in the liver of infected animals (mainly rabbits and rodents). Dogs can pass *C. hepaticum* eggs in the feces only after predation on the infected host. Eggs of the urinary parasite, *Pearsonema plica*, have a coarsely beaded shell wall surface pattern and are only found in fecal samples if accidentally ingested during grooming.^{3,6}

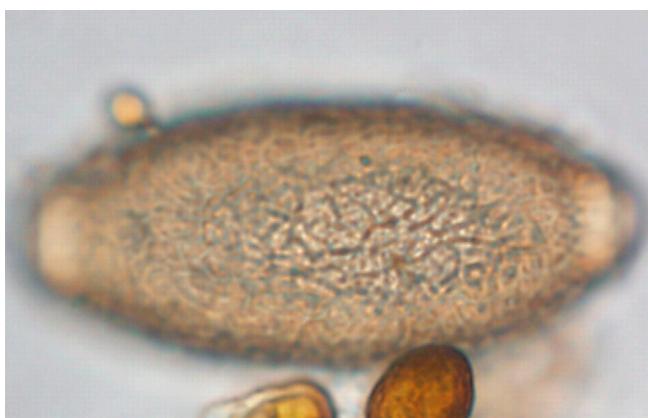


FIGURE 6 *E. aerophilus* egg (400× magnification). In contrast to *E. boehmi*, the shell wall surface of *E. aerophilus* is covered by a network of anastomosing ridges.

Rhinoscopy can be used to collect either biopsy or nasal mucus samples for the detection of worm fragments and eggs.^{4,5,8} In addition, diagnosis of *E. boehmi* infection through rhinoscopy by visualization of adult worms *in situ* was recently reported.⁷ In the dog from this report, rhinoscopy, performed 6 mo after the onset of clinical signs of nasal discharge, failed to detect any worms although the infection was likely present at that time.⁷ The long, thread-like, white worms were detected in the nasal passages on a second rhinoscopy performed 12 mo later. Infections where the entire worm burden was restricted to the sinuses would not be detected by rhinoscopy due to the inaccessibility of those sites for examination. As an inexpensive and noninvasive technique, centrifugal fecal flotation seems to be a logical first step to begin a diagnostic investigation in dogs suffering signs of nasal discharge and sneezing. Rhinoscopy could be performed if need be as a follow-up test if no eggs were detected on fecal examination and to investigate other potential etiologies.

Therapeutic response to treatment with anthelmintics in case reports involving *E. boehmi* infection in dogs has been highly variable. Both treatment successes and failures have been reported with the extralabel use of fenbendazole^c and ivermectin. Treatment with fenbendazole at a dose of 50 mg/kg PO q 24 hr for 10 days resulted in clinical improvement, and a negative posttreatment fecal examination at 30 days in one dog; however, the nasal discharge and fecal egg shedding resumed 4 mo later.⁴ Re-exposure, rather than treatment failure, may have been involved in that case. In another dog, clinical signs initially resolved, but returned 2 wk after treatment with fenbendazole (50 mg/kg PO q 24 hr for 14 days).⁷ The treatment failure was attributed to re-exposure through coprophagia. A second course of the treatment, coupled with heightened sanitation preventing coprophagia, resulted in clinical resolution; however, coprophagia would only lead to re-exposure if *E. boehmi* had a direct life cycle. In addition, *Eucoleus* spp. eggs are passed in the undifferentiated stage and therefore require time to develop to the infective stage once released to the environment in fecal deposits. Estimates of developmental times from the early life cycle studies for *E. aerophilus* eggs (some of which were probably *E. boehmi*) range from 15 days to 22 days at optimal temperatures (24–32°C).^{13–15} Given this time frame, re-infection would not occur following coprophagia of freshly passed fecal matter. A single oral treatment with ivermectin^d (0.2 mg/kg) was reportedly effective in the treatment of a dog infected with *E. boehmi*, resulting in complete resolution of clinical signs and negative posttreatment fecal examinations at 14 days, 28 days, 60 days, 90 days, and 120 days.⁸ In marked contrast, multiple oral treatments of ivermectin at the same or higher dosage

(0.2–0.3 mg/kg) were reportedly ineffective in the treatment of two dogs infected with *E. boehmi*.^{4,9}

Three of the dogs from the above case reports, as well as the boxer-Chinese shar pei crossbreed described in this report, were on monthly ivermectin^e, ivermectin-pyrantel pamoate, or milbemycin oxime heartworm prevention, which appeared to have had no impact as either a treatment or preventative on *E. boehmi* infections.^{4,7,9} Pyrantel pamoate^f treatments were administered 11 times to control an *Ancylostoma caninum* coinfection in one of the dogs, but appeared to have had no effect on *E. boehmi*.⁹ Pyrantel pamoate is poorly absorbed from the gastrointestinal tract and was therefore unlikely to have significant efficacy against worms dwelling in extraintestinal sites such as *E. boehmi*.¹⁷

Milbemycin oxime, administered at 0.5–1 mg/kg PO, was not effective in the treatment of the dog described in this case report, which probably reflects a true lack of efficacy at those doses. Re-exposure leading to reinfection was unlikely to have been a complicating factor due to the season of the year (winter) at the time of diagnosis and treatment. Deep snow cover and subfreezing environmental temperatures would prevent *E. boehmi* transmission, whether the life cycle was either direct or indirect. Milbemycin oxime, approved for use in dogs at 0.5 mg/kg (for the treatment of other parasitic infections), has a wide therapeutic safety margin and can be given safely at 1–2 mg/kg on a daily basis for prolonged periods of time for the treatment of generalized canine demodicosis.¹⁷ A single oral treatment with milbemycin oxime at 2 mg/kg resulted in a positive clinical response and the cessation of fecal egg shedding. To what degree, if any, the multiple treatments with the lower (0.5–1 mg/kg) doses of milbemycin oxime contributed to the successful control of the infection in the dog described in this report are unknown. The residual, slight, postexertion nasal discharge and low-level sneezing shown by the dog after treatment may have been due to breed disposition due to the brachycephalic conformation of a boxer-Chinese shar pei mixed-breed. Survival of a component of the worm burden was considered unlikely due to the numerous fecal examinations conducted in the posttreatment period.

Clinicians confronted with cases of parasitic infection in which there are no anthelmintics approved for use in treatment need to exercise caution regarding posttreatment diagnostic surveillance. From each of the published case reports involving *E. boehmi* infections in dogs, it is apparent that a single, negative fecal examination is not sufficient evidence to conclude treatment success. In addition to clinical improvement, multiple centrifugal fecal examinations should be monitored to confirm treatment success. Based on the present case, the authors recommend at

least three centrifugal fecal flotation examinations performed at about 7 days, 21 days, and 42 days posttreatment.

Conclusion

Nasal eucoleosis should be considered in dogs presented with clinical signs of nasal discharge and sneezing. Fecal flotation examination and possibly rhinoscopy should be included in the diagnostic investigation. Accurate identification of *E. boehmi* eggs detected on fecal flotation is difficult and is based on size (54–60 μ \times 30–35 μ) and visualizing the shell wall surface pattern (finely pitted). Based on clinical response and the cessation of fecal egg shedding, usage of milbemycin oxime at an increased dosage (2 mg/kg) appears to be an effective treatment for dogs infected with *E. boehmi*, the nasal capillarid. In addition to therapeutic response, multiple centrifugal fecal flotation examinations should be performed to monitor treatment success. ■

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FOOTNOTES

- ^a Heartguard Plus; Merial, Duluth, GA
- ^b Interceptor; Novartis, Mississauga, ON, Canada
- ^c Panacur; Intervet, Millsboro, DE
- ^d Eqvalan; Merial, Duluth, GA
- ^e Heartguard; Merial, Duluth, GA
- ^f Nemex; Pfizer, New York, NY

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